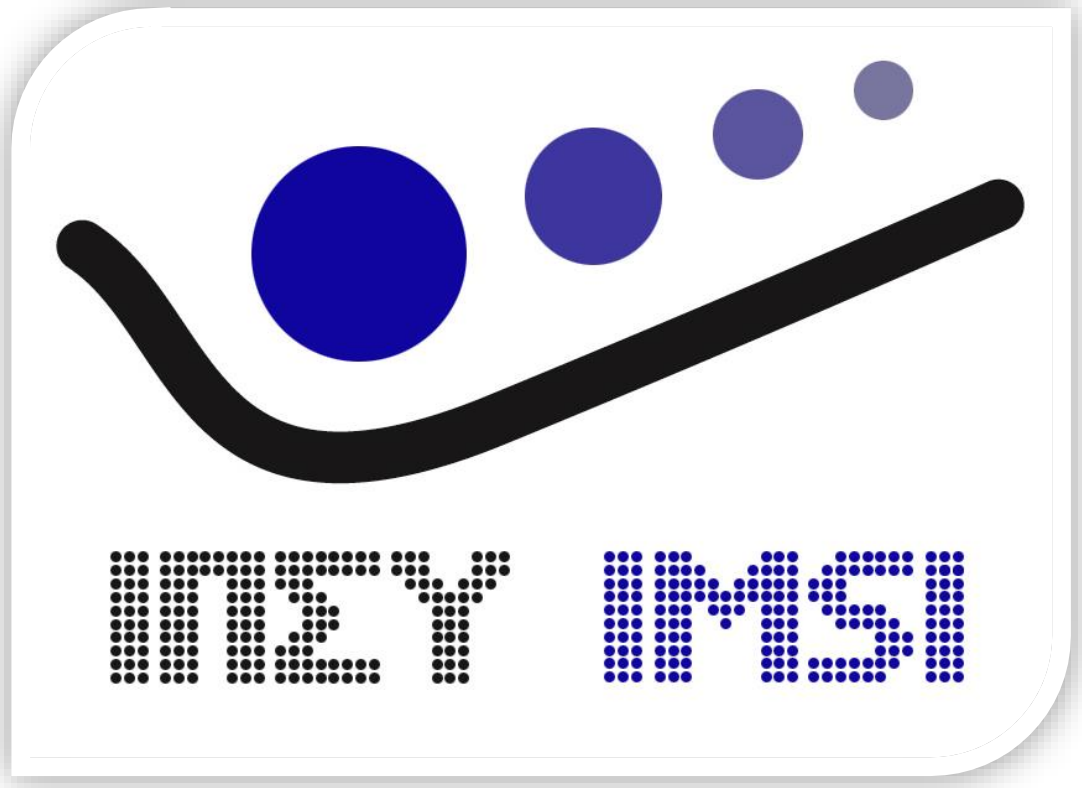
IMSI annual report 2017



Preface

Welcome to the Information Management Systems Institute (IMSI) of the ATHENA Research and Innovation Centre! Established in 2007, IMSI is today one of Greece's premier research centers in the areas of large-scale information systems and Big Data management. Over the past few years, IMSI researchers have been very successful in attracting and implementing numerous cutting-edge research & development projects, at both the national and international level; furthermore, IMSI has created strong collaborative ties with top European research institutions and has successfully promoted the development and use of state-of-the-art information systems in both local industry and various Greek government organizations.

As in previous years, in 2017, IMSI has significantly expanded the scope of its research efforts in a number of focus areas, including Big Data and Scalable Data Analytics, Web Data Management and Semantic Web Technologies, Geospatial Data Management, and Digital Curation and Research Infrastructures. In addition, IMSI researchers have led and/or participated in numerous activities promoting research and educational excellence in the areas of information systems and data management, as well as the development of novel software platforms and services, made available to the research community and employed by both local and international users.

Over the next few years, IMSI aims to continue to strengthen its collaborative ties with local and international industry and academia, promote the transfer of state-of-the-art information technology to national organizations and industry, and continue to strive for excellence further increasing the visibility of its research efforts and results.

Prof. Minos Garofalakis
Director, Information Management Systems Institute (IMSI)
ATHENA Research and Innovation Centre
Athens, Greece, 1/10/2018

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Profile

The Information Management Systems Institute (IMSI) is a research institute within the Research and Innovation Center in Information, Communication and Knowledge Technologies "ATHENA", which is the first research center in Greece with a focus exclusively on Information Society. Established in Athens in 2003, it is a research and technology organization supervised by the General Secretariat for Research and Technology of the Ministry of Education and Religion. IMSI was founded in 2007 with the mission to conduct research in the area of data management and large-scale information systems. In 2009, the Digital Curation Unit, which had been established in 2007 in "ATHENA" R.C, became a unit of IMSI.

The research at IMSI has a strong collaborative aspect, and ranges from basic to applied research. The collaborative aspect is expressed in that research is conducted with national and international partners from industry as well as academia, often also in the context of novel and innovative projects.

The mission of IMSI is to conduct research, develop applications and products and to offer services in the areas of information management and large-scale information systems. IMSI is particularly interested in the areas of database technology, software engineering and development methodologies, managing and exploiting information resources, as well as their large-scale applications.

The objectives of IMSI are:

- to participate and carry out research and development projects in the area of information technology and to cooperate with the academic community in topics of research, education and knowledge transfer to the industry.
- to produce experimental and industrial prototypes, and to develop new innovative products in cooperation with industry.
- to transfer knowledge on research and development topics and to offer training and certifications on information technology and related processes for the management of information and information systems.

To attain these objectives, IMSI is structured as follows:

- The Department of Database and Business Intelligence is responsible for basic and applied research in (a) database management systems, and (b) business intelligence systems. The focus is on design, optimization, scalability, security, privacy and high availability of databases and data warehouses, data mining and ETL.

- The Department of Distributed and Web Information Systems conducts basic and applied research on data management problems rising in Web applications and distributed computing in general. Focus is on methods and technologies to support search and exploration on the Web during a creativity cycle: from the abstraction describing the search domain, the information harvest and retrieval tasks and the adaptation of results to user needs, to the classification of results and exchange with other users. One of the use-cases we adopt is based on R&D for Web applications for biosciences. Strong interest also exists for modeling and data management issues for the Semantic Web and ontologies, heterogeneous data source integration problems, web services, and semistructured data storage and querying. Finally, focus is also given on real-time information systems, like sensor networks and p2p/grid systems.
- The Department of Geoinformatics conducts basic research and development of prototypes in the areas of geospatial data management, i.e., Geographic Information Systems, Spatial Data Infrastructures, Location-based services, geospatial data management on the Web, and human-machine interaction with spatiotemporal information.
- The Department of Scientific Databases and Simulation conducts basic and applied research on the modeling and efficient implementation of data management systems that support scientific applications and simulation processes. The focus is on biological data, environmental data, the management of evolution in scientific databases, and the management of imprecise information. Moreover, the Department concentrates on issues of design, development, and management of Digital Libraries.
- The Department of Software Engineering and Project Management Software is responsible for developing innovative applications that integrate cutting-edge research results and responding to needs of the Public and the Private Sector, based on professional standards and methodologies. It also conducts studies and provides consulting services and technical support to entities involved with IMSI. It also offers certifications to individuals and institutions with respect to the proficiency in software development and management of software project lifecycle (technical project description, project contract, project coordination, project delivery). Furthermore, it has the responsibility of training programs in specialized software issues, software development environments and project management software.
- The Digital Curation Unit (DCU) has the mission to conduct research, develop technologies and applications, provide services and training, and act as a national focus point in the field of digital curation. Digital curation encompasses a set of activities aiming at the production of high quality, dependable digital assets; their organization, archiving and long-term preservation; and the generation of added value from digital assets by means of resource-based knowledge elicitation. To ensure the adequate capture of the context of digital resources and their subsequent creative and effective use, the DCU adopts a multidisciplinary approach that

considers the full lifecycle of digital assets, such as records, digital surrogates and scholarly/ scientific datasets.

The activities of IMSI departments are supported by the “ATHENA” R.C. Economic and Administration Office.

Infrastructures

IMSI IT Infrastructure provides the necessary resources and services to support the organizational needs of the Institute and the development and support of quality IT services and solutions. It consists of the hardware, software and network components that are used in order to achieve the above goal.

In an effort to combine the best services IMSI Infrastructure is built upon both cloud computing and traditional locally implemented solutions. Local IT Infrastructure consists of servers hosted in IMSI owned facilities in a dedicated server room and is largely based on Virtualization technologies in order to achieve server consolidation and maximize the hardware's efficiency. It is the base upon which most of the Institute's IT services are built while at the same time it provides the required resources for a large number of projects the Institute participates in. It is also used by the affiliated researchers and students for larger scale experimentation and research.

Along with maintaining its own private local servers, IMSI also takes advantage of the benefits of cloud infrastructures. The resources made available to the Greek academic and research community through GRNET "Okeanos" IAAS Service are heavily used by the Institute's users for research and development purposes .Also, in collaboration with Microsoft and its Academic program Office 365 is used for providing mail and collaboration services.

Through the described infrastructures IMSI provides to its members and affiliates a variety of services, such as:

- Mail Services
- Directory Services used for centralized authentication and authorization
- Source Control
- Shared storage
- Virtual Private Network
- Web publishing
- Project Management and Collaboration
- Communication Services

The above services are provided and implemented using both commercial and open source operating systems and software, such as but not limited to:

- Operating Systems: Debian Linux, Ubuntu Linux, CentOS Linux. Microsoft Windows Server
- Virtualization Software: KVM
- Database Server: PostgreSQL, MySQL, MariaDB
- Distributed Processing: Apache Hadoop

IMSI network infrastructure provides high speed connectivity to its users and the provided services. IMSI network connects to the Internet using a 1Gbps fiber optics connection to GRNET. It consists of several Gigabit switches that offer wired connectivity and takes advantage of the Research Center's Wireless Infrastructure to provide high speed and reliable Wireless Connectivity. Also, through the Research Center's participation to the Eduroam Initiative, IMSI members can use their account to gain wireless internet access in research and academic institutions in more than 70 territories in the world.

Highlights

Events

- The former name of the Institute "Institute for the Management of Information Systems" changed to the current name "**Information Management Systems Institute**", as decided by the Management Board of the ATHENA R.C. Accordingly, the short name became **IMSI** in the place of the former short name IMIS.
- The **project WISE-ACT** (Cost Action) started in *October 2017*, which aims at studying the wider impacts and evaluate several scenarios for the autonomous and connected Transport in Europe. Project Coordinator from IMSI: George Papastefanatos.
- A new collaboration between **IMSI, Intracom Telecom S.A. and Ericsson S.A.** started in *October 2017*. IMSI has been contracted to design and develop a big data solution and methods for stream analytics on network data coming from IoT devices. Project Coordinator from IMSI: George Papastefanatos.
- The **EU (H2020-MSCA-ITN-2015) project ARCADES organized successfully the following two events during 2017:**
    a. The **1st Learning Week** on "Opportunity Recognition" that took place at the INRIA research center at Sophia Antipolis, France on April 3. It was organised to engage the doctoral candidates in the early stage of developing a feasible business, product or service idea connected to the CAD industry.
    b. The **1st Software & Industrial Workshop** and **Midterm Review** that took place in Athens on November 27.

  Project scientific coordinator: Ioannis Z. Emiris.

Awards

- **IEEE Senior Member:** Georgia Koutrika was elevated to IEEE Senior Member, a professional recognition for technical and professional excellence.
- **EU's Innovation Radar Prize, 'Tech for Society'**: The amphiro b1, an innovation developed by the DAIAD project coordinated by Athena RC, received the prestigious 2017 Innovation Radar Prize in the category Tech for Society. The Innovation Radar of the European Commission is actively identifying high potential EU-funded innovations and innovators and seeking to help them get their innovation 'out of the lab' and into (or at least closer to) the market. The annual 'Innovation Radar Prize' champions high potential innovations from around Europe, in a highly competitive process. Out of the thousands of EU-funded research projects, only 10 are selected per category from a panel of experts based on their

innovation excellence and commercialization potential. After a public open vote, the top 4 innovators present their work in an expert panel to decide the winner.

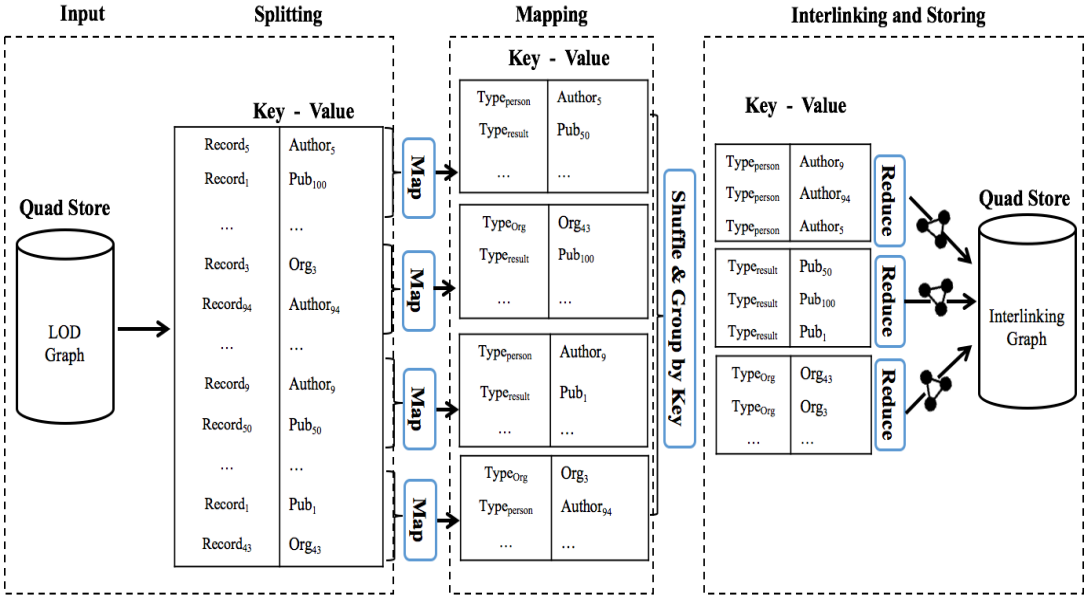
Research Directions

IMSI research activities fall into the following areas.

Big Data and Scalable Data Analytics

Current (ongoing) research directions in this area include:

- **Big Data Integration**



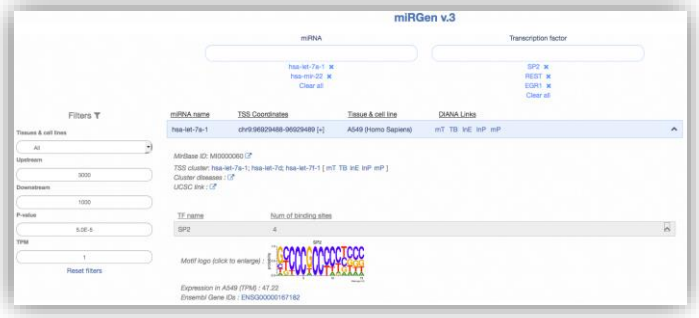
An area of interest concerns *Entity Resolution* in Big Data Integration settings, which can be used for duplicate detection and entity interlinking. Entity resolution constitutes a crucial task for many applications that involve integration of heterogeneous and noisy data; but it has an inherently quadratic complexity making brute-force methods inefficient to scale in big datasets. In order to enable entity resolution to scale to large volumes of data, blocking (cluster similar entities into groups and perform comparison only within groups) and metablocking techniques (clean overlapping blocks) are employed. In this direction, we have proposed novel metablocking techniques that aim to increase precision by orders of magnitude at a small cost in recall and exploited parallelization techniques (Map-reduce and Spark) to further improve the overall performance (in terms of efficiency and accuracy) of data integration. These methods have been implemented into a scalable framework for interlinking scholarly data, in the context of the *OpenAire* project. Still these methods operate in a more or less static mode, without considering fast updates on the data, or diverse user needs on the quality or the accuracy of the matched results.

- **Data Visualization, Exploration & Visual Analytics**
  One of the major challenges in the Big Data era is that it has realized the availability of a great amount and variety of big datasets for analysis by non-expert data analysts, such as research scientists, data journalists, policy makers, SMEs and individuals. The level of difficulty in transforming a data-curious user into someone who can competently access, analyze and consume that data is even more burdensome now for a great number of users with little or no support and expertise on the data (pre)processing part. Thus, data exploration and visualization methods and tools for visual analytics are of great importance nowadays. Modern systems must address the challenge of on-the-fly scalable visualizations over large dynamic sets of data, offering efficient exploration techniques, as well as mechanisms for information abstraction, summarization and meaningful visualization of different types of data (graph, geo, biological, etc). In this context, we have developed a tool, called *GraphVizDB* that enables the visualization and exploration of very large graphs using spatial indexing techniques. In addition, a parallel direction of our work aims at enabling efficient and interactive visual analysis of raw data files (e.g., csv, json, etc). We work on developing in-memory data structures that address the visual needs and enable users to perform several visual exploration scenarios. Furthermore, we have developed *Socioscope* (www.socioscope.gr), a visual analysis tool, used by social scientists, for the visualization and exploration of social and political data. Another application developed within the project *CitySense* aims to integrate city data from disparate sources and provide a visual way to combine them and filter city areas.
- **Mathematical Modeling and Analysis**
  Mathematical modeling of the physical world is crucial in a number of applications. Despite the complexity of three-dimensional models, current algorithms and software are making enormous progress in efficiently representing, handling, exchanging, and operating on such models. The ARCADES Network contributes in this direction by exploiting cutting-edge research in mathematics and algorithm design so as to design and implement robust methods in Computer-Aided Design and manufacturing (CAD/CAM). However, geometric modeling is facing new challenges in modern engineering analysis, simulation, manufacturing, and construction. This is becoming evident in new sectors such as the movie and game industry, where CAD methods are not penetrating fast enough, or are facing new challenges arising from massive and fast point acquisition (e.g. by laser scanners), big data and mobile computing. This captures precisely the challenge taken up by the ARCADES Network, namely to build the next generation of CAD software based on strong mathematical foundations from computer algebra, geometric computing, numerical analysis, and algorithm design. The crux of our method relies on algebraic representations, understood in the widest sense of the term, namely relying on polynomial expressions, and including parametric, implicit, and semi-algebraic representations, which can be converted to/from further representations such as

point clouds or subdivision surfaces. Compared to classical discrete representations, algebraic representations not only drastically reduce the size of the data, but also provide a small number of parameters (e.g. control points). The Network participants represent a multidisciplinary and multisectoral spectrum for implementing this vision, thus also offering an excellent opportunity for career development to the ARCADES fellows.

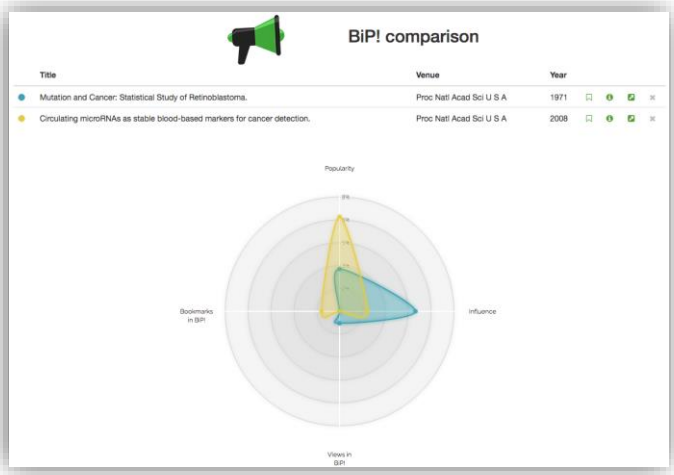
- **Scalable Analytics for Social Data**
  The increasing use of online social networks and microblogging platforms, such as Facebook and Twitter, and the content generated by millions of users, has led to the development of a multitude of innovative applications based on the analysis of big data from social networks. The selection of an appropriate sample for each different application data analysis is critical to the quality of the analysis results. In this direction, technologies supporting efficient collection and modeling of social network data are key components of an innovative information management platform for social networks. Such a platform fills the gap that exists between the restrictive and cumbersome interface offered by online social networks and the need of applications for easy collection and flexible sample selection. At IMSI, we are developing a novel platform, called *TwitHoard*, for managing information obtained from OSNs and we incorporating in it the results of relevant research activities. Moreover, the National (Synergasia) project *RealEstate2.0* develops an infrastructure for collecting and integrating comments about specific geographical areas from various social media platforms.
- **Influence Maximization in Social Networks**
  Influence maximization in social networks focuses on how to distribute a message in a social network to reach the widest possible audience. While traditional methods investigate the choice of the most suitable users as broadcasters of the initial message, our work focuses on choosing the best features, i.e., interest topics, that can work as communication channels.
- **Privacy Preservation**
  The protection of user privacy in data analytics is one of the major challenges faces by modern information systems. IMSI has worked extensively in the field of data anonymization, where personal data are transformed to anonymous where the identities of individuals are hidden and sensitive properties can no longer be attributes to them. IMSI has developed a series of anonymization algorithms for complex data (tree structured, RDF, set-values) and a tool, AMNESIA, that allows non-expert users to use anonymization techniques on their data. The work on privacy preservation has resulted in a series of publication and it is used in the *OpenAIRE*, *My Health My Data* and *MEDA* projects.
- **Scientific databases and bioinformatics**
  We work on models, architectures and methods to store, preserve, process and query genomic and life science data. The vision is to provide high-performance computing methods and tools to perform real-time analysis and processing of big and complex

life science datasets. Emphasis is given to genomic data related to miRNAs sequencing process and their analysis. IMSI, Univ. of Thessaly and GRNET have designed, implemented and maintained a research infrastructure for genomic data management, oriented to processing, analysis and visualization of computationally predicted miRNA targets (http://diana.imis.athena-innovation.gr). Part of the work is being integrated into the ELIXIR-GR research infrastructure that develops the Greek Node of the ESFRI European RI ELIXIR (https://www.elixir-europe.org), a distributed e-Infrastructure aiming to build a sustainable European infrastructure for biological information. The research is supported by EXCELERATE, an H2020-INFRADEV project for fast-track ELIXIR implementation and ELIXIR-GR, a Greek project of the National Structural fund to support the Greek Roadmap for Research Infrastructures.



- **Text Mining and Information Retrieval for Scientific Publications**

Scientific publications retrieval and ranking based on their impact has been a long-established research topic, especially due to the massive number of papers being published annually. We are working on technologies to identify high-impact research output, focusing on the study of impact aspects like long-term influence, popularity, etc. Our approach is based on PageRank adaptations for citation networks and machine learning on paper metadata. We also apply text mining techniques on scientific texts to automatically extract useful knowledge. Finally, we develop powerful information retrieval systems that are based on the previously described technologies to provide useful services to the research & science community (e.g., BiP! finder).



- **Information and Communications Technologies for Big Data**

Specifically broadband networks and converged telecommunications and media services, cloud based large data processing, storage and network programming

systems. The research is supported by EU and National projects related to scientific data infrastructures, currently ELIXIR-EXCELERATE and ELIXRI-GR. Note that IMSI, in collaboration with GRNET and Univ. of Thessaly, has designed, implemented and maintained an e-science platform for genomic data management, oriented to processing, analysis and visualization of computationally predicted miRNA targets (http://diana.imis.athena-innovation.gr). The platform is running on GRNET's cloud, providing reliable and high-performance data analysis and processing services to more than 2K active users.

New (emerging) research directions in this area include:

- **Big Data Analytics**
  The attention Data Science receives recently is partly due to the availability of huge volumes of data and the opportunity to mine and extract useful knowledge. IMSI has already a significant activity and expertise around Big Data management, thus a natural next step is to focus on Data Science and Big Data Analysis. An interesting objective for IMSI is to examine how the machine learning techniques and statistical methods of Data Science can be combined with the Big Data need for scaling, particularly for non-conventional data types, like temporal, spatial, graph, stream, and scientific. We also plan to investigate the processing of deep learning operations (e.g., matrix factorization) in modern CPU architectures.
- **Data-driven Circular Economy**
  Based on the successful results of AI4B (www.ai4b.gr/), a national R&D project that designed and developed innovative ICT for biomass supply chains, we plan to launch a multi-disciplinary research and innovation activity in data-driven approaches to unlock the circular economy potential. Contrary to the 'take, make, dispose' production model of a linear economy, in a circular economy, resource input, waste, emission, and energy leakage are minimised by narrowing material and energy loops through recycling, reuse, remanufacturing, repair, etc. Our aim is to build on state-of-the-art technologies and scientific solutions in data science and big data analytics, and provide novel methods, algorithms and tools to collect, process and analyze data to support key areas of circular economy, like smart waste management, automatic detection of resource/material flows in industrial networks, analysis and visualization of complex industrial symbiosis networks, etc. We are launching a spin-off, transferring research results on data-driven waste/by-product valorization and industrial symbiosis applications into commercially exploited data services for industry to align their business plans with circular economy principles and best practices.
- **Cloud Infrastructures**
  Based on the experience from CONFES project that developed integrated wireless-wired transmission network infrastructure of ultra-high capacity optical technologies, project proposals are submitted to address challenges of the Future

Internet especially in Network Function Virtualization - NFV / Software defined Networks –SDN for example by elaborating and constructing a dynamic Cloud infrastructure and in particular a converged Telco and IT node in access networks. One goal is to support advanced 5G/IoT services and applications with demanding QoS and edge analytics needs, with applications in many areas of great interest like in precision farming and 5G access and backhaul networks.

Semantic Web Technologies

Current (ongoing) research directions in this area include:

- **OLAP Analytics in the Web of Data**
  Another direction of research is related to the application of efficient analytics on multidimensional RDF data, i.e., data usually treated under the OLAP prism, where they are represented as observations that are instantiated over pre-defined dimensions and measures (similar to traditional DW modelling). The increasing volume and diversity of these data (statistical authorities, academic institutes, financial organizations and pharmaceutical companies publish such data) pose the challenge of finding hidden relations between them in a most efficient and accurate way, with the aim to detect inconsistencies or infer new facts. We have addressed this problem, by introducing new relationships (e.g., containment and complementarity of data) between multidimensional RDF data, and new algorithms for efficient and scalable computation of these relationships.
- **Scalable Query Processing in the Web of Data**
  Another line of work addresses the need for efficient processing of SPARQL queries over voluminous RDF stores. Many indexing approaches have been proposed in this area; still few of them take into account the inherent structure of RDF graph data and how this structure can be exploited for efficient processing and optimization of SPARQL queries. For that, we have developed a scalable approach for query processing of RDF stores, based on a novel indexing technique, called Extended Characteristic Sets, which builds on top of the characteristics of the triples in an RDF dataset and enables the efficient processing of complex multi-join queries.

New (emerging) research directions in this area include:

- **Distributed Storage and Parallel Query Execution**
  Future interesting directions involve the distributed storage of the index and the parallel execution of such queries. Future directions include the extension of these techniques to cover more complex analytic techniques such as finding missing values, outliers and causalities on such data and make them scalable for very large volumes via parallelization. Some emerging directions, concern online entity resolution techniques, which aim at integrating the blocking\metablocking\entity

matching tasks (in the form of query operators) in the query processing phase. The goal is to enable users to seamlessly analyze on query-time heterogeneous (e.g., different schemas, disparate data sources) datasets that involve highly noisy data of different quality.

User-Data Interaction Systems

New (emerging) research directions in this area include:

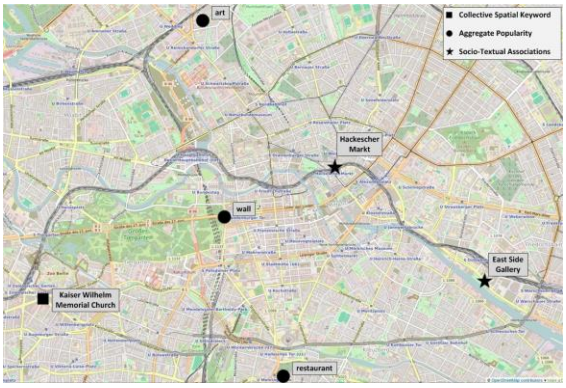
- **Intelligent Data Interfaces to Databases**
  The advent of computers drastically improved mankind's opportunities to information access. Unfortunately, the volume and complexity of available data preclude easy access to information for most people but the savviest technical experts. For the majority, standard keyword-search interfaces allow users to ask simple questions and receive answers to them, without however actively assisting their users in satisfying their information needs. The volume of data and the need for data democratization call for shift from the classical «query-based information access paradigm» popularized by existing systems to a novel information access paradigm, where the system takes upon a more conversational and active role in helping users effectively explore data of varying quality, complexity, and relevance. We are looking into several aspects of such systems:
  (a) *conversational systems*: the system converses with the user not only returning results to her queries but offering advice, explanations and suggestions in a natural language interaction with the user
  (b) *data exploration*: the system actively guides the user through their information access endeavor by offering just-in-time recommendations, exploration options, and help as needed
  (c) *interaction in context*: the system keeps track of the context (e.g., goals, background information, earlier queries) of a user quest, and it can respond and adapt accordingly
  (d) *proactive systems*: the system anticipates user needs proactively presenting information and suggestions without the user explicitly prompting the system, thus promoting continuous and easier learning.
- **Modern Recommender Systems**
  Recommender systems provide advice on items that may be of interest to a user (e.g., movies, products, travel, and leisure activities) by learning user preferences and relationships between users and items, and they have become a salient part of Amazon, Google, Netflix and other web sites. Early recommender systems used simple computational or machine learning models to learn user preferences (content-based approaches) or to capture relationships between users or items (collaborative filtering approaches) to make recommendations. The landscape of recommender systems has drastically shifted from these early systems. Novel algorithmic

approaches, including matrix factorization, multi-armed bandits and deep learning, show outstanding results and open up new opportunities and research paths. We are looking into this area from:
(a) *The data perspective*: where the objective is to explore non-conventional types of data and inputs to recommendations,
(b) *The problem perspective*: where the objective is to study recommendation problems beyond typical ones focusing on user consumption problems (selecting movies to watch, products to buy, applications to download, and so forth). Such problems include data exploration, query optimization, visualization, data integration, and workflow design among others, where the purpose is to select tuples, queries, views, exploration actions, query plans, visualization graphs etc.
(c) *The methods perspective*: where the objective is to build on the newest algorithmic developments in the field of recommender systems.

Geospatial Data Management

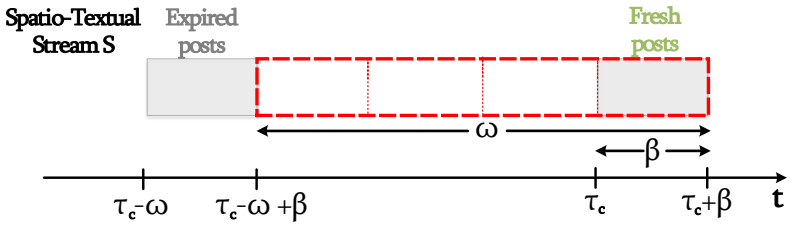
Current (ongoing) research directions in this area include:

- **Identifying Areas of Interest**



Large amounts of user-generated content are becoming available on the Web daily, with an increasing portion of it being associated with geospatial information. Typical examples include community-based mapping projects, such as OpenStreetMap, databases of Points of Interest (POIs), e.g., from Wikipedia or Foursquare, geotagged photos, e.g., from Flickr or Instagram, etc. This information constitutes a valuable resource for discovering and exploring locations and areas of interest, with numerous applications in location-based services, geomarketing, trip planning, and other domains. Our work in this context has focused on identifying sets of locations that are strongly associated under social and textual criteria. A set of locations is associated with a set of keywords if there exists a user with posts around these locations whose textual descriptions contain the given keywords. We measure the strength of this association by the number of users with posts that support it. The studied problem has some similarities to frequent itemset mining; however, the support measure in this case does not satisfy the anti-monotonicity property which is used to efficiently prune the search space. Still, we can devise efficient and scalable algorithms based on hybrid spatio-textual indices. Our experimental results indicate that our approach can identify meaningful location sets which are not discovered by other existing approaches.

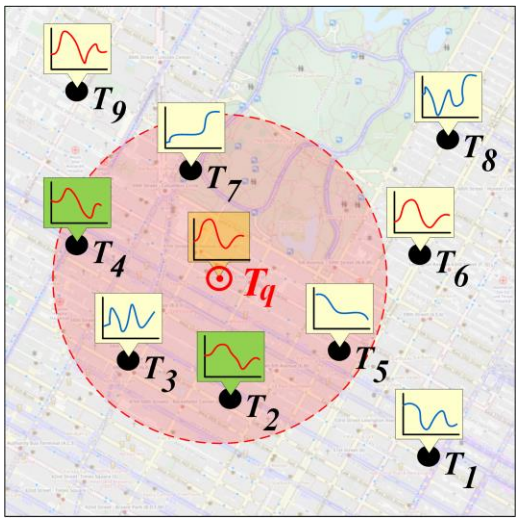
- **Spatio-Textual Stream Summarization**
  Millions of geotagged posts are generated constantly by users in social media. Keeping track of a whole stream of spatio-textual content can easily become overwhelming for the user. In our work, we address the problem of selecting a small, representative and diversified subset of posts, which is continuously updated over a sliding window. Each such subset constitutes a concise summary of the stream's contents within the respective time interval, being dynamically updated every time the window slides to reflect newly arrived and expired posts. We define the criteria for selecting the contents of each summary and we present several alternative strategies for summary construction and maintenance that provide different trade-offs between information quality and performance. Furthermore, we optimize the performance of our methods by partitioning the newly arriving posts spatio-textually and computing bounds for the coverage and diversity of the posts in each partition. The proposed methods are evaluated experimentally using real-world datasets containing geotagged tweets and photos.



- **Anonymization of Spatial Data**
  Our work has been directed towards the anonymization of trajectories. The main innovation of our proposal was the use of splitting a trajectory to smaller ones, as a data transformation operator in data anonymization.

New (emerging) research directions in this area include:

- **Indexing Geolocated Time Series**
  Time series associated with specific locations, such as visitor check-ins or sensor readings, have increased in size and popularity in various domains. Although several works have focused on efficient time series similarity search, there has been limited attention to the inherent challenge that geolocated time series introduce for hybrid queries on both spatial proximity and time series similarity. To efficiently process such queries, our work focuses on the design of hybrid indices. In particular, we propose the TSR-tree index, which



extends the R-tree by introducing appropriate bounds for the time series indexed at each node. We also present an optimized version, the BTSR-tree, which uses tighter bounds by bundling together similar time series in each node. Our experiments show that these indices can be used to efficiently evaluate different variants of hybrid queries combining spatial and time series filtering or ranking.

Digital Curation and Research Infrastructures

Current (ongoing) research directions in this area include:

- **Digital Curation**
  Digital curation encompasses a set of activities aiming at the production of high quality, dependable digital assets; their organization, archiving and long-term preservation; and the generation of added value from digital assets by means of resource-based knowledge elicitation. In order to ensure adequate representation and long-term access to digital information as its context of use changes we adopt a lifecycle approach to the representation of curated information objects and a cross-disciplinary scope, so as to cater for differences between diverse scientific and functional contexts of use. Our work programme includes conducting research, developing innovative systems and services, and promoting best practices for digital curation, with special focus on selected domains. Lines of research and development work include: modelling and managing digital curation and preservation processes; developing and maintaining knowledge resources and knowledge organization systems, repository systems, registries, aggregation services, curation micro-services, metadata quality assurance; ontologies, semantic search and process discovery; understanding and modelling working practices and information behaviours in specific research and professional communities, especially in the humanities; user community modelling and social tagging; streamlining curation and scientific communication; establishing and disseminating best practices with regard to data curation and management.
- **Digital research infrastructures**
  A strategic action line is the development of digital research infrastructures for the humanities at the national and European levels. At the national level, IMSI leads the APOLLONIS Greek Infrastructure for Digital Arts, Humanities and Language Research and Innovation (P. Constantopoulos, coordinator). At the European level, IMSI actively participates in the European Digital Research Infrastructure for the Arts and Humanities (DARIAH) since the preparatory phase, currently with leading roles in VCC2, DARIAH's Virtual Competence Centre for Research and Education (A. Benardou is VCC2 Co-Chair, C. Dallas chairs the Working Group "Digital Methods and Practices Observatory"). IMSI, through DCU, has been heavily involved in building the ARIADNE infrastructure for archaeology. It provides advanced aggregation services for the Europeana ecosystem, and actively

contributes to the Research Data Alliance (RDA). It has developed the ESF NeDiMAH methods ontology (NeMO), now used to drive the automatic extraction of research processes. Collaborations with other research infrastructures, also in areas besides the humanities, are actively pursued.

New (emerging) research directions in this area include:

- **Electronic Records Management**
  We plan to work on curation services for electronic records management. Records are important both for their content and as evidence of communications, decisions and actions. The development of electronic records management systems, especially tools for metadata management, classification, semantic annotation and preservation, constitutes a promising direction for applying our work.

Projects

EU R&D Projects

ARIADNE - Advanced Research Infrastructure for Archaeological Dataset Networking in Europe

Project coordinator	Costis Dallas/ Chistos Papatheodorou
Coordinator	PIN Soc. Cons. A R.L. – Servizi Didattici e Scientifici Per L' Universtita Di Firenze
IMSI - funding	537,440 euros
Programme	FT4-Infrastructures -2012-1
Start date	1/2/2013
Duration	4 years
Website	http://www.ariadne-infrastructure.eu/

The ARIADNE project is aimed to integrate the existing archaeological research data infrastructures so that researchers can use the various distributed datasets and new and powerful technologies as an integral component of the archaeological research methodology. DCU led Work Package WP3, which was responsible for: a metadata registry for archaeological resources, the design and implementation of long term preservation services, and the implementation of the interoperability framework of the ARIADNE infrastructure. It also organized two Summer Schools and Expert Forums on digital curation and digital research in archaeology.

DSI-3 - Access to digital resources of European heritage Europeana

Project coordinator	Dimitris Gavrilis

Coordinator	STICHTING EUROPEANA(EF)
IMSI - funding	58,000 euros
Programme	Service Contract-"Deployment and Maintenance of Europeana DSI Core Services-SMART-2016/1019"
Start date	1/9/2017
Duration	12 months
Website	https://pro.europeana.eu/project/europeana-dsi-3

The Europeana DSI-3 project builds on and continues operation of the existing Europeana Digital Service Infrastructure's (DSI) Core Service Platform (CSP) following on from the Europeana DSI-1 and DSI-2 actions under CEF. It is the third project for the completion of Europeana's strategy 2015-2020. It is in line with the Connecting Europe Facility (CEF) Trans-European Telecommunications Network's work programme for 2015, delivering interoperability, connectivity and coordination for digital cultural heritage at a European level and providing efficient solutions for access and distribution of multilingual and multi-domain resources in digital European cultural heritage. IMSI participates in DSI-3 both as a technical partner with the MORe platform (supporting the CARARE network as part of DSI) and also through Europeana Research.

NEP4DISSENT – New Exploratory Phase in Research on East European Cultures of Dissent. European Cooperation in Science and Technology

Project coordinator	Costis Dallas
Coordinator	Polish Academy of Sciences (PL)
IMSI - funding	About 50,000 euros (The funding of COST actions is adjusted yearly)
Programme	Open Call Collection OC-2016-2
Start date	16/10/2017
Duration	4 years
Website	http://www.cost.eu/COST_Actions/ca/CA16213

Resistance and dissent in former socialist Europe 1945-1989 constitutes a remarkable chapter of Europe's recent past, which not only informs in a decisive way the identities of post-socialist societies, but has also reshaped the continent as a whole and still provides an important reference for contemporary social

movements worldwide. The proposers of this Action believe that, after a period of growth and consolidation, this field of study and the respective domain of cultural heritage have stalled and fell short of its true significance. This state of affairs results from (1) the inheritance of Cold War-era conceptual distinctions, (2) confinement of research within national silos and (3) neglecting the problem of access to original archival sources for digitally enabled research due to both their heterogeneity and uneven investment in research infrastructures.

	Wider Impacts and Scenario Evaluation of Autonomous and Connected Transport
Project coordinator	George Papastefanatos
Coordinator	University of Greenwich
IMSI - funding	-
Programme	COST ACTION
Start date	30/7/2015
Duration	4 years
Website	https://wise-act.eu/

Autonomous vehicle (AV) trials are currently taking place worldwide and Europe has a key role in the development of relevant technology. Yet, very limited research exists regarding the wider implications of the deployment of such vehicles on existing road infrastructure, since it is unclear if and when the transition period will start and conclude. It is anticipated that improved accessibility and road safety will constitute the primary benefits of the widespread use of AVs, whilst co-benefits may also include reduced energy consumption, improved air quality or better use of urban space. Therefore, the focus of this COST Action is on observed and anticipated future mobility trends and implications on travel behaviour, namely car sharing, travel time use or residential location choice to name a few. Other important issues to be explored under different deployment scenarios are social, ethical, institutional and business impacts. To achieve this, it is essential to culminate co-operation between a wide range of stakeholders at a local, national and international level, including academics and practitioners. Consequently, this COST Action will facilitate collaboration within Europe and beyond about this emerging topic of global interest.

Europeana Cloud

Project coordinator	Costis Dallas
Coordinator	The Europeana Foundation
IMSI - funding	154.533 euros
Programme	CEF-TC-2015-1-01
Start date	1/2/2013
Duration	4 years
Website	http://pro.europeana.eu/europeana-cloud

Europeana Cloud was a Best Practice Network coordinated by the Europeana Foundation, designed to establish a cloud-based system for Europeana and its aggregators. Europeana Cloud provided new content, new metadata, a new linked storage system, new tools and services for researchers and a new platform: Europeana Research, an initiative facilitating the use of Europeana Collections in research. In Europeana Cloud, DCU led the Work Package responsible for Assessing Researcher Needs in the Cloud and Ensuring Community Engagement, which was responsible for: a) The identification and definition of the Humanities and Social Sciences research communities that will be supported via the Europeana Cloud, b) The development of an effective research content strategy for Europeana, based on an evidence-based account of usefulness of Europeana and The European Library resources for research in the Humanities and Social Sciences, c) The improvement of the understanding of digital tools, research processes and content used in the Humanities and Social Sciences, thus informing the development of tools and aggregation of content in the Europeana Cloud, d) The active engagement of the Humanities and Social Sciences research communities in establishing user requirements for the development of Europeana Cloud.

GLOBAQUA - Managing the effects of multiple stressors on aquatic ecosystems under water scarcity

Project coordinator	Prof. Phoebe Koundouri
Coordinator	CSIC, Spain
IMSI - funding	368,360 euros
Programme	EU's 7th Programme for research, technological development and demonstration
Start date	2/2014
Duration	5 years
Website	www.globaqua-project.eu

The main aim of GLOBAQUA is to achieve a better understanding of how current water management practices and policies could be improved by identifying their main drawbacks and alternatives. Freshwater systems are under threat by a variety of stressors (organic and inorganic pollution, cover change, water abstraction, land use, etc…). The join occurrence of many stressors (chemical, geomorphologic, biological) under water scarcity may produce novel and unfamiliar synergies and effects of unknown consequences. Therefore, it is crucial to understand deeply how water scarcity interacts with other stressors in freshwaters and to convey this information to managers, stakeholders and policymakers in order to minimize impacts, to adapt to oncoming changes, and to improve our management and policies. GLOBAQUA (Managing the effects of multiple stressors on aquatic ecosystems under water scarcity) has assembled a multidisciplinary consortium in order to study the interaction of multiple stressors within the frame of strong pressure on water resources. GLOBAQUA assesses the effects of water scarcity on aquatic ecosystems by focusing on six river basins (Adige, Anglian, Ebro, Evrotas, Sava and Souss Massa). These basins encompass a rich set of socio-ecological conditions and a wide geographic coverage, and focus on a specific set of stressors to illustrate different management scenarios.

DAIAD - Open Water Management

Project coordinator	Spiros Athanasiou
Coordinator	IMSI
IMSI - funding	1,06 MEuros

Programme	STREP, FP7-ICT-2013-11
Start date	1/3/2014
Duration	3.5 years
Website	http://www.daiad.eu

DAIAD is an EU-funded research project developing technologies for real-time monitoring, analysis, and understanding of water consumption data, aiming to induce sustainable changes in consumer behavior. Efficient water management is a challenging issue with the potential to affect the long-term well-being, economy and security of society. Policies for sustainable water management have been established in the EU. However, measures to support efficient water use for citizens are currently lacking. Consumers have limited means to accurately monitor their water consumption and thus stimuli to modify their behavior towards a sustainable lifestyle. A potentially groundbreaking approach for efficient water use and reuse lies within the empowerment of consumers. The principles of open knowledge and participation have provided solutions and driven innovation in similar challenging and complex issues. We believe that a similar bottom up method, in which citizens can voluntarily adopt low cost water monitoring services, self-induce behavioral changes, and accordingly demand better services, can be a catalyst for large-scale changes in efficient water management. The DAIAD project constitutes an innovative approach for addressing the challenge of efficient water management through real-time knowledge of residential water consumption, bringing together leading members of the water and ICT domains. Our goal is to research and develop innovative low cost, inclusive technologies for real-time, high granularity water monitoring and knowledge extraction. We will devise multi-modal feedback interfaces, recommendation, and analysis services to communicate knowledge and incur behavioural changes to consumers in residential settings. We will apply big data management and analysis technologies to provide efficient management and analysis of real-time water consumption data, as well as multiple relevant data sources. This will enable water stakeholders to gain novel insight and explore the hidden correlations of the parameters that shape water demand strategies and water pricing, thus leading to more efficient water management.

SLIPO - Scalable Linking and Integration of Big POI Data

Project Coordinator	Spiros Athanasiou

Coordinator	IMSI
IMSI - funding	748 KEuros
Programme	IA, H2020-ICT-14-2016
Start date	1/1/2017
Duration	3 years
Website	http://www.slipo.eu

SLIPO (www.slipo.eu) is an Horizon 2020 Innovation Action (IA) developing technologies for the scalable and quality assured integration of Points of Interest (POI) Big Data assets. POI data are the cornerstone of any application, service, and product even remotely related to our physical surroundings. From navigation applications, to social networks, to tourism, and logistics, we use POIs to search, communicate, decide, and plan our actions. The creation, update, and provision of POIs consists a multi-billion cross-domain and cross-border industry, with a value chain natively incorporating most domains of our economy. The evolved POI value chain introduces opportunities for growth, but also complexity, intensifying the challenges relating to their quality-assured integration, enrichment, and data sharing. However, the integration of POIs using current approaches remains labor-intensive and scalable only for domain-specific or small-scale efforts. In SLIPO, we argue that linked data technologies can address the limitations, gaps and challenges of the current landscape in integrating, enriching, and sharing POI data. Our goal is to transfer the research output generated by our work in project GeoKnow, to the specific challenge of POI data, introducing validated and cost-effective innovations across their value chain. Specifically, SLIPO develops effective and scalable software and processes for: transforming conventional POI formats and schemas into RDF data; interlinking POI entities from different datasets; enriching POI entities with additional metadata, including temporal, thematic and semantic properties; fusing Linked POI data in order to produce more complete and accurate POI profiles; assessing the quality of the integrated POI data; offering value added services based on spatial aggregation, association extraction and spatiotemporal prediction.

City.Risks - Avoiding and mitigating safety risks in urban environments

Project coordinator	Dimitrios Skoutas

Coordinator	SPACE HELLAS
IMSI - funding	452,125.00 euros
Programme	H2020-FCT-2014 - Research and Innovation action
Start date	1/5/2015
Duration	3 years
Website	http://project.cityrisks.eu/

The main objective of the City.Risks project is to increase the perception of security of citizens in big urban environments. This is achieved by activating in a more transparent and sustainable way their participation in communities, through which information and interventions can be provided both proactively, to protect citizens from falling victims to criminal activities, as well as reactively, to provide more timely and effective response and assistance. City.Risks leverages a set of innovative technologies, city infrastructures and available data sources. Moreover, it makes the citizens' smart phones the modern tool for increasing their personal and collective sense of security. The project designs and develops an innovative ecosystem of mobile services that transform the smart phone or the tablet of the citizen into a tool that collects, visualises and shares safety-critical information with the appropriate authorities and communities. The project relies on a wide spectrum of available technologies to design and implement an interactive framework among authorities and citizens through mobile applications that allows in a collaborative way to prevent or mitigate the impact of crime incidents or other security threats. Thus, it contributes to an increase of the citizens' perception of security, which is measured and validated in real-life scenarios and conditions through the deployment and operation of pilot trials at several selected cities by the project partners.

ELIXIR-EXCELERATE - Fast-track ELIXIR implementation and drive early user exploitation across the life-sciences

Project coordinator	Theodore Dalamagas (Deputy: Stelios Sartzetakis)
Coordinator	European Molecular Biology Laboratory - EMBL
IMSI - funding	40,000 euros
Programme	EU, INFRADEV-3-2015
Start date	1/9/2015

Duration	4 years
Website	https://www.elixir-europe.org/excelerate

The precipitous drop in costs for high-throughput biology has enabled European research laboratories to produce a huge amount of complex and heterogeneous data. However, data will only generate long-term value if it is Findable, Accessible, Interoperable and Re-usable (FAIR). This requires a scalable infrastructure that connects local, national and European efforts and provides standards, tools and training for data stewardship. Motivated by this, ELIXIR, a distributed organisation comprising national bioinformatics research infrastructures and the European Bioinformatics Institute, has developed ELIXIR-EXCELERATE. The project will fast-track ELIXIR's early implementation phase by i) coordinate and enhance existing resources into a world-leading data service for academia and industry, ii) grow bioinformatics capacity and competence across Europe, and iii) complete the management processes needed for a large distributed infrastructure. ELIXIR-EXCELERATE will enable cost-effective and sustainable management and re-use of data for millions of users across the globe and improve the competitiveness of European life science industries through accessible data and robust standards and tools.

RDA3 - RDA Europe – the European plug-in to the global Research Data Alliance

Project coordinator	Yannis Ioannidis
Coordinator	MAX PLANCK GESELLSCAFT ZUR FOERDERUNG DER WISSENSCHAFTEN E.V.(MPG)
IMSI - funding	232,292.50 euros
Programme	H2020-EINFRA-2014-2
Start date	1/9/2015
Duration	2.5 years
Website	https://www.rd-alliance.org/rda-europe-0

The Research Data Alliance (RDA) Europe project aims at facilitating European representation within the RDA Global alliance. IMSI participates in the main RDA Global governance body, namely the RDA secretariat with responsibilities in the RDA Organisational Assembly and Advisory Board. IMSI also participates in the European Policy Level engagement with emphasis on both research and industry

engagement. IMSI participates in the outputs uptake work package which has a number of responsibilities: a) mapping the landscape of RDA outputs that are produced by the various working and interest groups, b) supporting collaboration projects, c) development and support of the "Atlas of Knowledge" knowledge base d) organisation of datathon/hackathon events to promote the adoption and reuse of RDA outputs. Finally, IMSI is also involved in the dissemination work, focusing mainly on publications tracking, including tracking the RDA Working Group ones using the OpenAIRE Research Impact Service.

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Coordinator	European Molecular Biology Laboratory - EMBL
IMSI - funding	40,000 euros
Programme	EU, INFRADEV-3-2015
Start date	1/9/2015
Duration	4 years
Website	https://www.elixir-europe.org/excelerate

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SLIDEWIKI - Large-scale pilots for collaborative OpenCourseWare authoring, multiplatform delivery and learning analytics

Project manager	Theodore Dalamagas
Coordinator	FRAUNHOFER IAIS
IMSI - funding	570,000 euros
Programme	EU, ICT-20-2015
Start date	14/11/2015
Duration	3 years
Website	https://slidewiki.eu

A major obstacle to increase the efficiency, effectiveness and quality of education in Europe is the lack of widely available, accessible, multilingual, timely, engaging and high-quality educational material (i.e. OpenCourseWare). The creation of comprehensive OpenCourseWare (OCW) is tedious, time-consuming and expensive, with the effect, that often courseware employed by teachers, instructors and professors is incomplete, outdated, inaccessible to those with disabilities and dull. Similarly to Wikipedia for encyclopaedic content, SlideWiki allows (1) to collaboratively create comprehensive, multilingual OCW (curricula, slide presentations, self-assessment tests, illustrations etc.) online in a crowdsourcing manner, (2) to support skills recognition and validation through learning analytics based on fine-grained content structuring and comprehensive learning self-assessment, and (3) set up an OCW community, where all relevant stakeholders from material provisioning, content production, translation, learning delivery and analytics are integrated into sustainable educational content value chains. SLIDEWIKI will perform four large-scale trials in secondary education, vocational and professional training, higher education and community-driven open-education. Each of these large-scale trials will be performed with hundreds of educators and thousands of learners in countries all over Europe.

ARCADES - Algebraic Representations in Computer-Aided Design for complEx Shapes

Project	Ioannis Z. Emiris

coordinator	
Coordinator	IMSI
IMSI - funding	485,000 euros
Programme	Marie Sklodowska-Curie Innovative Training Networks
Start date	1/1/2016
Duration	4 years
Website	http://arcades-network.eu

ARCADES aims at disrupting the traditional paradigm in Computer-Aided Design (CAD) by exploiting cutting-edge research in mathematics and algorithm design. Today, several approaches of the CAD industry are outdated, and 3D geometry processing is becoming increasingly the weak link. This is alarming in sectors where CAD faces new challenges arising from fast point acquisition, big data, and mobile computing, 3D printing, but also in robotics, simulation, animation, fabrication and manufacturing where CAD strives to address crucial societal and market needs. The challenge taken up by ARCADES is to build the next generation of CAD software based on strong foundations from algebraic geometry, differential geometry, scientific computing, and algorithm design. Our game-changing methods lead to real-time modelers for architectural geometry and visualisation, to isogeometric and design-through-analysis software for shape optimisation, and marine design & hydrodynamics, and to tools for motion design, robot kinematics, path planning, and control of machining tools

DSI-2 - Access to digital resources of European heritage Europeana

Project coordinator	Dimitris Gavrilis
Coordinator	STICHTING EUROPEANA(EF)
IMSI - funding	153,010 euros
Programme	CEF-TC-2015-1-01
Start date	1/7/2016
Duration	14 months
Website	http://pro.europeana.eu/get-involved/projects/project-list/europeana-dsi-2

The Europeana DSI-2 project builds on and continues operation of the existing Europeana Digital Service Infrastructure's (DSI) Core Service Platform (CSP) following on from the Europeana DSI-1 action under CEF (CEF-TC-2014-2). It is the second project for the completion of Europeana's strategy 2015-2020. It is in line with the Connecting Europe Facility (CEF) Trans-European Telecommunications Network's work programme for 2015, delivering interoperability, connectivity and coordination for digital cultural heritage at a European level and providing efficient solutions for access and distribution of multilingual and multi-domain resources in digital European cultural heritage. IMSI participates in DSI-2 both as a technical partner with the MORe platform (supporting the CARARE network as part of DSI) and also through Europeana Research.

ARKWORK - Archaeological practices and knowledge work in the digital environment

Project coordinator	Costis Dallas
Coordinator	Uppsala University (SE)
IMSI - funding	About 50,000 euros (The funding of COST actions is adjusted yearly)
Programme	COST European Cooperation in Science & Technology Programme, Action CA15201
Start date	6/10/2016
Duration	3 years
Website	https://www.arkwork.eu/

The COST action ARKWORK is aimed at forming an interdisciplinary network that will collect the knowledge and experiences of researchers and projects, national as well as European, in producing and exploiting archaeological knowledge. The network thus intends to contribute to the coordination of current efforts to study archaeological practices, and the potential for social and economic exploitation of archaeological knowledge in the digital environment. The network seeks to establish the state of the art in promoting archaeological knowledge and its application for the benefit of society, and to provide expert guidance in the production, validation, reproduction, management and use of archaeological knowledge. Apart from networking and information activities, the project collects and charts basic information and approaches concerning archaeological practices

in field research, collections, and the production and validation of knowledge, through a combination of approaches from archaeological theory and methodology, information science, computer science, and social studies of science and technology.

DARIAH Reference Curriculum / DariahTeach

Project coordinator	Panos Constantopoulos
Coordinator	Maynooth University, Ireland
IMSI - funding	34,591 euros
Programme	Erasmus+
Start date	1/1/2015
Duration	30 months
Website	http://dariah.eu/teach/

In the DariahTeach project a consortium of 7 universities and research centres is developing online course material in the broader area of Digital Humanities, to be delivered openly and asynchronously. IMSI contributes to the design and evaluation of educational material, as well as by developing the unit *Introduction to conceptual modeling*.

National R&D Projects

ELIXIR-GR - Information Infrastructure for the Life Sciences

Project manager	Theodore Dalamagas (Deputy: Stelios Sartzetakis)
Coordinator	Biomedical Science Research Center Alexander Fleming
IMSI - funding	92,600 euros
Programme	National Roadmap for Research Infrastructures

Start date	9/2017
Duration	3 years
Website	http://www.elixir-greece.org

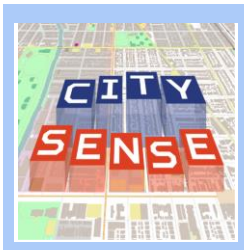
ELIXIR (http://www.elixir-europe.org/) is one of the ESFRI's pan-European research infrastructures (RIs) with key importance for the research and innovation in the life sciences. The aim of ELIXIR is to provide the facilities necessary for Europe's life scientists to manage and safeguard the massive amounts of data being generated every day by publicly funded research. Greece has recently joined ELIXIR, which has already entered its construction phase. ELIXIR operates a distributed research infrastructure based on ELIXIR nodes (at national level) which are connected to the ELIXIR Hub in order to provide infrastructure for data, tools, standards and training, as well as support for other ESFRI biological and medical science infrastructures. BSRC A. Fleming is joining forces with Athena RC and GRNET to lead the construction of the Greek component, ELIXIR-EL. Setting up ELIXIR- EL will be a dynamic process, taking into account user needs, available tools and datasets and technological advancements. The RI will be designed and setup using GRNET's Okeanos cloud IaaS service (http://okeanos.grnet.gr/) and ViMa service (http://vima.grnet.gr). The proposed RI aims to develop ELIXIR-EL RIs at the following levels: computing resources, data-intensive programming components, data resources, and tools.

MEDA 2: Moving from Big Data Management to Data Science

Project manager	Theodore Dalamagas
Coordinator	IMSI
IMSI - funding	800,000 euros
Programme	National Roadmap for Research Infrastructures
Start date	9/2017
Duration	3 years
Website	http://web.imsi.athenarc.gr/projects/meda.2

The Information Management Systems Institute (IMSI) has already established a strong technical and scientific background on big data technologies. IMSI has recently completed MEDA, a national funded R&D project focusing on the efficient management of big data, in three important data categories: operational, scientific and social data. The project comprised a significant development action

for IMSI, offering added value to existing research results and delivering novel algorithms, models and prototype tools for managing big data. MEDA.2 makes a step ahead towards data science, exploiting S&T results from MEDA. The objectives of MEDA.2 are: (a) study and experiment with data science tools and technologies, (b) setting up a data science infrastructure (tools and data collections), (c) delve into pilot cases relevant to national RIS3 smart specialization requirements, and identify related data science problems to deal with (d) design and develop innovative technologies and data services to deal with problems in (c).



CitySense - Retrieving, Visualizing and Combining Datasets on Urban Areas

Project coordinator	Yannis Stavrakas
Coordinator	IMSI
IMSI - funding	95,000 euros
Programme	Data value chain in industrial and urban environments - SIEMENS
Start date	1/4/2015
Duration	2 years
Website	http://web.imis.athena-innovation.gr/projects/CitySense/

Social networks, available open data and massive online APIs provide huge amounts of data about our surrounding location, especially for cities and urban areas. Unfortunately, most applications and research usually focus on one kind of data over the other, thus presenting a biased and partial view of each location in question, hence limiting the benefits of such approaches. To remedy this, the CitySense framework combines data from administrative sources (e.g., public agencies), massive Point of Interest APIs (Google Places, Foursquare) and social microblogs (Twitter) to provide a unified view of all available information about an urban area, in an intuitive and easy to use web-application platform. Our use case shows how different sources of information can be combined to provide an accurate and diverse visualization for the urban area of Chicago, USA.

APOLLONIS

Greek Infrastructure for Digital Arts, Humanities and Language Research and Innovation

Project coordinator	Panos Constantopoulos
Coordinator	IMSI
IMSI - funding	615,500 euros
Programme	ESPA
Start date	1/11/2017
Duration	3 years
Website	-

APOLLONIS is the Greek Infrastructure for Digital Arts, Humanities and Language Research and Innovation, recently formed by the union of two existing ESFRI-related national research infrastructures: clarin:el, the CLARIN-related Greek network for language resources, technologies and services; and DARIAH-GR/DYAS, the DARIAH-related Greek network for digital research in the Humanities. The development of the APOLLONIS infrastructure advances the existing clarin:el and DARIAH-GR/DYAS services within a common framework that will ensure interoperability and reach to broader user communities, as well as promoting open science principles. Clarin:el will provide a permanent, stable infrastructure for accessing language resources and language processing web services, will support all kinds of language-related activities (regardless of subject), and collaborative workspace for application development environment. DARIAH-GR/DYAS will provide access to curated digital resources and services for the development, analysis and visualization of data, best practice guidelines, and dissemination and training activities on the use of digital methods and tools in the Humanities. A Digital Humanities Observatory will monitor the penetration of digital practices in the Humanities.

eLib GGDE - eLib of Independent Authority for Public Revenue

Project coordinator	George Papastefanatos
Coordinator	Remaco S.A.
IMSI - funding	51,200 euros
Programme	NSRF - Pubic Tender
Start date	30/7/2015
Duration	3 years (ongoing)
Website	http://www.publicrevenue.gr/elib/

The project eLib aims at developing a digital library for the Independent Autority ofor Public Revenue (I. A.P.R). eLib analyzes and provides information to public servants and citizens on the legislation concerning the areas of IAPR competence (taxation, public revenues, etc). Legal documents are automatically harvested from institutional sources (National Printing Office, Di@ygeia), their content and metadata are extracted, semantically analyzed and structured according to the AKOMA NTOSO,and ELI) specifications. Moreover, content is indexed for full-text search, browsing and faceted filtering. Users can search and navigate the legal content and create personal collections with references to whole documents or parts of them.

Other Projects

TwitHoard - retrieving, modeling and analyzing Social Data

Project coordinator	Yannis Stavrakas
Coordinator	IMSI
Programme	Internal project

Start date 12/2015

Duration 2 years and 10 months

An increasing number of innovative applications use data from online social networks. In many cases data analysis tasks, like opinion mining processes, are applied on platforms such as Twitter, in order to discover what people think about various issues. In our view, selecting the proper data set is paramount for the analysis tasks to produce credible results. This direction, however, has not yet received a lot of attention. TwitHoard is a platform for supporting processes such as opinion mining on Twitter data, with emphasis on the selection of the proper data set. The key point of our approach is the representation of term associations, user associations, and related attributes in a single model that also takes into account their evolution through time. This model enables flexible queries that combine complex conditions on time, terms, users, and their associations.

Digital Curation Services

Project coordinator Panos Constantopoulos

Coordinator IMSI

IMSI - funding 48,786 euros

Programme Internal project

Start date 1/2/2016

Duration 2 years

Website -

The internal project Digital Curation Services supports the advancement of research and development efforts in the research directions and work programme of IMSI by using chiefly funds remaining from the execution of service provision projects. In view of parallel externally funded projects, this project on one hand ensures the continuity of our work programme, while on the other it enables actions of topical interest for which external funds may be insufficient at the time. It also allows better integrating and employing results of completed projects in sustained and new digital curation services, thus supporting the capitalization of those results.

Industry – Funded R&D Projects

Design and Development of big data solution and methods for stream analytics on network data

Project coordinator	George Papastefanatos
Coordinator	Intracom Telecom S.A.
IMSI - funding	115,320 euros
Programme	Contract
Start date	16/10/2017
Duration	9 months (ongoing)
Website	-

A new collaboration between **IMSI, Intracom Telecom and Ericsson** started in *October 2017*. IMSI has been contracted to design and develop a big data solution and methods for stream analytics on network data coming from IoT devices. The solution is based on well-established big data platforms, i.e., Cloudera Ecosystem and SPARK streaming and enables the collection of vast amount of network measurement streams from connected devices, their scalable processing, analysis and storage and the visualization of several KPIs.

Publications

Book chapters

- Benardou, A., and Dunning, A., (2017). "**From Europeana Cloud to Europeana Research: Tools, Users and Methods**", in Benardou, A., Champion, E., Dallas, C., and Hughes, L., (eds) (2017). Cultural Heritage Digital Tools and Infrastructures, Routledge, pp. 136-152.

Journal Publications

- Konstantinos Zagganas, Thanasis Vergoulis, Maria D. Paraskevopoulou, Ioannis S. Vlachos, Spiros Skiadopoulos, Theodore Dalamagas. **BUFET : boosting the unbiased miRNA functional enrichment analysis using bitsets.** BMC Bioinformatics 18(1): 399:1-399:8 (2017).
- Danae Pla Karidi, Yannis Stavrakas, and Yannis Vassiliou. **Tweet and Followee Personalized Recommendations Based on Knowledge Graphs**. In Journal of Ambient Intelligence and Humanized Computing, https://doi.org/10.1007/s12652-017-0491-7, 2017.
- Danae Pla Karidi, Harry Nakos, Alexandros Efentakis, and Yannis Stavrakas. **CitySense: Combining Geolocated Data for Urban Area Profiling**. International Journal On Advances in Software, v10 n3&4, 2017.
- Sophia Karagiorgou, Dieter Pfoser, Dimitrios Skoutas: **A Layered Approach for More Robust Generation of Road Network Maps from Vehicle Tracking Data**. ACM Trans. Spatial Algorithms and Systems 3(1): 3:1-3:21 (2017).
- D. Papadimitriou, G. Koutrika, J. Mylopoulos, Y. Velegrakis. **Finding Related Forum Posts through Content Similarity over Intention-based Segmentation**. IEEE TKDE, Issue 99.
- V. Efthymiou, G. Papadakis, G. Papastefanatos, K. Stefanidis, T. Palpanas. **Parallel Meta-blocking for Scaling Entity Resolution over Big Heterogeneous Data**, Information Systems 65: 137-157 (2017).
- N. Bikakis, G. Papastefanatos, M. Skourla, T. Sellis**. Hierarchical Visual Exploration and Analysis on the Web of Data**. Semantic Web Journal, vol. 8, no. 1, pp. 139-179, 2017.
- V. Pertsas and P. Constantopoulos, "**Scholarly Ontology: modelling scholarly practices**", Intl Journal on Digital Libraries, Vol. 18 (3), pp. 173–190, 2017.
- Penny Nymark, Linda Rieswij, Friederike Ehrhart, Nina Jeliazkova, Georgia Tsiliki, Haralambos Sarimveis, Cris T Evelo,Vesa Hongisto, Pekka Kohonen, Egon Willighagen, Roland C Grafström: **A data fusion pipeline for generating and**

enriching Adverse Outcome Pathway descriptions. Toxicol. Sci. 162(1): 264-275 (2017).

- Sandra Karcher, Egon L Willighagen, John Rumble, Friederike Ehrhart, Cris T Evelo, Martin Fritts, Sharon Gaheen, Stacey L Harper, Mark D Hoover, Nina Jeliazkova, Nastassja Lewinski, Richard L Marchese Robinson, Karmann C Mills, Axel P Mustad, Dennis G Thomas, Georgia Tsiliki, Christine Olgilvie Hendren. **Integration among Databases and Data Sets to Support Productive Nanotechnology: Challenges and Recommendations**. NanoImpact 9: 85-101 (2017).
- Manolis Terrovitis, Giorgos Poulis, Nikos Mamoulis, Spiros Skiadopoulos. **Local Suppression and Splitting Techniques for Privacy Preserving Publication of Trajectories**. IEEE Trans. Knowl. Data Eng. 29(7): 1466-1479 (2017).

International Conference / Workshop Publications

- Paras Mehta, Dimitris Sacharidis, Dimitrios Skoutas, Agnès Voisard: **Finding Socio-Textual Associations Among Locations**. EDBT 2017: 120-131.
- Paras Mehta, Manuel Kotlarski, Dimitrios Skoutas, Dimitris Sacharidis, Kostas Patroumpas, Agnès Voisard: **μTOP: Spatio-Temporal Detection and Summarization of Locally Trending Topics in Microblog Posts**. EDBT 2017: 558-561.
- Georgios Chatzigeorgakidis, Dimitrios Skoutas, Kostas Patroumpas, Spiros Athanasiou, Spiros Skiadopoulos: **Indexing Geolocated Time Series Data**. SIGSPATIAL/GIS 2017: 19:1-19:10.
- Dimitris Sacharidis, Paras Mehta, Dimitrios Skoutas, Kostas Patroumpas, Agnès Voisard: **Continuous Summarization of Streaming Spatio-Textual Posts**. SIGSPATIAL/GIS 2017: 53:1-53:4.
- Giannis Nikolentzos, Polykarpos Meladianos, Yannis Stavrakas, and Michalis Vazirgiannis. **K-clique-graphs for Dense Subgraph Discovery**. The European Conference on Machine Learning & Principles and Practice of Knowledge Discovery in Databases (ECML-PKDD 2017), Skopje, 18-22 September, 2017.
- Giannis Nikolentzos, Polykarpos Meladianos, Francois Rousseau, Yannis Stavrakas, and Michalis Vazirgiannis. **Shortest-Path Graph Kernels for Document Similarity**. SIGDAT Conference on Empirical Methods in Natural Language Processing (EMNLP 2017), Copenhagen-Denmark, September 9-11, 2017.
- Danae Pla Karidi, Harry Nakos, Alexandros Efentakis, and Yannis Stavrakas. **CitySense: Retrieving, Visualizing and Combining Datasets on Urban Areas**. The Ninth International Conference on Advances in Databases, Knowledge, and Data Applications (DBKDA 2017), Barcelona-Spain, May 21-25, 2017.

- Giannis Nikolentzos, Polykarpos Meladianos, Francois Rousseau, Yannis Stavrakas, and Michalis Vazirgiannis. **Multivariate Gaussian Document Representation from Word Embeddings for Text Categorization**. 15th European Chapter of the Association for Computational Linguistics Conference (EACL 2017), Valencia-Spain, April 3-7, 2017.
- I. Emiris, K. Gavriil, and C. Konaxis. **Interpolation of syzygies for implicit matrix representations**. International Conference on Algebraic Informatics 2017, Kalamata, Greece, June 25-28, 2017.
- I. Z. Emiris, C. Konaxis, I. S. Kotsireas, and C. Laroche. **Matrix Representations by Means of Interpolation**. In Proc. ACM Intern. Symp. Symbolic & Algebraic Comput. (ISSAC), Kaiserslautern, Germany, July 25–28, 2017. DOI: http://dx.doi.org/10.1145/10.1145/3087604.3087629
- G. Avarikioti, I.Z. Emiris, L. Kavouras, and I. Psarros. **High-dimensional approximate r-nets.** In Proc. SIAM/ACM Symp. On Discrete Algorithms (SODA), Barcelona, January 2017.
- M. Koniaris, G. Papastefanatos, M, Meimaris, G. Alexiou. **Introducing Solon: A Semantic Platform for Managing Legal Sources**. In 21st International Conference on Theory and Practice of Digital Libraries (TPDL'17), 18-21 September 2017, Thessaloniki, Greece.
- Georgios Chatzigeorgakidis, Dimitrios Skoutas, Kostas Patroumpas, Spiros Athanasiou, Spiros Skiadopoulos. **Indexing Geolocated Time Series Data**. 25th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems (ACM SIGSPATIAL 2017), 2017.
- Katharina Eckartz, Anja Peters, Spiros Athanasiou, Aaron Burton, Ignacio Casals del Busto, Alejandro Garcia Monteagudo. **Effects of real-time shower feedback on showering behaviour and psychological determinants – a pilot study**. International Conference on Human Dimension of Environmental Risks, 2017.
- P. Manousis, A. Zarras, P. Vassiliadis, G. Papastefanatos. **Extraction of Embedded Queries via Static Analysis of Host Code**. In 29th International Conference on Advanced Information Systems Engineering (CAiSE'17), 12-16 June 2017, Essen, Germany.
- M. Meimaris, G. Papastefanatos, N. Mamoulis, I.Anagnostopoulos. **Extended Characteristic Sets: Graph Indexing for SPARQL Query Optimization**. In 33rd IEEE International Conference on Data Engineering (ICDE 2017), San Diego, California, USA, April 2017.
- M. Meimaris, G. Papastefanatos. **Distance-Based Triple Reordering for SPARQL query optimization**. In 8th International Workshop on Data Engineering meets the Semantic Web (DESWeb), April 22, 2017, in conjunction with ICDE 2017, San Diego, California.

- Dallas, C.. "**Curation at the Sensor's Gaze: Connecting Representation and Performance in Archaeological Visualization**". Presented at the Computer Applications and Quantitative Methods in Archaeology 2017 (CAA2017), Atlanta, GA. http://caaconference.org/wp-content/uploads/sites/18/2017/03/CAA2017_Program_Abstracts.pdf
- C. Dallas. "**Re-assembling Context: Archaeological Things beyond Objects**". In Building Bridges: 23rd Annual Meeting of the European Association of Archaeologists (EAA2017), Maastricht, The Netherlands (2017): 334-335. http://www.eaa2017maastricht.nl/download2476
- C. Dallas, N. Chatzidiakou & A. Benardou. "**Archaeological Research Practices, Infrastructures and Needs in the Digital Environment: a European Survey**". In Building Bridges: 23rd Annual Meeting of the European Association of Archaeologists (EAA2017), Maastricht, The Netherlands (2017): 419. < http://www.eaa2017maastricht.nl/download2476>
- C. Dallas & I. Kelpšienė. "**Archaeological Interactions between Objects, Amateurs and Professionals on Facebook: a Meta-analysis and Conceptual Framework**". In Building Bridges: 23rd Annual Meeting of the European Association of Archaeologists (EAA2017), Maastricht, The Netherlands (2017): 198-199. < http://www.eaa2017maastricht.nl/download2476>
- C. Dallas. "**Things, 'Us' and 'Them': Affiliative Curation of the Archaeological Record in the Digital Continuum**". In The Medium is the Message: Media and Mediation in Archaeology. Theoretical Archaeology Group - North America 2017 (TAG2017), Toronto (2017): 44. http://www.archaeology.utoronto.ca/assets/tag-2017-may-1program.pdf
- R. Laužikas & C. Dallas "**Wandering the Archaeological Semiosphere with Yuri Lotman: Things, Signs, and Translation at the Boundaries of Professional Archaeology**". In The Medium is the Message: Media and Mediation in Archaeology. Theoretical Archaeology Group - North America 2017 (TAG2017), Toronto (2017): 55-56. http://www.archaeology.utoronto.ca/assets/tag-2017-may-1program.pdf
- Z. Batist & C. Dallas. "**A View from the Bridge: Human- and Thing-centred Approaches to Research Practice, Disciplinary Discourse, and Local Engagement with the Archaeological Record**". In The Medium is the Message: Media and Mediation in Archaeology. Theoretical Archaeology Group - North America 2017 (TAG2017), Toronto (2017): 34-35. http://www.archaeology.utoronto.ca/assets/tag-2017-may-1program.pdf
- Huvila, M. Olsson, I.M. Faniel, M. Dalbello & C. Dallas. "**Archaeological Perspectives in Information Science**". Proceedings of the Association for Information Science and Technology 54, no. 1 (2017): 570–73. https://doi.org/10.1002/pra2.2017.14505401075
- Katerina Doka, Ioannis Mytilinis, Ioannis Giannakopoulos, Ioannis Konstantinou, Dimitrios Tsitsigkos, Manolis Terrovitis, Nectarios Koziris. **Exploiting Social**

Networking and Mobile Data for Crisis Detection and Management. ISCRAM-med 2017: 28-40

- Sergei Ivanov, Konstantinos Theocharidis, Manolis Terrovitis, Panagiotis Karras. **Content Recommendation for Viral Social Influence**. SIGIR 2017: 565-574

National Conference / Workshop Publications

- M. Meimaris, G. Papastefanatos, N. Mamoulis, I.Anagnostopoulos. **Extended Characteristic Sets: Graph Indexing for SPARQL Query Optimization**. In 15th Hellenic Data Management Symposium (HDMS'17), Athens, August, 2017.
- P. Manousis, A. Zarras, P. Vassiliadis, G. Papastefanatos. **Extraction of Embedded Queries via Static Analysis of Host Code**. In 15th Hellenic Data Management Symposium (HDMS'17), Athens, August, 2017.

Other Publications / Technical Reports

- Benardou, A., Champion, E., Dallas, C., Hughes, L., (eds.) (2017): "**Cultural Heritage Digital Tools and Infrastructures**", Routledge. Edited Volume.
- Thanasis Vergoulis, Ilias Kanellos, Maria Krommyda, Nikos Bikakis, Theodore Dalamagas. **Biomedical Publication Finder: A research analytics system for open access publication in life sciences.** Poster at Open Science Fair 2017.
- Danae Pla Karidi, Harry Nakos, and Yannis Stavrakas. **Twitter usage analysis in Greece – 2017-B**. Part of the subscription-based public survey report "TASEIS"-MRB Hellas S.A., Athens, December 2017.
- Danae Pla Karidi, Harry Nakos, and Yannis Stavrakas. **Twitter usage analysis in Greece – 2017-A**. Part of the subscription-based public survey report "TASEIS"-MRB Hellas S.A., Athens, July 2017.

Dissemination Activities

Invited / Keynote Talks

IMSI members participated in the following invited / keynote talks:

- 04/2017, "**Visual Exploration in the Web of Data"**, George Papastefanatos, Keynote speaker, In 8th International Workshop on Data Engineering meets the Semantic Web (DESWeb), April 22, 2017, in conjunction with ICDE 2017, San Diego, California.
- 09/2017, "**EOSCPilot Open Science Monitoring Framework**". George Papastefanatos, Invited Speaker, In 1st workshop on Open Science Monitor in conjunction with Open Science Fair Conference (Athens, Greece 2017).
- "Data-driven Circular Economy", Theodore Dalamagas, Panhellenic Electrical and Computer Engineering Students Conference "ECESCON 10", Xanthi, Oct 27-29, 2017.
- "From linear to circular: Managing materials and energy in a Circular Economy", Theodore Dalamagas, Athens Science Festival, Mar 30, 2017.
- "Lies in Scientific Research", Thanasis Vergoulis, Athens Science Festival, Apr 1, 2017
- "The ELIXIR view of Open Science", Thanasis Vergoulis, Open Science Fair 2017, Sep 7, 2017
- 11/2017, "**Recommender Systems: It's Not Just About User Preferences**", Georgia Koutrika – invited talk at Visa Research, Palo Alto, California, USA
- 11/2017, "**Bringing Preferences and Recommendations closer to the Database**", Georgia Koutrika – invited talk at Huawei, Santa Clara, California, USA
- 10/2017, "**Modern recommender systems: matrices, bandits, and neurons**", Georgia Koutrika – Guest Speaker, for the course CS 7290, Fall 2017: Special Topics in Data Science: Foundations in Scalable Data Management, Northeastern University, College of Computer and Information Science.
- 07/2017, "**User analytics for Recommender Systems**", Georgia Koutrika – invited course for the 1st ACM Europe Summer School on Data Science/Big Data, in Athens, Greece.
- Benardou, A., LIBER Conference 2017, "**Libraries, Humanities Research Data and Humanities Research Communities: Challenges and opportunities**", Patras, July 2017
- Benardou, A., General Secretariat of Communication, Hellenic Ministry of Press and Mass Media, "**Digital Tools and re-Use of Digital Cultural Content in Education**", Athens, May 2017
- Benardou, A., AIUCD 2017 Conference / DIXIT Workshop Keynote Lecture, "'**Signatures of all things I am here to read': Digital Research as Practice, Digital Networks as Public Engagement**", Sapienza Universita Roma, January 2017

- Dallas, C . **Social encounters with cultural heritage: Facebook, affiliative objects and institutional logic**. Lecture presented at the Encounters of amateurs and professionals with tangible cultural heritage seminar, Archives, Libraries and Museums Department, Uppsala University (April 2017). http://www.idehist.uu.se/office-for-history-of-science/calendar/evenemang/?eventId=25350
- C. Dallas. "**Archaeological Fieldwork as Information Practice: Theory and Process**". In Training School on the Study of Archaeological Fieldwork, Arkwork - Archaeological Practices and Knowledge Work in the Digital Environment COST Action, Union of Greek Archaeologists, Athens (7 November 2017).
- C. Dallas. "**Heritage Encounters in Social Network Sites**". Research in Progress (RIP) Talks, Faculty of Information, University of Toronto (17 October 2017).
- M. Terrovitis. "**Governance: Shape the advisory Stakeholder Forum**". Session chair in EOSC Stakeholder Forum, Brussels. (November 2017).
- M. Terrovitis. "**Amnesia: Anonymization made easy**". RDA 9th Plenary. Barcelona (April 2017).
- M. Terrovitis. "**Data Anonymization**". OpenAIRE General Assembly 2017. Oslo. (February 2017).

Scientific Community Service

IMSI members have served in the **Program Committee** of more than 23 International Conferences and Workshops in 2017, including well-known Conferences like VLDB, ICDE, EDBT, TPDL, ISWC, ESWC, ODBASE and more.

IMSI members have participated in the **organization** or co-organization of the following events:

- 1st Workshop on **Open Science Monitor** in conjunction with Open Science Fair Conference (Athens, Greece 2017) – George Papastefanatos.
- 1st International Workshop on **Big Data Visual Exploration and Analytics** (BigViz2017) – George Papastefanatos.
- **CARARE Workshop**, Leiden, June 2017.
- **ExploreDB, Workshop on Exploratory Search in Databases and the Web.** In conjunction with SIGMOD. Georgia Koutrika member of steering committee.

IMSI members with **editorial** roles:

- **ACM SIGMOD Blog.** Georgia Koutrika - ACM SIGMOD Associate Information Director.

Other Dissemination Activities

- **Researchers Night 2017**: IMSI participated in the event presenting the results of many research and development activities.
- **Athens Science Festival 2017**: IMSI participated in the event presenting the results of many research and development activities.
- **RDA Blue Bridge Datathon**, Crete, June 2017.
- **Europeana Aggregators Forum**, Amsterdam, April 2017.
- **RDA 9th Plenary event**, Barcelona, April 2017.

Systems

- **Mopseus**

MOPSEUS is a scalable, curation-aware repository system designed to be metadata schema agnostic. It can support any complex data model either at the digital resource level or at the collection level. This means that content can be organized using any structure ranging from simple hierarchies to complex graphs. The entire structure both at the digital resource level and at the collection level is stored and represented in RDF and can be accessed through a SPARQL endpoint. MOPSEUS employs an expressive data model that supports both intra- and inter- object relations thus allowing arbitrary organization of objects. In particular, all entities in MOPSEUS are digital objects each of which may include an unlimited number of metadata and/or data files and may be associated with multiple metadata schemas. A special class of digital objects, the containers, are used in order to organize information (digital evidence). Containers can be interconnected using semantic links thus giving rise to semantic graph structures of arbitrary complexity. Metadata can be represented either as XML or RDF triples. MOPSEUS gives special focus on interoperability and digital preservation and is compliant with the PREMIS standard ensuring that the entire lifecycle of each digital resource is stored and semantically annotated. In order to access the MOPSEUS services a modular architecture is employed whereby the user interacts with the system through a set of Web-based interfaces that allow one to define metadata schemas and thesauri and to manage the entire content stored within the system. A SKOS editor supports maintaining term thesauri, while a linked data approach is adopted in associating terms with relevant data objects. Moreover, semantic relationships between objects are supported and can be defined through the GUI. Finally, all operations are organized in workflows which are also defined via the GUI. Supported site installations of the Mopseus repository system include: “Digital Academy” – Repository of the digital collections of the Academy of Athens, and “Pyxida” – Academic repository and digital library, Athens University of Economics and Business.

- **MORe**

The Metadata and Object Repository (MORe) is a metadata aggregator designed to: harvest content (metadata records) from different sources and providers; enrich/curate; map to a target schema (e.g. EDM); and deliver the metadata using the OAI-PMH protocol to other systems, such as the Europeana library. MORe focuses on enriching / curating the aggregated content. This is accomplished through a set of micro-services that are streamlined in a workflow. These micro-services perform various curation

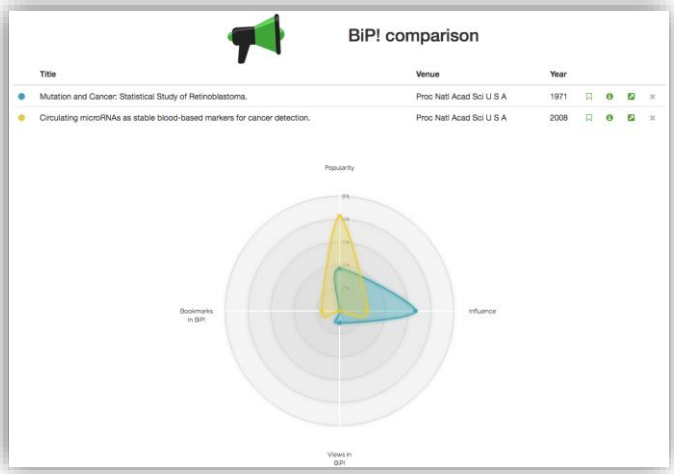
actions like normalizing, associating records (e.g. those in close proximity to each other), transforming spatial coordinates to a given coordinate system (e.g. WGS84), creating elements like place labels, etc. MORe is OAIS-compliant and preserves the whole lifecycle of each digital object. All ingestion and curation actions create new versions of metadata streams that are stored and semantically annotated, thus allowing to view the entire history of changes associated with each digital resource. MORe is tuned to support massive imports in the order of about 0.8 million records per hour. Online services with the MORe system are provided to Europeana and the related communities formed and supported through the projects CARARE, 3-D ICONS, ARIADNE, LoCloud and CEF Europeana. A total of approximately 70 content providers in over 20 countries, are being regularly served by the MORe aggregation service to aggregate, enrich and deliver content to Europeana, with approximately 10 million heritage asset records processed so far.

- **DAIAD system**

DAIAD is the first *integrated residential demand management* system for water. It applies Big Data and Machine Learning technologies to leverage smart water meter data, engaging and informing consumers to induce sustainable changes in consumption behaviour, as well as providing novel large-scale analytics to improve short-, medium-, and long-term demand management for water utilities. DAIAD provides personalized pricing and non-pricing interventions to consumers through mobile and web applications, adapted to their profile, individual determinant sensitivity, and consumption behaviour. Water utilities have access to several analysis services (segmentation, clustering, forecasting) enabling them to understand consumption behaviour at the household level, target specific consumer groups, and anticipate demand under various time scales. The average sustainable total water savings in residential water consumption achieved by the DAIAD system is -12%. DAIAD is available as an open source software under the Apache License.
https://github.com/DAIAD
https://www.youtube.com/watch?v=YuLU9nitlss

- **BiP! Finder**

BiP! finder is a tool that assists the discovery of high-impact publications in the field of life sciences. This tool supports ranking and comparing of scientific articles based on different aspects of their impact



in their discipline, like their popularity (i.e., the current attention they receive) or influence (i.e., their long-term impact in the discipline). Furthermore, the tool provides useful features like intuitive infographics for each article and a mechanism of bookmarks.
http://bip.imis.athena-innovation.gr/

- **BUFET**

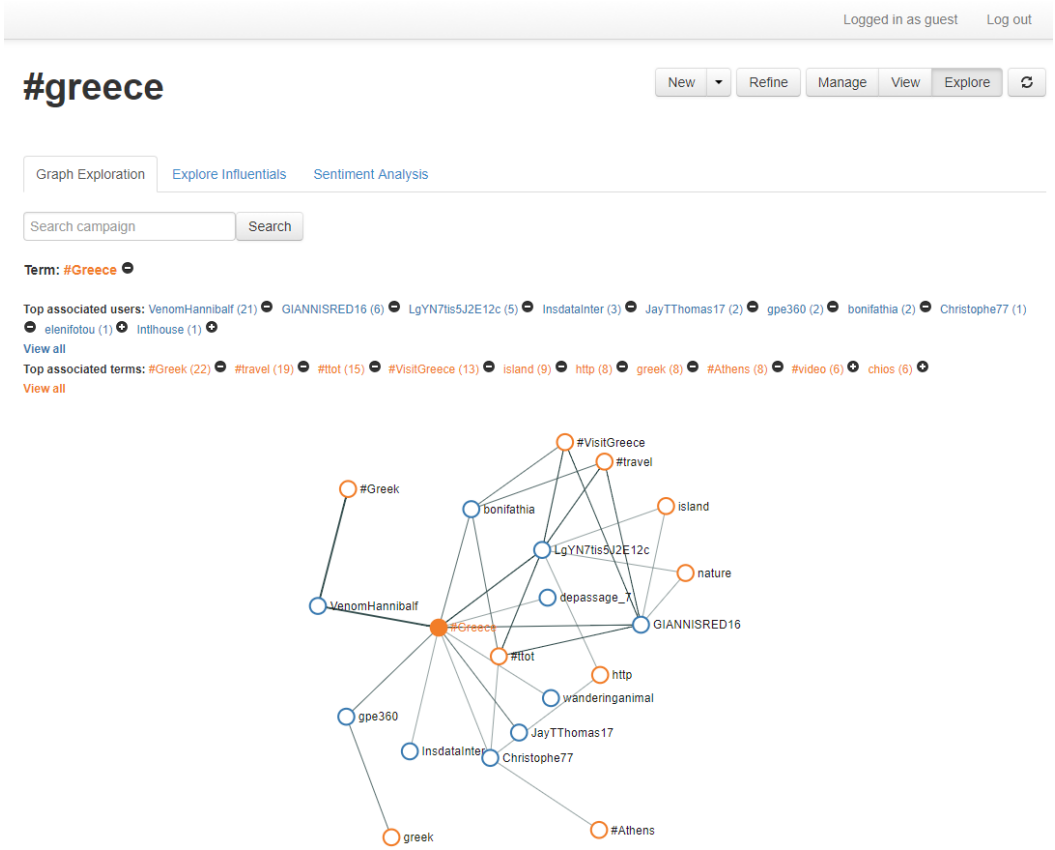
BUFET is an open-source software under the GPL v.3 licence, designed to speed up Bleazard's unbiased miRNA enrichment analysis algorithm. BUFET generates an empirical distribution of genes targeted by miRNA and calculates p-values for related biological processes. Benjamini-Hochberg FDR correction produces a '*' or '**' for significance at 0.05 FDR and 0.01 FDR respectively.
https://github.com/diwis/BUFET

- **PaperRanking**

PaperRanking is an open source library containing implementations of paper ranking methods that have been proposed in the literature. Our implementations utilise a suite of MapReduce scripts and can be used either on a single machine, or a Hadoop cluster. All codes were developed in the context of a paper ranking survey that aimed to evaluate each method's strengths and weaknesses.
https://github.com/diwis/PaperRanking

- **TwitHoard**

An increasing number of innovative applications use data from online social networks. In many cases data analysis tasks, like opinion mining processes, are applied on platforms such as Twitter, in order to discover what people think about various issues. In our view, selecting the proper data set is paramount for the analysis tasks to produce credible results. This direction, however, has not yet received a lot of attention. TwitHoard is a platform for supporting processes such as opinion mining on Twitter data, with emphasis on the selection of the proper data set. The key point of our approach is the representation of term associations, user associations, and related attributes in a single model that also takes into account their evolution through time. This model enables flexible queries that combine complex conditions on time, terms, users, and their associations.



http://twithoard.imis.athena-innovation.gr:8080/twithoard

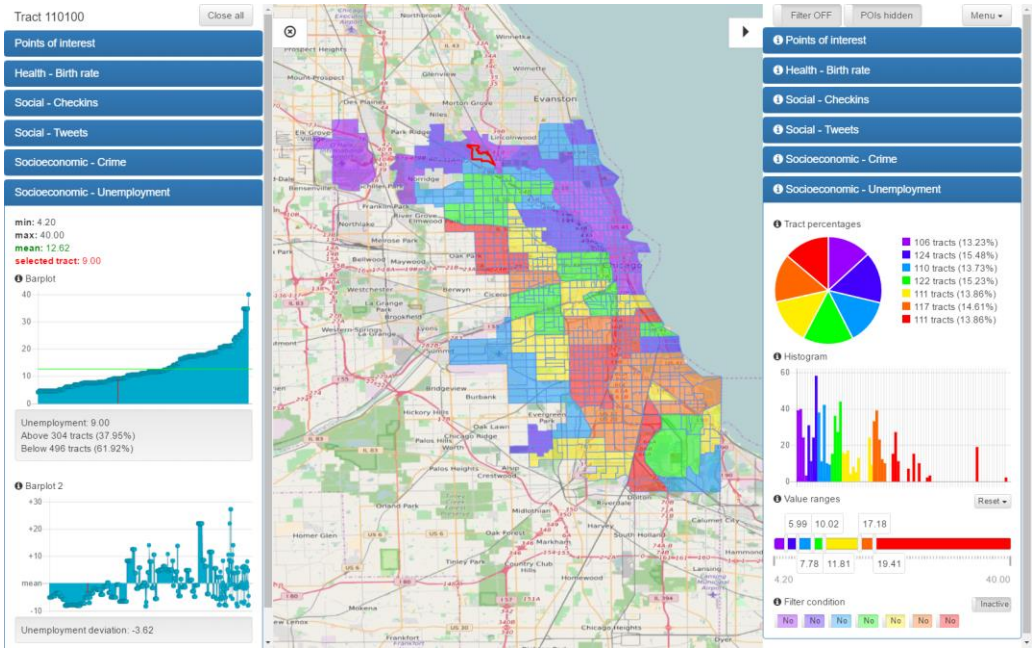
- **eLib**

The project eLib aims at developing a digital library for the Independent Autority for Public Revenue. eLib analyzes and provides information to public servants and citizens on the legislation concerning the areas of IAPR competence (taxation, public revenues, etc). Legal documents are automatically harvested from institutional sources (National Printing Office, Di@ygeia), their content and metadata are extracted, semantically analyzed and structured according to the AKOMA NTOSO,and ELI) specifications. Moreover, content is indexed for full-text search, browsing and faceted filtering. Users can search and navigate the legal content and create personal collections with references to whole documents or parts of them.
http://www.publicrevenue.gr/elib

- **GeoProfiler**

Social networks, available open data and massive online APIs provide huge amounts of data about our surrounding location, especially for cities and urban areas. Unfortunately, most applications and research usually focus on one kind of data over the other, thus presenting a biased and partial view of each location in question, hence limiting the benefits of such approaches. To remedy this, the GeoProfiler framework, developed within the CitySense project, combines data from administrative sources

(e.g., public agencies), massive Point of Interest APIs (Google Places, Foursquare) and social microblogs (Twitter) to provide a unified view of all available information about an urban area, in an intuitive and easy to use web-application platform. Our use case shows how different sources of information can be combined to provide an accurate and diverse visualization for the urban area of Chicago, USA.



City of Chicago Demo: http://geoprofiler.imis.athena-innovation.gr/

- **linkzoo**

Linkzoo is a web-based, linked data enabled tool that supports collaborative management of information resources. www.linkzoo.gr enables users to create and manage diverse types of web resources into common data spaces such as files, web documents, people, datasets and calendar events.
www.linkzoo.gr

- **Socioscope**

A visual analysis tool, used for visualization and exploration of social and political data (www.socioscope.gr) seeks to deliver a visual analytics platform for the social scientist to explore and analyze social facts through a user-friendly visual interface. The Socioscope platform offers a variety of interactive visualizations for each different type of data: charts and histograms, pies and tacked diagrams for numerical data; timelines for indices; and choropleth and point maps for geographical data. The platform is based on a multidimensional modeling approach and offers several visual operations for data exploration and analysis, such as filtering through faceted browsing, hierarchical representation of coded lists in charts, free keyword search of literal values, and capabilities for combining different datasets along common dimensions. Moreover, it

makes knowledge reusable by making all data available for download in various formats including Linked Open Data.
www.socioscope.gr

- **TripleGeo**

TripleGeo is an ETL utility that can extract geospatial features from various sources (e.g. shapefiles, spatial DBMSs) and transform them into Basic Geo or GeoSPARQL compatible RDF triples, in several serialization formats. It copes with most common spatial data types, like points, linestrings and multi-linestrings, polygons and multi-polygons and supports on-the-fly transformations between different coordinate reference systems. Also, TripleGeo supports the transformation of INSPIRE-aligned spatial data and metadata into RDF, using XSL stylesheets, for selected INSPIRE data themes.
https://github.com/SLIPO-EU/TripleGeo

- **OSMRec**

OSMRec is a tool that trains on a set of spatial entities annotated with categories and provides category recommendations for new geospatial entities. OSMRec's goal is to exploit the richness of available geospatial datasets than contain entities already annotated with several categories (e.g., OpenStreetMap), to enrich new geospatial entities. OSMRec supports two modes of deployment: a generic command line, and a JOSM plugin, which allows the real-time recommendation of OSM categories for geospatial entities created within the JOSM user interface.
https://github.com/SLIPO-EU/OSMRec
http://wiki.openstreetmap.org/wiki/JOSM/Plugins/OSMRec

- **Amnesia anonymization tool**

Amnesia transforms a dataset with direct identifiers and quasi identifiers to an anonymized dataset, where formal privacy guaranties hold. Amnesia allows the use to customize the anonymization process, to choose the trade-off between data utility and privacy protection. Moreover, it allows uses who are not IT experts to visually explore the data and the impact of different anonymization settings on them. It helps use to create supportive material to the anonymization process, like generalization hierarchies. Amnesia offers k-anonymity and km-anonymity and a parallel scalable anonymization algorithm.

- **FAGI**

FAGI is a tool that allows the fusion of geospatial Linked Data. It is designed to retrieve data through SPARQL endpoints, and implements a wide range of fusion actions both on spatial properties of the entities and on non-spatial metadata. These include moving, rotating, scaling and aligning the geometries of the entities, combining multiple,

semantically related properties, maintaining both descriptions of a property of two linked geospatial entities, etc. It also supports batch fusion actions, automatic classification of fused entities using OSM categories, and provides a map-based UI.
https://github.com/SLIPO-EU/FAGI

- **CityRisks Crime Mapper**

This is a set of applications developed in the context of the EU funded City.Risks project. Specifically, it comprises the following: (a) descriptive and predictive analytics over crime data with respect to a variety of location-based features, including demographics, Points of Interest, transportation data, geotagged photos, etc.; (b) a routing service that incorporates safety-related criteria during route computation; (c) a simulation engine for simulating and visualizing various scenarios for stolen item tracking via participatory sensing.
http://cityrisks.imis.athena-innovation.gr

Education

PhD / MSc / Diploma Thesis Co-supervision

IMSI members actively co-supervise several undergraduate and graduate university students, who often conduct their work in IMSI premises. As a result, in 2017 several MSc and Diploma thesis have been co-supervized by IMSI members, who often serve as members in the respective examination committees.

IMSI members also co-supervise PhD students. The following PhD dissertations have been completed in 2017:

- Dimitra Papadimitriou. **Extraction and Exploitation of User Goals and Intentions for Querying and Recommendation**. University of Trento, Italy. PhD Thesis Committee Member: Georgia Koutrika.

The following PhD students collaborated closely with IMSI members in their research during 2017:

- Marialena Kyriakidi. Topic: **Recommendations as Graph Exploration Problems**. Joint supervision with the University of Athens. Collaborating researchers: Georgia Koutrika.
- Niousha Hormozi. Topic: **Query Disambiguation and Expansion of NL Queries in Relational Databases**. Joint supervision with the University of Athens. Collaborating researchers: Georgia Koutrika.
- Andrea Barazza. Topic: **Multi-armed bandits in recommender systems**. Joint supervision with the Insights Center, Galway, Ireland. Collaborating researchers: Georgia Koutrika.
- Vassilis Kaffes. Topic: **Keyword queries on road networks**. Joint supervision with the University of Peloponnese. Collaborating researcher: Dimitris Skoutas.
- Serafeim Chatzopoulos. Topic: **Text mining and Information Retrieval for Scientific Texts**. Joint supervision with the University of Peloponnese. Collaborating researchers: Theodore Dalamagas, Thanasis Vergoulis.
- Marios Meimaris. Topic: **Evolution and Query processing of RDF data**. Joint supervision with the University of Thessaly. Collaborating researcher: George Papastefanatos.
- Giorgos Alexiou. Topic: **Entity disambiguation and data interlinking**. Joint supervision with the National Technical University of Athens. Collaborating researcher: George Papastefanatos.

- S. Maroulis. Topic: **Data visualization techniques**. Joint supervision with the National Technical University of Athens. Collaborating researcher: George Papastefanatos.
- Theodora Galani. Topic: **Modeling and querying the data evolution and provenance**. Joint supervision with the National Technical University of Athens. Collaborating researchers: Yannis Stavrakas, George Papastefanatos.
- Danai Pla-Karidi. Topic: **Recommendation models using Social Networks**. Joint supervision with the National Technical University of Athens. Collaborating researcher: Yannis Stavrakas.
- Konstantinos Zagganas. Topic: **Efficient techniques for data intensive analysis and processing in life sciences**. Joint supervision with the University of Peloponnese. Collaborating researchers: Theodore Dalamagas, Thanasis Vergoulis.
- Ilias Kanellos. Topic: Da**ta extraction from scientific publications and research analytics**. Joint supervision with the National Technical University of Athens. Collaborating researchers: Theodore Dalamagas, Thanasis Vergoulis.
- Giorgos Chatziogeorgakidis. Topic: **Big Data Management and Analysis**. Joint supervision with the University of Peloponnese. Collaborating researcher: Spiros Athanasiou.
- Pantelis Chronis. Topic: **Development of Data Mining Methods for Temporal Databases**. Joint supervision with the University of Peloponnese. Collaborating researcher: Spiros Athanasiou.

Facts and Figures

Financial report

In 2017, IMSI continued its participation in EC funded research and development projects. The key economic indicators regarding the expenses and revenues in 2017 are shown in Table 1 and their distribution in categories is illustrated in Figure 1. We can see that the highest percentage of the revenue stream, about 80%, comes from EC funded projects. It is important to note that the revenues from the activities of IMSI (EC projects, Product and Service Sales) are more than 9 times the public expenditure received by IMSI.

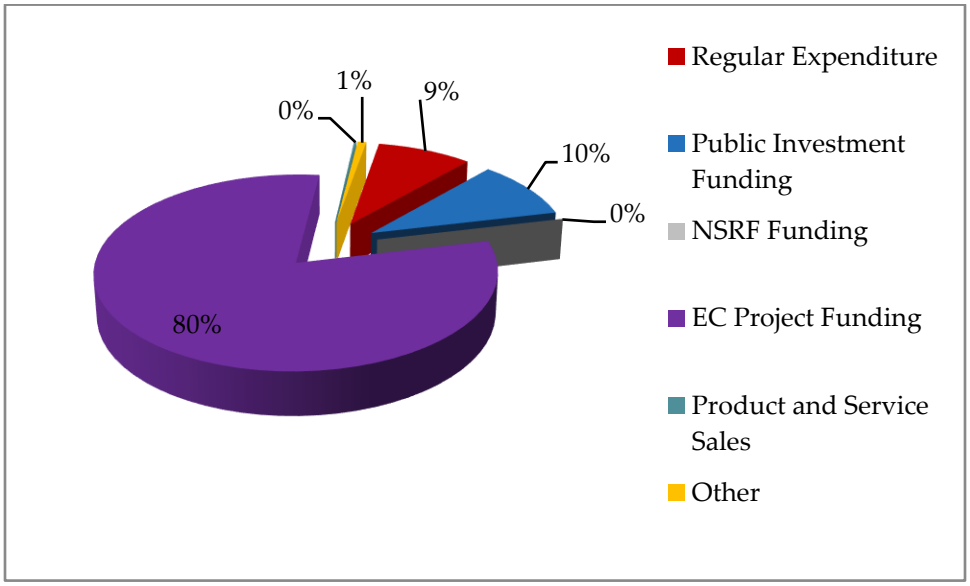


Figure 1. Distribution of revenues in 2017

Table 1. Expenses and Revenues for 2017

Expenses 2017	
Travel Expenses	185.863,91
Operational Costs	49.540,85
Equipment	94.187,97
Other Expenses	1.008.098,55[1]
Personnel fees and payments to third parties	2.126.153,94
Total	3.463.845,22
Revenues 2017	

[1] This number included the transfer of 744.452,8€ for the expenses of publications arising from FP7 projects in open access journals within the WP "Gold OA: FP7 post grant APCs Pilot" of the EC project "OpenAIRE2020 (GA No 643410)"

Regular Expenditure	290.802,02
Public Investment Funding	328.701,50
NSRF Funding	0,00
EC Project Funding	2.690.098,90[2]
Product and Service Sales	6.384,60
Other	26.797,83
Total	3.342.784,85

Table 2 shows the revenues of IMSI since 2014 while a comparison of the revenues in the years 2014 - 2017 is illustrated in Figure 2. We can see that the revenues coming from participation in European projects reached almost 2.7M euros in 2017, an increase of 40% from 2014. Due to the fact that a big part of the NSRF Funding within the Partnership Agreement 2007-2013 was paid off in 2015, the revenues from NSRF Funding in 2015 are much higher than the ones in the next years. Increased NSRF Funding is expected the years to come from the participation of IMSI in national funded projects within the new Partnership Agreement 2014-2020.

Table 2. Revenues from 2014 to 2017

	Revenues			
	2014	2015	2016	2017
Regular Expenditure	76.226,10	82.307,98	164.154,00	290.802,02
Public Investment Funding	454.421,97	185.186,15	-	328.701,50
NSRF Funding	790.948,38	2.055.402,11	102.597,68	0,00
EC Project Funding	1.916.199,47	2.335.227,81	3.804.217,79	2.690.098,90
Product and Service Sales	291.943,42	368.338,97	-	6.384,60
Other	85.508,66	27.506,22	40.983,75	26.797,83
Total	**3.615.248,00**	**5.053.969,24**	**4.111.953,22**	**3.342.784,85**

[2] This number included the funding of 770.267,84€ to cover the expenses of publications arising from FP7 projects in open access journals within the WP "Gold OA: FP7 post grant APCs Pilot" of the EC project "OpenAIRE2020 (GA No 643410)"

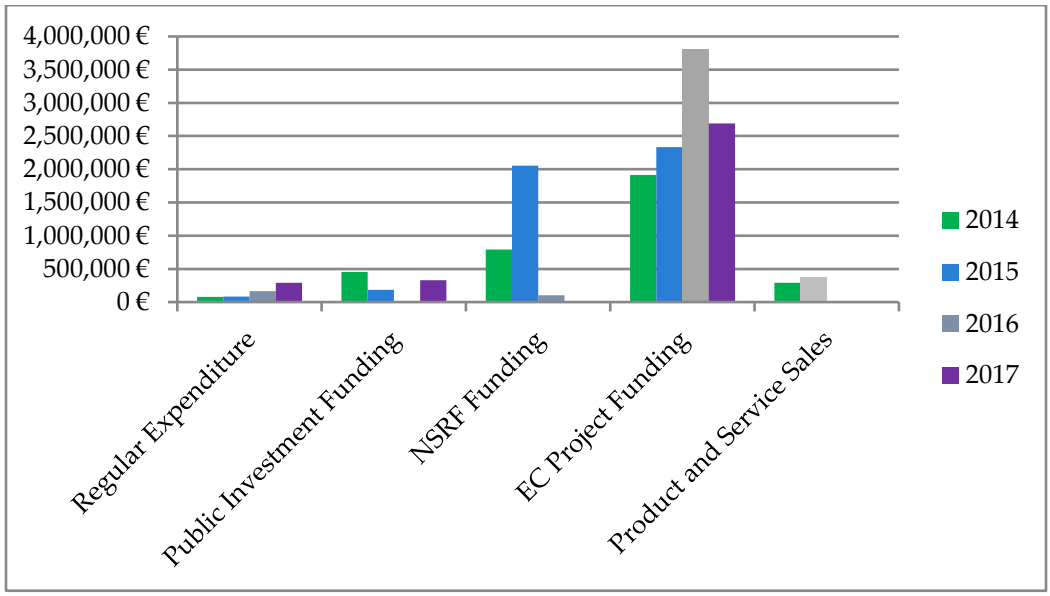


Figure 2. Comparison of revenues 2014 - 2017

Staff

Director & Researchers

- Garofalakis Minos, Professor, Technical University of Crete, Director
- Koutrika Georgia, Researcher A
- Sartzetakis Stylianos, Researcher A
- Dalamagas Theodore, Researcher B
- Stavrakas Yannis, Researcher B
- Skoutas Dimitris, Researcher C
- Terrovitis Manolis, Researcher C

Associate Researchers / Professors

- Androutsopoulos Ion, Associate Professor, AUEB
- Chatziantoniou Damianos, Assistant Professor, AUEB
- Chatzigeorgiou Artemis, Professor, University of Thessaly
- Chatzopoulos Michael, Emeritus Professor, University of Athens
- Christofidis Vasilios, Professor, University of Crete
- Christopoulos Dionisios, Professor, Technical University of Crete
- Constantopoulos Panos, Professor, AUEB
- Dagklis Ioannis, Professor, University of Athens
- Dallas Costis, Assistant Professor, Toronto University
- Deligiannakis Antonis, Assistant Professor, Technical University of Crete
- Delis Alexios, Professor, University of Athens
- Dokoumetzidis Aristidis, Assistant Professor, University of Athens
- Emiris Ioannis, Professor, University of Athens
- Giaglis Georgios, Professor, AUEB
- Giaoutzi Maria, Professor, NTUA
- Katsiri Eli, Assistant Professor, Democritus University of Thrace
- Kavouras Marinos, Professor, NTUA

- Kavouras Pavlos, Professor, University of Athens
- Kokosis Antonis, Professor, NTUA
- Kontogiannis Constantinos, Assistant Professor, NTUA
- Kotidis Yannis, Associate Professor, AUEB
- Koubarakis Emmanouil, Professor, University of Athens
- Kountouri Phoebe, Assistant Professor, AUEB
- Koziris Nectarios, Professor, NTUA
- Mamoulis Nikos, Assistant Professor, University of Ioannina
- Papatheodorou Christos, Professor, Ionian University
- Patsakis Konstantinos, Assistant Professor, University of Piraeus
- Pittis Nikitas, Professor, University of Piraeus
- Prezerakos Georgios, Professor, Technological Education Institute of Piraeus
- Roditi Evgenia, Assistant Professor, University of Athens
- Sellis Timos, Professor, Swinburne University of Technology
- Sivridis Dimitrios, Professor, University of Athens
- Skiadopoulos Spiros, Assistant Professor, University of Peloponnese
- Stavdas Alexandros, Professor, University of Peloponnese
- Theodoratos Dimitrios, Associate Professor, NJIT USA
- Theodoridis Yannis, Professor, University of Piraeus
- Vasileiadis Panos, Assistant Professor, University of Ioannina
- Vassalos Vassilis, Associate Professor, AUEB
- Vazirgiannis Michalis, Professor, AUEB
- Zarras Apostolos, Assistant Professor, University of Ioannina

Postdoctoral Researchers / Scientific Collaborators

- Arkoumanis Constantinos, Elec. & Comp. Eng. NTUA, PhD NTUA
- Belesiotis Alexandros, Dept. of Inform. University of Piraeus, PhD University of Edinburgh
- Benardou Agiatis, BA, PhD in Ancient History, King's College London
- Dimitropoulos Charalampos, Elec. & Elec. Eng. City University London, PhD University of London
- Efentakis Alexandros, Dept. of Physics UoA, PhD NTUA
- Gavrilis Dimitris, Elec. Comp. & Eng. University of Patras, PhD University of Patras
- Giannopoulos Giorgos, Elec. & Comp. Eng. NTUA, PhD NTUA
- Giatrakos Nikolaos, BSc in Informatics, University of Piraeus, MSc in Information Systems, AUEB, PhD, Department of Informatics, University of Piraeus
- Karagiannis Fotis, Elec. & Comp. Eng. NTUA, PhD NTUA
- Konaxis Christos, Dept. of Mathematics UoA, PhD . Dept Informatics & Telecoms, UoA
- Papastefanatos George, Elec. & Comp. Eng. NTUA, PhD NTUA
- Pierrakos Dimitris, Dept. of Physics UoA, PhD UoA
- Tsani Stella, Dept. Of Economics UoA, PhD University of Reading
- Tsiavos Prodromos, Dep. of Law UoA, Master of Laws (LL.M), Univ. of London, MSc Analysis Design & Management of Information Systems, LSE & Political Science, PhD LSE
- Vergoulis Thanasis, Elec. Comp. & Eng. University of Patras, PhD NTUA
- Zacharia Eleni, Dept. of Inform. and Telecom. UoA, PhD UoA

Administrative and Technical Personnel

- Apostolopoulou Nelly, Mech. Eng. NTUA, Msc NTUA, Head of Administration
- Chrysovitsioti Maria, Dept. of Comm., Media and Culture, Administrative Support
- Georgantas Panagiotis, Elec. & Comp. Eng. NTUA, Technician

- Paradissi Eva, Secretarial Support

Research Staff

- Afiontzi Eleni, Elec. & Comp. Eng AUTH, Msc, Dept. of Inform, AUEB
- Aggelis Stavros, Dept. of Archives, Libr. Science & Museum Studies, Ionian University
- Aidonopoulos Orfeas, Comp. & Inform. Eng. Univ. of Patras, Msc Dept. of Inform. & Telecom, UoA
- Alexakis Michalis, Elec. & Comp. Eng. NTUA
- Alexiou George, University of Aegean, Msc AUTH
- Athanasiou Spyros, Elec. & Comp. Eng. NTUA
- Baltzi Sofia, Dept. of Inform. and Telecom. UoA
- Bartzos Vangelis, Dep. of MBG, DUTH, Dep. of Math., Univ. of Patras, Msc Ecole normale superieure, Lyon, Msc Universite 1, Lyon
- Bikakis Nikolaos, Dipl. Electr. & Comp. Eng, Technical University of Crete, PhD Computer Science NTUA
- Chatzidiakou Nefeli, BA in French, UoA, Msc, University of Aegean
- Chatzigeorgakidis George Elec. & Comp. Eng. T.U.C., MSc D.T.U.
- Chatzopoulos Serafeim, BA, Msc, Dept. of Inform. and Telecom. UoA
- Christoforidis Stamatios, Dept. of Inform. and Telecom. UoA
- Chronis Pantelis, Comp. & Inform. Eng. University of Patras
- Diplas Ioannis, Dept. of Inform. and Telecom. UoA
- Foufoulas Ioannis Dept. of Inform. and Telecom. UoA, Msc UoA
- Galouni Constantina, Dept. of Inform. and Telecom. UoA
- Gentimis Thanassis, Elec. & Comp. Eng. NTUA, Msc UoA
- Georgomanolis Nikos, Comp. & Inform. Eng. University of Patras
- Giannakopoulos Anastasios, Dept. of Inform. and Telecom. UoA
- Giannopoulos Athanasios, BA, MSc, Dept. of Inform. and Telecom. UoA
- Iatropoulou Katerina, BA, Msc, Dept. of Inform. and Telecom. UoA
- Kaffes Vassilis, Elec. & Comp. Eng. NTUA
- Kakaletris Georgios, BA, Msc, Dept. of Inform. and Telecom. UoA
- Kanellos Ilias, Elec. & Comp. Eng. NTUA
- Karagiannakis Nikos, Comp. & Inform. Eng. University of Patras
- Karamanolis Georgios, Dept. of Inform, AUEB
- Kokogiannaki Argiro, Dept. of Inform. and Telecom. UoA
- Koltsida Panayota, BA, Msc, Dept. of Inform. and Telecom. UoA
- Kostoulas Georgios, Dipl., MSc, Electr. & Comp. Eng, Technical University of Crete
- Koulalis Antonios, BA Dept. of Inform. and Telecom. UoA
- Koulocheri Eleni, Dep. of Math UoA, Msc, Hellenic Open University
- Kouvaras Ioannis, Elec. & Comp. Eng. NTUA
- Kravvaritis Constantinos, Dept. of Inform. and Telecom. UoA, Msc, Dept. of Inform, AUEB
- Laroche Clement, Fundamental Mathematics Universite Paul Sabatier, Msc Universite Paul Sabatier, Mathematics for Research Universite Paul Sabatier
- Lebesis Antonis, BA, Msc, Dept. of Inform. and Telecom. UoA
- Levantis Eleftherios, Dep. of Law, UoA, Msc Environmental Mana gement EAEME
- Livisianos Tsabikos, Dept. of Inform. and Telecom. UoA
- Manola Natalia, Dept. of Physics, UOA
- Manousopoulos Stelios, Elec. & Comp. Eng. NTUA
- Maroulis Stavros, Elec. & Comp. Eng. NTUA
- Martziou Stefania-Varvara, BA, Msc, Dept. of Inform. and Telecom. UoA

- Meimaris Marios, Elec. & Comp. Eng. NTUA, Msc NTUA, University of Edinburgh
- Metaxas Omiros, BA, Msc, Dept. of Inform. and Telecom. UoA
- Mouris Dimitrios, BA Dept. of Inform. and Telecom. UoA
- Mpilidas Dimitrios, BSc in Informatics, University of Piraeus, MSc Dept. of Inform. and Telecom, UoA
- Nakos Charalampos, Elec. & Comp. Eng. NTUA
- Nasikas Christos, BSc in Informatics, University of Piraeus
- Nomikos Vangelis, Dept. of Inform. and Telecom. UoA
- Oikonomou Leonidas, Architecture, School of Architecture NTUA, MSc NTUA
- Panagiotou Nikolaos, Dept. of Inform. & Telecom. UoA, Msc Artif. Intelligence Univ. of Edinburgh
- Papachristopoulos Leonidas, BA, Msc, Dep. of Archives, Libr. Science&Museology, Ion.University
- Papadopoulou Elli, BA Librarian & Informatics Scientist, Alexander Technological Educational Institute of Thessaloniki
- Papaki Eliza, History and Archaeology, University of Cyprus, Msc Trinity College Dublin
- Papanikos Georgios, BA, MSc, Dept. of Inform. and Telecom. UoA
- Patroumpas Konstantinos, Comp. & Inform. Eng. University of Patras, Msc NTUA
- Pavlidou Androniki, BA Mathematics, AUTH, MSc on Science in Innovation Management, Univ. of Utrecht
- Paza Efthimia, BA, Msc, Department of Archives, Library Science & Museology, Ionian University
- Petra Eleni, Comp. & Inform. Eng. University of Patras, BA University of Manchester
- Pla-Karidi Danae, Elec. & Comp. Eng. NTUA
- Pristouris Costis, Elec. & Comp. Eng. NTUA, MSc in Geoinformatics, NTUA
- Psallidas Michail, Comp. & Inform. Eng. University of Patras
- Renieris Loukas, Dept. of Inform, AUEB, MSC University of Piraeus
- Souliotis Ioannis, Dep. of Intern. & European Econ. Studies, AUEB, Msc University of Copenhagen
- Theocharidis Constantinos, Dep. of Electrical and Computer Engineering ,University of Thessaly
- Trachaliou Antigoni, Dep. of Law UoA, Master of Laws (LL.M) in Copyright, George Washington University
- Tsitsigkos Dimitris, Dept. of Inform. and Telecom. UoA
- Vagianou Maria, Dept. of Inform. University of Piraeus, Msc UoA
- Zagganas Constantinos, Elec. & Comp. Eng. NTUA
- Zigouras Nikolaos, Comp. & Inform. Eng. Univ. of Patras, Msc Artif. Intelligence Univ. of Edinburgh

Contact

Information Management Systems Institute (IMSI)

Athena Research and Innovation Center in Information, Communication and Knowledge Technologies

Postal Address:
Artemidos 6 & Epidavrou
15125, Maroussi, Athens
Greece

Phone: +30 210 6875403
Fax: +30 210 6856804
e-mail: contact@imis.athena-innovation.gr

Most current information about activities and contacts for the staff are available on the IMSI website:
https://www.imsi.athenarc.gr/