EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

cost

RESEARCH CONFERENCES

ESF-COST High-level Research Conference

Future Internet and Society:
A Complex Systems Perspective

Hotel Villa del Mare• Aquafredda di Maratea • Italy

3 - 8 October 2010

Chair: **Romualdo Pastor-Satorras**, Universitat Politècnica de Catalunya, ES

Co-Chair: **Claudio Castellano**, Sapienza Universitá di Roma, IT

Programme Committee: **Thibaut Lery**, ESF, FR; **Gian Mario Maggio**, CREATE-NET, IT; **Alain Peyraube**, CNRS, FR; **Peter Richmond**, Trinity College Dublin, IE; **Fabrizio Sestini**, EU DG INFSO, BE; **Caroline Whelan**, COST office, BE

www.esf.org/conferences/10341

Highlights & Scientific Report

www.esf.org

Conference Highlights

Please provide a brief summary of the conference and its highlights in non-specialist terms (especially for highly technical subjects) for communication and publicity purposes. (ca. 400-500 words)

The digital revolution represented by the ever more widespread access to the Internet is transforming the way we work, how we spend our free time, how we relate and socialize with people and even our consuming habits. At the same time, people accessing Internet and expressing new demands and necessities are shaping new tools and developments in a positive feedback loop. Internet can thus be viewed as a complex system, resulting from a continuous deployment of new technologies but ultimately driven (and explained) by needs and uses that society makes of it.

The purpose of this conference has been to bring together a panel of experts in Information and Communication Technologies, social scientists and researchers in the area of complex systems, in order to assess the state-of-the-art, identify new trends and envision future developments in the intertwined domains of future Internet and society. The discussions and presentations delivered at the conference featured different relevant issues related to the interplay Internet-society, among which we can highlight the necessity of a better understanding of the present layout of the physical Internet (the computers and physical connections joining them) in order to be able to cope with the future traffic demands in a sustainable Internet; the need to consider socio-economical factors in the design of future Internet tools and applications; the increasing role played of online social communities, such as Facebook or Twitter, and its effect in shaping our personal social relations; the possibility that these social communities offer in order to gain a better understanding of how social relations are created and maintained; the possibility of visualize and analyze emotions in online media, with the possibilities that this implies with respect to social conflict resolution; the present capacity of describing off-line social communities in real time; the future of Internet based automatic search and retrieval of information, based on semantic tools and concepts.

☐ I hereby authorize ESF – and the conference partners to use the information contained in the above section on 'Conference Highlights' in their communication on the scheme.

Scientific Report

Executive Summary

(2 pages max)

The conference was held in Acquafredda di Maratea, from October 2 to October 7, 2010. There were 74 participants (from 25 different countries), including 16 invited speakers, the Chair, the Co-Chair, the Rapporteur Prof. Slavko Splichal and Ms. Antje Teegler, the Conference officer. 29 participants were younger than 36 years und 18 were female.

Almost all participants attended the Conference for its full duration. The background of participants was extremely varied. The three largest groups were composed by computer scientists, physicists interested in the theory of complex systems (networks in particular) and social scientists. But other disciplines, ranging from economics to philosophy and medicine, where also represented. The impressive degree of heterogeneity was one of the challenges faced by the organisation of the conference, but it has turned out to be one of the keys to its success.

The programme included 13 invited talks (50 minutes long), 3 invited evening lectures (1 hour long) and 22 contributed short talks (15 minutes long). In addition, a representative of ESF and COST presented the activities of those organisations during the opening session, while a representative of the European Commission introduced the upcoming call for applications for the program on "Internet Science" by the EU. The conference ended with a Forward Look session, a short panel discussion followed by a lively discussion with the audience. Two poster sessions were devoted to the presentation of 19 scientific poster.

The conference budget, excluding fees paid by participants, consisted of EUR 50.790,00, including contributions of EUR 20.000,00 from ESF, EUR 20.000,00 from COST, EUR 2.500,00 from the Basilicata local government and EUR 8.290,00 additional funding by COST to support participation of members of COST Actions.

The budget was used to provide conference and travel grants to invited speakers, Chairs and to a number of participants that are also members of COST Actions. The remaining budget (over EUR 25.000,00) has been distributed to participants through full or reduced conference grants and travel allowances, with the goal of maximizing the chance of female applicants, young applicants or applicants from less rich countries to attend the conference.

The conference officer did a terrific work, providing a perfect support to all participants and allowing them to enjoy a seamless conference.

The traditional football match against the Hotel team was undeservedly lost by the conference team, which was nevertheless hailed as "moral winner" by the vast public of connoisseurs.

Scientific Content of the Conference

(1 page min.)

- *Summary of the conference sessions focusing on the scientific highlights*
- *Assessment of the results and their potential impact on future research or applications*

The goal of the conference was to set up a truly interdisciplinary environment composed of investigators working in different fields but sharing a common interest in the internet as a complex evolving techno-social system. Each of the three main communities of scholars present (computer scientists, physicists/complex systems experts, social scientists) contributed from their different points of view to this endeavor in a very lively and constructive atmosphere. To stimulate mutual understanding and effective interaction all sessions were intentionally designed to be as multidisciplinary as possible.

The interdisciplinarity that characterized the spirit in which this conference was called led to a set of invited and contributed talks in which many aspects of the interplay between internet and social systems were touched. Despite this heterogeneity, most of the contributions presented at the conferences can be included in one or more of a set of common themes that we will summarize in the following paragraphs.

- The Internet as a technological complex system

A fundamental fact stressed in several contributions has been the multi-level nature of the internet, where on top of a fundamental structure of physical connections, several different layers, from protocols to applications, live. As one

proceeds towards the top of this (hourglass-like) structure, the role of intentional planning and engineering control is reduced, and emergent phenomena occur, which require the tools of complex network theory and the insight of social scientists for their characterization and understanding. Nevertheless one should never forget that layers are strongly interacting with each other. Processes occurring at the top level are constrained by how lower levels of the structure (protocols, physical connections) work. These latter are in their turn strongly affected by what happens at high levels. For example, models for the behavior of applications end-users are needed to have reliable predictions of traffic patterns, which are crucial for planning and optimization of the hardware and protocols layers.

A more comprehensive understanding of the physical levels of the Internet requires, on the other hand, better and deeper efforts to gather data about the actual distribution of Internet components. Another topic discussed in the conference has thus been the present effort to collect information on the Internet physical layout, as well as the analysis of the Internet maps thus obtained. The picture previously held of this system is composed by aggregate elements known as domains or autonomous systems (Internet Service Providers, ISP) that distribute their traffic in a more or less self-organized hierarchical structure, in which traffic is rerouted from its origin to higher level tiers before it can reach down its destinations. It has been recently realized, however, that this picture is becoming less and less reliable. The reason of this fact is the ever increasing presence of Internet exchange points, defined as physical infrastructures through which ISP's can exchange traffic between their networks, bypassing the hierarchical structure. The increasing number of exchange points has a number of relevant consequences in Internet traffic. As the most relevant, it creates a core of high traffic nodes that does not necessarily coincide with the classical high tier hierarchy. This fact must be taken into account in a future planning on the Internet, in particular regarding the design of more efficient routing protocols that can take advantage of the topological properties of the Internet, and that that will the able to replace the present ones in order to satisfy the ever increasing demand of traffic in a future sustainable Internet.

- Internet social communities

One of the ways in which Internet has revolutionized how we carry out our everyday social interactions is through the recent advent of the so-called virtual social communities. Well-known examples are Facebook and Twitter services, which allow sharing comments, pictures and messages on real time. During the conference, several of the main contributions dealt with the different types of Internet social communities active at the moment: Internet message boards, online chat rooms, virtual worlds and social network systems.

Internet message boards and online chat rooms are essentially forums in which people can discuss thoughts or ideas on various topics. Users start a discussion and other users can respond in a follow up discussion. At this respect it is notable the presentation of the results obtained in the Cyberemotions European project. By means of a combination of network science, theory of complex systems and text analysis, it is possible to perform a large scale-analysis of the content of messages posted on Internet boards and blogs that allow understanding the role of collective emotions in creating, forming and breaking-up ICT mediated communities as a spontaneous emergent behavior. Proposed applications of these analysis range from the issue of how to support and maintain the emotional climate of security, trust, hope, and freedom in future techno-social communities to the prevention and resolution of conflicts within them.

On the other hand, in virtual worlds people are connected to an online computer-based game by creating a character, or avatar, whose life and interactions with other characters are controlled by the player in the 3-D virtual world. People not only interact by means of the avatar during game play, performing different activities based in the game, but can also hold conversations in real time with other participants. Analysis of virtual worlds can provide information about the real world, since online games exhibit many of the features observed in real social processes (networking, economics, communication, conflict, etc.) Moreover, they constitute a huge amount of data, already collected in databases, and ready to be analyzed. The main results presented in the conference about this problem highlight the particular features of this type of Internet social community. In particular, it has been shown that selectivity and transitivity exists in all online relations; homophily of age and game experience is preponderant; and most surprisingly, despite the virtual character inherent in the game, distance matters, being individuals living close together more inclined to establish game partnerships than individuals living far apart. This kind of studies highlights the strong connection between Internet and social human behavior, and open new paths to tackle capital problems in social science.

- Semantic Web and the Web 2.0

Many contributions have focused on the investigation of social behavior of internet users, leveraging the huge amount of data made available by Web 2.0 platforms. The term Web 2.0 is associated with web applications that facilitate interactive information sharing, interoperability and collaboration on the Word Wide Web (WWW). In this respect, it is highly relevant the new concept of the Semantic Web, defined as a set of methods and technologies that allow

machines to understand the meaning, or semantics, of the information stored in the WWW. The advent of Web 2.0 platforms has created an incredibly huge amount of information, mostly user-generated, that is interconnected and interrelated in complex and nontrivial ways. It thus is a very difficult task to locate and extract relevant information by using the standard user-friendly representations of data commonly used for human users. The Semantic Web project is based in the idea of further characterizing web content with metadata (tags) than can be read and analyzed directly by computers in such a way that they can analyze and retrieve information automatically. Several presentations in the conference dealt with the description of the methods of the Semantic Web, as well as to its application to implement web based recommenders.

This line of research is strongly connected to other projects that aim at investigating quantitatively social behavior using sensors or the digital fingerprints that each of us leaves behind when using pervasive technology such as smart mobile phones. Studies in this direction presented at the conference allow describing the patterns of human mobility and behavior, and opening the path to a future, possibly not very distant, science of human behavior forecasting. Other presentations dealt as well with the analysis of the interplay between online and offline social networks. In this respect, several presentations described the SocioPatterns platforms, devised to obtain real online information about the structure and evolution of social networks of face-to-face contact by using personal RFID devices. In recent experiments described at the conference, it has been possible to correlate the properties of these dynamically obtained social networks with underlying virtual networks shared by the same people.

To sum up, the most important result of the conference was probably the impressive level of real dialogue going on, with members of the different communities constantly interacting with people with different backgrounds. If, as many speakers pointed out, the future of the internet as a techno-social system depends on our ability to understand it from a multidisciplinary point of view, the conference has been a useful step forward towards the construction of a real Internet Science.

Forward Look

(1 page min.)

- *Assessment of the results*
- *Contribution to the future direction of the field – identification of issues in the 5-10 years & timeframe*
- *Identification of emerging topics*

As pointed out by several speakers, predictions in this area are exceedingly difficult even on a relatively short time scale. The current internet is radically different not only from what pioneers devised in the '70s and '80s, but also from the internet that existed just five years ago. From a technical point of view, the physical layout of the Internet should be redesigned, if it is expected to cope with the needs of emerging economies that will demand higher levels of connectivity in future years. From the point of view of applications, especially from the social sciences perspective, new developments are appearing at such fast rate that it is probable that present high-interest topics will become obsolete in the near future.

Nevertheless, the analysis of the experts summoned at the conference, and expressed specially at the panel discussion that closed the conference, allows to identify some trends in the field, which are likely (and worth) to be followed in the future:

- Designed versus self-organized Internet. It is clear that a future sustainable Internet will need a redesign starting from basic principles. Such endeavor will not be completed only by network engineers, but will need a mostly multidisciplinary approach, involving the communities of social sciences and complex systems alike.
- Socio-economical aspects of Internet. The Internet is not only driven by its uses but also by its users, whose socio-economical characteristics must be recognized and implemented.
- Uses and applications of virtual communities. Virtual communities allow the possibility of working with huge amounts of data, which can be profitably used to shed light on different social phenomena.
- Large-scale applications of the Semantic Web. The Semantic Web project is barely at its beginnings, in the process of defining its standards of protocols. However, it promises to represent a huge transformation in the way we use Internet.
- The Internet of things. The increased pervasiveness of Internet allows envisioning a near future in which virtually every object is interconnected. The first steps in this direction have already been made; by the possibility of cheap RFID deployment combined the analytic capabilities of Semantic Web tools.

▪ Is there a need for a foresight-type initiative?

To close this report, we would like to mention that an overwhelming majority of the participants has expressed a strong interest in new initiatives that could represent a follow-up of the contents of the conference. Many have explicitly suggested that this conference should constitute the first of a series on the same topic, with the same marked multidisciplinary content. With a similar spirit, some have also put forward the idea that a natural follow-up of the conference must be the preparation of a proposal for a COST Action that could allow people to start collaborating on specific problems.

The organizers are taking both suggestions into consideration.

Atmosphere and Infrastructure

▪ The reaction of the participants to the location and the organization, including networking, and any other relevant comments

The conference took place in an informal and stimulating atmosphere, with all sessions attended by virtually all participants. This is something that is not often seen in similar events.

Moreover, the minutes allocated for questions to speakers at the end of talks have always been an extremely lively time, with many in the audience, including young people, taking actively part in the discussions. The role of session chairs has been not to stimulate the discussion, but rather just to stop the question time to stay on schedule, while inviting all to continue the interactions during coffee breaks or lunch breaks.

The location has been a very pleasant surprise for all participants and definitely a plus for the success of the conference. Many (including the chairs) were initially quite skeptical because Acquafredda di Maratea is difficult to reach, being far from any airport, so that even participants from European countries had to spend almost a full day traveling to get to the conference site. This is probably one of the reasons why quite a few of the scholars first contacted as prospective invited speakers turned down the invitation (see below for more on this).

However, once on site, many if not all the participants have enjoyed a lot the beauty of the setting, the comfort of the accommodation and the possibility to spend some time on the beach after lunch. The infrastructure of the conference hall and of the room for poster sessions was perfectly adequate.

The fact that the hotel is in a very small village and not close to any town turns out to help people concentrating on the scientific part of the conference.

The responses to the questionnaires distributed to the participants at the end of the event reveal a remarkable appreciation of all aspects of the conference. 88% of the respondents think that the conference should be repeated.

Some suggestions to further improve the success of future conferences (either on the same topic or on others) to be held in Acquafredda di Maratea.

- The first week of October is not the ideal time for a conference that is supposed to attract high level participants from academia since it interferes with the beginning of the academic year in many universities. This, together with the fact that the conference location is not easily reached, represents a serious hindrance against the goal of attracting busy top-notch experts. Moving the conference to a different location clearly implies the loss of the many pluses associated with Acquafredda di Maratea. Scheduling the conference one or two week earlier would instead be only beneficial.
- By the same token, beginning the conference on a Saturday night is probably not worth the effort. Starting on Sunday night would be a much better option.
- A hands-free wireless microphone in the conference hall would help speakers being fully concentrated on their talks.
- Faster internet connectivity is needed.

Date & Author:

Romualdo Pastor-Satorras

Claudio Castellano

Tuesday, November 9, 2010