The EIFFEL approach towards Visions for a Future Networked Society

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Abstract: The Internet was not designed to be a critical part of the economy—but it has become exactly that. In fact, it has become a critical infrastructure for the overall society in developed countries. There are many questions today on how the Internet will or should develop in the future. What has been asserted throughout the industry and the research community is that the Internet must change, and that the degree of change must be revolutionary. However, the directions and extent of the changes are not obvious. This leads to the logical argument that new research paradigms need to be explored and more interdisciplinary research is required in this domain. The EIFFEL project supports this investigation through the organization of Think Tank meetings between international experts, debating agreed topics of investigation, such as Future Internet Architecture, Infrastructure, Security, Privacy, and Governance, as well as, sociological and economical aspects. As EIFFEL promotes discussion and interaction between the different ideas, there will be, over time, a coming together of developing vision trajectories, along different explorative and evolutionary paths, towards the common vision of a Future Networked Society. In this paper, in addition to the EIFFEL findings, we also relate the EIFFEL approach to the many Clean Slate research efforts around the Globe.

Keywords: Future Internet, Clean Slate, Internet evolution vs. revolution

1. Introduction

The Internet was not designed to be a critical part of the economy's infrastructure—but it has become exactly that. In fact, it has become a critical infrastructure for the overall society in developed countries. Most aspects of society are today reflected in the Internet in an integral and very real way. From real (Internet only) business and Internet based distance education with degrees obtained online recognized by many organizations and countries, through social networks, to cybercrime and cyberwarfare.

However, there are many questions today on how the Internet will or should develop in the future. The EIFFEL Initiative concluded with a white paper discussing these issues at as perceived at the end of 2006 [1]. What has been asserted is that the Internet must change, and that the degree of change must be revolutionary. The future Internet should be able to sustain at least an order of magnitude increase of the number of people connected to it, and the addition of billions—perhaps even tens or hundreds of billions—of devices, such as sensors, tags, micro-controllers, etc. Important questions that need to be considered include:

- How will we streamline interconnectivity and go beyond today's IPv4/NAT tricks?
- Can we eliminate spam, anti-spam blacklists, rogue packets, the power play of search engines, advertising invasion, privacy invasion, viruses, and other exploits?

- How will edge networks develop? Who will own the last mile? Should users control the last mile?
- Which wireless constraints do we need to face first? Will we have mobile access gateways? Who owns these gateways?
- Stronger copyright protection for cyberspace: is it desirable, is it inevitable, is it irrelevant? How will IPR handling evolve?
- With the cost of information distribution being close to zero, will all business models that depend on controlling distribution vanish?
- How will the Internet industry reshape? Who will be the new power brokers?

Many more questions will inevitably arise.

Many efforts around the world are trying to address these and many other related questions. Section 5 of this paper discusses some of the most influential such projects and tries to relate them to the Clean Slate approach. It is clear that neither the problem is entirely clear, nor the exact goal can be specified, nor the means to approach it are obvious.

The EIFFEL project has a particular approach to try to discover the right questions and then to explore the space of answers. That approach is based on selecting, supporting and employing a Think Tank to bring out the important issues, debate them and come up with research manifestos and suggestions for research priorities. Working groups from the Think Tank develop the questions, agenda and work on the issues between Think Tank meetings. The first and second Think Tank meeting of the EIFFEL project, the process to arrive to it, some points from its working format and its initial findings, are described in Section 3 and 4 of this paper, respectively, after an introduction into the issues immediately next, in Section 2.

2. Need for a Balanced Agenda

The Internet has become a critical communication medium that is progressively reaching its technical limits. It has recognized shortcomings in areas including security, resiliency/robustness, accountability, mobility and manageability. It is widely accepted by the Internet community at large that these limitations cannot be resolved anymore by minor incremental adjustments. These shortcomings, if they remain unaddressed, will seriously impact the society's ability to utilize and exploit the Internet in the future. From this fundamental observation, there are many resulting questions today on how these limitations shall be addressed and subsequently how the Internet will develop in the future.
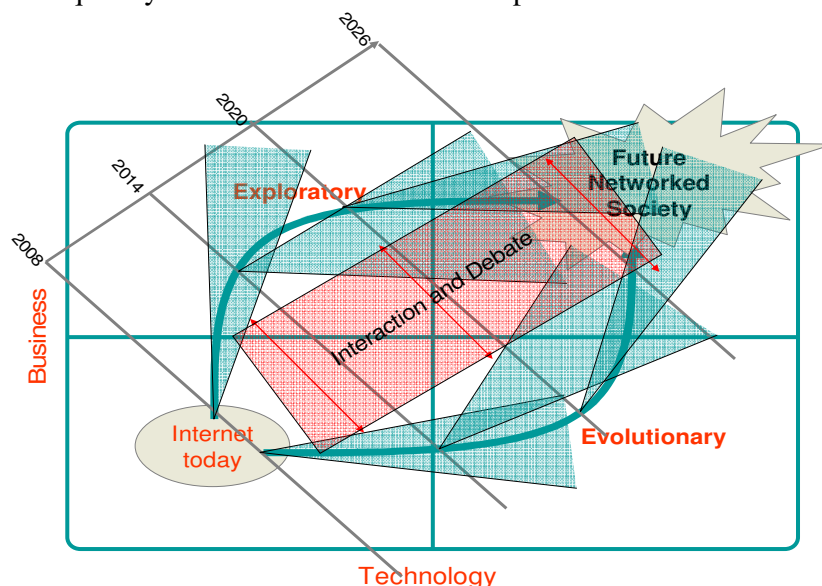

Figure 1: The Phased Approach of a Balanced Research Agenda

What has been clearly identified throughout the industry and research community is that the Internet must transform, and that the degree of transformation must be significant, almost

revolutionary. Once we determine what transformations are needed, we can start working on how to migrate from today's Internet to the forecasted 2020-25 Internet, and beyond. But it is crucial to understand what approach will bring us towards our vision of the Future Networked Society. One of the key findings by several study groups, the EIFFEL group among them, is the need for a balanced research agenda, as illustrated in Figure 1.

There is clear need to support evolutionary, applied engineering research, based on present industry needs towards the future. But this is not enough to ensure that great opportunities are grasped by Europe. The evolutionary path has to be complemented by a portfolio of explorative research activities that will push beyond the limits of existing systems and open the doors for new opportunities towards the future. In this balanced approach, the following list of potential technical areas is expected to attract interest:

- **Future Architecture**: to debate and roadmap the research and development advancements in the domain of the architecture and architectural principles, covering a wide domain of issues including theoretical and practical issues, interoperability, complexity of architectures, and also societal and economical boundary conditions.
- **Security, Privacy and Rules Enforcement**: to provide overarching understanding on these issues, not only in the technological domain, but by considering also social, economical, legal and law-enforcement issues.
- **Emerging Paradigms and Technologies**: a link towards the foundational, fundamental and emerging research issues that may have disruptive or high impact. This includes issues such as cognitive network technologies, applications of AI in the networking domain, game theory, biology inspired models (e.g. virology, genetic), new unexpected services, etc.
- **Governance and Policy Aspects**: to bring into the discussion a strong dimension on the governance and policy aspects that are related to networking, so far not taken into account seriously enough by the technical community and even by policy makers.
- **Societal, Sociological and Economical Aspects**: to address issues related to the changes and challenges in the society and economical domain.

3. Starting the Debate: The First Think Tank Meeting

Following the recommendation of the EIFFEL study group, expressed in [1], the EIFFEL Think Tank (TT) has been formed as the main tool for stimulating debate among practicing experts. Researchers with strong track records from all over the world are invited to come to various topical TT meetings in order to discuss the status and directions of Future Internet research and identify the key issues where significant effort needs to be directed at. The scope and direction of discussions is defined by the participants' positions and the degree of consensus on key challenges.

3.1 Format of the First EIFFEL TT Meeting

This general model of a think tank for Future Internet debate was implemented in a first EIFFEL TT meeting that took place in Frankfurt-Langen, Germany, 30/9-1/10/2008. The mandate of the first meeting was to gather possible issues and see which ones had the potential to significantly improve the Future Internet if they were addressed. This would allow determining a list of critical issues on which EIFFEL should form innovative positions at future TT meetings. Another objective of the first meeting was to bootstrap the discussions and topics through position statements and group work. Hence, the meeting was dominated on the first day by position statements of TT members. These statements were solicited beforehand. The guideline for these statements was to focus on critical challenges for the Future Internet and visions that might drive its development. The statements were supposed to create debate and form the foundation for the break-out groups later on.

A first discussion was sparked from the opening remarks on research style. It was interesting to see that the debate of "engineering" vs. "science" emphasized the fundamental limitations of the current "networking/computer communication community": there is little

available when it comes to predicting the current behaviour and the evolution of the system. Most of the effort is oriented toward engineering and building the system and then observing and measuring the result - this is the baseline of an empirical approach.

The afternoon session was dedicated to defining the break-out groups. The plenary was continued the next day with the break-out groups summarizing their discussions from the first day. In the final session, feedback was gathered from the participants on the general usefulness of the meeting, the approach and the steps forward.

3.2 Formation and initial sessions of working groups

The structuring of the break-out session was not dictated in advance, but rather the topics and composition of the break-out sessions were left for the members of the TT to decide. The organizers facilitated the process by arranging a short session for input collection on possible topics for the break-outs, which were then synthesized into a smaller number of topics. In the end, three groups of topics were adopted as a basis for the remainder of the meeting, namely:

- **Technical Challenges**, aiming to crystallize the key "Grand Technical Challenges" the Internet of the future has to face.
- **Business**, with the objective to discuss and debate the role of business models, value chains and related issues in networking and challenges arising from those considerations.
- **Security and privacy**, the focus of which was to understand the issues related to ever increasing complexity and availability of personal information in the future.

All of the break-out sessions received good numbers of participants with a industry bias in the Business session. The chair of the meeting was rotating between groups to monitor the progress and also to ensure that there is enough cross-fertilization of ideas between groups. This approach proved as a workable method to ensure progress and cohesion in different aspects.

Overall the discussion was lively and productive, and all the groups produced substantial amount of notes into the collaborative TT wiki tool to serve as a basis for future work. Due to the relatively short time available the objective was not to arrive at consolidated inputs, but rather to obtain inputs that could be used to form the first actual working groups that would also be operational in the times between the actual TT meetings. In this role all the break-outs were successful. Following the TT meeting the input from the groups was used to establish three areas of further investigation, namely (a) Technology, (b) Economics, and (c) Society.

3.3 First TT meeting outcomes

1. **Creation of an initial community:** in accordance with the agreed process for establishing the EIFFEL TT, the first meeting served the purpose of creating an initial community out of which we can bootstrap future meetings and discussions. The participating TT members specifically appreciated the intent of the TT and showed the willingness to participate in future meetings of this kind.
2. **Creation of the first areas of work:** the presentations and break-out groups led to a first set of work areas, namely technology, economics, and society. These work areas will form the basis for the next EIFFEL TT meeting in terms of discussions and debate. But it also guides the process of extending the TT membership by inviting new members that would enrich the discussions in these areas. The work areas, together with the notes from the break-out groups, have been transferred to the EIFFEL wiki in order to serve as the grounds for online discussions among the TT members. Areas leaders have been appointed to facilitate the discussions within each area. In addition, area-specific mailing lists have been established with sub-groups according to the interests of individual TT members.
3. **Creation of a first TT report:** a small editing team of EIFFEL caretakers as well as TT members was formed to summarize the findings of the meeting in a concise report. This report was released to the think tank in preparation for the second TT meeting, stimulating discussion during the second meeting. This report focussed on the importance of agreeing

on clear disagreements within the research community, an issue that rose to an important issue during the second TT meeting.

4. Continuing the Debate: The Second Think Tank Meeting

The momentum of the first TT meeting was used to organize a second one in February 2009, taking place in London. It is important to notice that many attendants of the first TT meeting decided to return, with some time conflicts preventing such returns although opening the possibility for others to attend. Overall, the outcome of the meeting was very positive, both in attendance (some 36 participants came to London) and results.

4.1 Format of the Second EIFFEL TT Meeting

The format of the second meeting was changed compared to the first one. Few selected presentations were sought to stimulate debate in key topics that had arisen from the first meeting in Frankfurt. These topics included technical challenges (Vijay Gill, Google), privacy and security issue on architectural level (David Clark, MIT CSAIL), governance and values for the Future Internet (Ian Brown, OII) and finally data measurements (Kimberly Claffy, CAIDA). The presentations sparked debate during and after the presentations, which were intensified through the construct of *challenger sessions*. In these sessions, the audience was divided into groups, each of them challenging the presenters on more dedicated issues.

While the first day was dedicated to the intense discussions around the topical presentations, the second day was dedicated to discussing style and potential outcome of the TT work. Open discussion in the plenary was chosen, gathering the output in the collaborative TT wiki. Actions were agreed upon by the plenary (see below), to be executed in preparation for the next event of such kind.

4.2 The Topical Presentations

The following presents a summary of the topical presentations of the first day:

- Vijay Gill (Google): This talk examined practicalities in supporting the large scale compute systems that underpin one of the most universally important distributed applications on today's Internet. This talk was chosen both because of the immense practical importance and scale of operation of the Google product suite and because it is representative of application driven systems that manipulate, filter and present information to users.

- David Clark (MIT CSAIL): This talk argued that there are desirable design patterns that can be supported by the provision of tools other than simple network layer byte streams. The talk also contended that trust was a key concept in application design and that appropriate decomposition of application services and the positioning of their critical components in trustworthy locations was of particular importance. Finally, David argued that this was not at variance with the end-to-end principle.

- Ian Brown (OII): Ian's main thrust lay in the question of whether it was necessary to design constraints on the power of governments into the Future Internet architecture. The talk started from the tussles that arise from conflicts between an individual's need for privacy and the desires of the state to monitor individuals and/or control access to undesirable information. He discussed constitutional protections as a means of limiting the power exercised on behalf of the people by governments and considered ways of designing technologies to protect privacy and free speech.

- Kimberly Claffy (CAIDA): The presentation covered the motivation for the work undertaken by CAIDA, identifying 16 operational Internet problems, and selecting from these 4 key issues: *safety*, *scalability*, *sustainability* and *stewardship*. Whilst there has been considerable activity on these four activities, real and measurable progress is more elusive.

Specifically, a misunderstanding of the economics of the current architecture represents a real threat. Scientifically sound research can help in this area, but our ability to measure is surprisingly poor and cooperative data sharing approaches to measurement and analysis represent the key to enlightened policy.

4.3 Agreeing on Disagreements

A large part of the second day was spent on reflecting on the contentious areas of research, i.e., where do we need to see progress and why? It was noted that getting the research community to agree on these contentious areas in a well-articulated way is a major task. While the TT members spent considerable time on an initial list of such *disagreements*, time was also spent on the approach to debate and agree on these disagreements. It was noted that to agree on what we disagree on holds a component of resolving contentions in some areas as much as formulating them in others. In other words, compiling a set of disagreements is the argumentation on why further dialogue is important. This includes the formulation of potentially opposing viewpoints on the importance of a particular area.

Hence, an approach must include the aspect of discussion, even defense, of one's viewpoint with respect to the importance of the topic at hand. An approach must further include a component of *community contribution*, building on and therefore recognizing the collective intelligence of the wider community who feels strongly about the importance of their work when it comes to relevance for the Future Internet.

After an original proposal of capturing this debate in form of a book was presented, careful consideration during the think tank meeting led to the conclusion of establishing a Wikipedia-like online platform as a first step for this debate. This platform is chartered with gathering opinions and consolidating the debate of a growing and contributing community of researchers. The platform will most importantly serve as a tool to formulate disagreements, debate on different, potentially opposing viewpoints, and finally converge to some agreed view on these disagreements. It will further serve as a repository for relevant work in areas relevant for the Future Internet. The usage of collaborative editing tools like wikis will allow for recording and structuring this debate. It is important to note the differences to a Wikipedia-like encyclopedia in the sense that the online platform discussed here will include a clearly identified editorial team, solicit contributions from identified (registered) users while being open to be read by anybody, and allow individual contributors to retain the copyright of their contributions.

4.4 Second TT meeting outcomes

1. **Extending the community:** the second TT meeting demonstrated the success of the first meeting by having a noticeable number of returning TT members, time permitting. There was a clear recognition for the necessity of this forum with positive feedback captured from most participants, all of which included constructive suggestions to improve the think tank operations.
2. **Continuing the technical debate;** based on the stimulating thoughts of the EIFFEL TT report produced for the meeting, technical discussions continue on the EIFFEL wiki among the TT members in the areas identified during the meeting. This will serve the preparation of the next meeting in Fall 2009.
3. **Establishing an online platform:** As an outcome from this meeting, an initial editorial team is in the process of setting up the suggested online platform. A launch is expected during spring 2009, seeded with results from the initial EIFFEL think tank meetings, but also incorporating other material from experts worldwide. While not enforcing a particular timeframe, we do expect the debate to pick up quickly, leading to early results on disagreements throughout the year.

5. Other Activities in the Future Internet Space

The Future Internet is a vital topic in many parts of the world and in many different communities and associations, being discussed by international political and economic associations such as United Nations within the Global Alliance for ICT, World Summit for Information Society, International Governance Forum, OECD, Commission of European Union and many other governments that have set up initiatives or wider socio-economic forums that spread over a whole continent [14]. Although most of them approach similar themes crucial for the evolution of the Internet, including technical problems of the current network infrastructure and issues related to the network management and governance, they differ in scope and motivation. Also, many R&D initiatives are currently undertaken within the EU, U.S., and Asia [10][11], including national initiatives in several European countries such as Germany, Sweden, Finland, and France. Furthermore, most of the current technical problems of the real Internet related to addressing and routing, DNS security, IPv4 address exhaustion, security of the networked services and deployment of IPv6 are discussed and approached within the initiatives of the major governing bodies of the Internet such as ICANN, ISOC, IETF, IRTF and the five RIRs [2].

The U.S initiatives are focused around two programs managed by NSF: FIND (Future Internet Design) [4] within the NSF NetSE (Network Science and Engineering) program and GENI [3], a program focusing on a flexible and reconfigurable network test bed and related experimental projects. The FIND program solicits "clean slate" research proposals in the broad area of network architecture, principles, and design, aimed at answering many of the technical questions within the area of Future Internet. The philosophy of the programme is to help conceive the Future Internet by enabling a network design that is free from the current collective mindset about the constraints of the network.

The European initiatives are focused on test beds and experimental facilities, research towards major architectural and other technical themes and other aspects related to the operational infrastructure, as well as service developments, GRID visualisation etc. The experimental facilities projects within FIRE [5] aim at creating independent and federated test beds for enabling experimentally driven research. It is expected that the test beds will address issues from early proof-of-concept to validation aspects, performed in collaboration between industry and academia, identifying migration paths for new concepts, and in particular supporting the exploitation of research results.

The Future Internet Assembly [6] represents a forum where a growing number of FP7 programme Future Internet projects meet and exchange ideas, opinions and develop future research agendas. An important aspect of this European initiative is the collaboration of industry with academic institutions gathered under the umbrella of the ETPs (the European Technology Platforms) [7]. Three ETPs are working in the area of the Future Internet: e-Mobility, Networked and Electronic Media (NEM) and the Networked European Software and Services Initiative (NESSI). The association of the European Academic networks is contributing in this area through a joint collaboration within the recently launched project FEDERICA [9]. The project is aimed towards testing and exploitation of most recent developments and R&D results that introduce innovation in the network architecture of the GEANT2 network [8].

Important activities are carried out within the Internet Society and the associated organizations, the IRTF and the IETF. The IRTF research group "Routing and Addressing" is investigating and designing a new routing architecture that is expected to improve the Internet's ability to scale to potentially billions of new users and IETF working groups are defining new standard documents related to new networking architectures, security, and accessibility of network services. The major scope of the recent initiatives of the ICANN, organization, which is managing the Domain Name Space and the 13 DNS root servers, are related to the deployment of secure DNS service for the roots and on related technical matters that guarantee operational Internet security. Another ICANN initiative aimed towards the implementation of the Future Networked Society is the introduction of IDN-enabled (Internationalized Domain

Names) TLDs (Top Level Domains) into the DNS root and the new IDN gTLD names without any restriction on the name content in the future.

This overview of the most important Future Internet activities around the world points out to the complexity of the subsystems that form the core technologies within the Internet and the Internet itself, to the interdependence of various systems that enable the current operation of the Internet and point to the fact that it is very hard to assess the effects of any particular proposed change. In order to measure, compare and validate scientifically and also to provide a realistic basis for a scientifically rigorous impact assessment at technological, economic and social levels, cooperation and interactions between many of the initiatives is certainly required. The liaison activities within EIFFEL aim at establishing these relations and interactions.

6. Conclusions and Future Work

There are many questions today on how the Internet will or should develop in the future. Many efforts around the world are trying to address these and many other related questions. The EIFFEL approach to discover the right questions and then to try to explore the space for answers is based on a Think Tank (TT) approach, involving renowned experts in the field to debate concrete topical areas of investigation during and between the actual meetings.

Two think tank meetings have now taken place, given an initial proof of concept for this type of initiative, this proof driven by the recognition of the members for the necessity of such tool and by the return rate of initial TT members to the second meeting. With concrete topical discussions in the second meeting, outcomes of the first meeting were incorporated by selecting the topical presentations from the identified list of technical, societal and economic challenges. A focus of the current TT discussions lies on getting the wider community engaged to agree on the contentious areas, the disagreements, where further investigation is required, including a concise formulation of the contention. This led to a concrete action, driven by international TT members, namely the creation of an online platform that will be dedicated to this debate, including the collection of relevant Future Internet work. It is expected that this platform will increase the momentum of the EIFFEL initiative even further.

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