

iSocial Final Report

The Online Social Network (OSN) industry is currently dominated by global behemoths, such as Facebook, Google and Twitter, that built their businesses by monetizing private data of their customers. Not surprisingly, their services come with a wide spectrum of serious concerns, including issues of ownership of private information, the protection of privacy, service interoperability, etc. Furthermore, such centralized services require heavy investment in infrastructure (e.g., building power-hungry data centers), preventing easy entrance to any new service provider, and thus effectively monopolizing the market. However, emerging technological trends are bringing a transformational change into the market, by enabling the shift from centralized services to totally decentralized systems that bring promise to address the aforementioned issues.

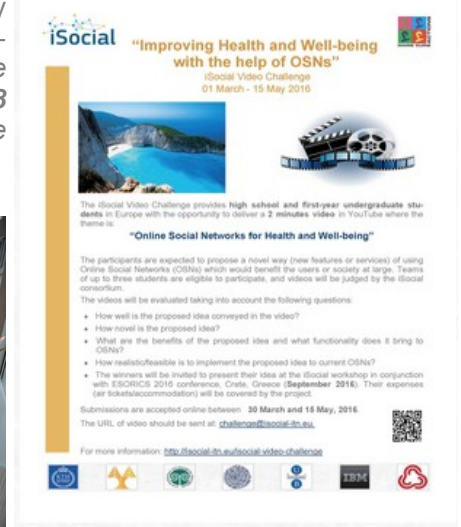
The main objective of *iSocial* is to develop such decentralized technologies for OSNs and provide world class training for a next generation of researchers and computer scientists. *iSocial* emphasizes on a strong combination of advanced understanding, in both theoretical and experimental approaches, of methodologies and tools that are required to develop decentralized platforms.

iSocial's consortium is made of 7 full academic and industrial partners from different European countries, and 6 associate business partners. *iSocial* training network funded and trained **11 ESRs and 5 ERs**, who collectively **carried out 32 secondments** at the academic and industrial partners of *iSocial*.

Furthermore, the consortium organized **two intensive post-graduate summer schools, 7 online courses, three thematic workshops, and a final comprehensive workshop**. Social and outreach activities have also been undertaken

The consortium organized **two international video challenge programs** targeting high school students, and published periodic public newsletters.

The research output of *iSocial* contributed to the fields of P2P systems, big data analytics, decentralized machine learning, decentralized security and privacy, as well as modelling and simulation of complex social networks. *The corresponding academic results within the duration of the project are 47 publications at renowned journals and conferences, 8 submissions under review, and 3 defended Ph.D. theses (7 more Ph.D. candidates are expected to finish next year).*



Comprehensive Summary Overview of Results

Throughout the lifetime of *iSocial* project, research on the following tracks were pursued: Decentralized Infrastructure, Big Data Analytics and Machine Learning, Security and Privacy, and Simulation and Modeling.

Decentralized Infrastructure: *iSocial* fellows have designed and built a Peer-to-Peer (P2P) architecture for Distributed Notification Systems over Decentralized Online Social Networks (DOSNs). The proposed architecture provides a novel topology of the P2P network and exploits the social graph to establish connections between peers. By this, the latency required for the communication between two users in the social network is significantly reduced. *iSocial* fellows have also investigated real-time P2P video streaming using WebRTC, a new W3C standard for browser to browser communication. This study resulted in a new commercial project at Peerialism (an industrial partner of *iSocial*), and is being deployed at multiple customers. Big efforts were also dedicated to designing algorithms for processing big and fast streams of data coming from various sources, e.g., event logs, sensor networks. The load-balancing problems were addressed, resulting in the development of novel algorithms to reduce the load imbalance across distributed systems. The algorithms were integrated into Apache Storm, an open source stream processing framework.

Big Data Analytics and Machine Learning: *iSocial* fellows developed novel massively parallel graph-based algorithms that suitably fit DOSNs and eliminate the need of centralized aggregation points. New efficient algorithms were developed for multiple graph mining problems, such as top-k densest subgraph problem in a fully dynamic setting, and streaming graph partitioning. This enabled new approaches for efficient extraction of knowledge from the streams generated within the online social media, including topic detection, entity disambiguation and location prediction. *iSocial* fellows also worked on the integration of graph analytics with machine learning, to analyze autonomous data sources as well as users interactions in decentralized settings. This resulted in the development of privacy preserving trust management schemes for identity validation, anomaly detection and spam filtering; hence minimizing risk and insecurity in DOSNs.

ITN training activities

iSocial consortium organized a total of **4 International Workshops**, **2 Summer Schools**, and **Annual Research Meetings**, where *iSocial* fellows had the opportunity to present their work through different media (talks, posters, discussion panels). *iSocial* consortium has also offered **7 online courses** covering knowledge topics in distributed systems, complex networks, security, and data privacy preserving computing. **Some events** (both Summer Schools) were **jointly organised** together **with other EU initiatives**, in particular with **Erasmus Mundus Joint Doctorate in Distributed Computing Programme**, as well as with **EIT Digital** to bring in entrepreneurial aspects to the fellow training.

Dissemination

Research within *iSocial* resulted in **37 conference** and **10 journal publications**, including a **groundbreaking publication in Nature Physics (Impact Factor: 20)**, and the **best student paper award in IEEE Big Data Conference, 2016**. *iSocial* fellows presented their research at internal project seminars as well as international conferences, workshops and other events. All the research was summarized in a periodic ***iSocial* newsletter** disseminated to all the stakeholders as well as available online. *iSocial* consortium also organized **two Video Challenge Programs** open to High School students from all the world. Selected winners were invited to present their videos at *iSocial* organized events.

Socio-economic impacts and conclusions

iSocial project trained **16 fellows** who will be joining the ranks of expert data scientists **with expertise in security & privacy, decentralized technologies, and modelling of complex systems**. It also significantly advanced the field of Decentralized Online Social Networks, by making available completely new technologies that will pave the way for more decentralized, sharing-based digital economy of the future. **The groundbreaking research on Social Networks modelling was published in Physics Nature**. Some of the **technologies developed within *iSocial* are adopted by European SMEs**, such as Hive Streaming, and Gavagai.

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