Vision document

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Rationale

Internet is now an essential part of our society. Its success has exceeded by far the original expectations of an end-to-end, simple communication network. The required incremental improvements to satisfy the ever increased demands in terms of reliability, mobility, efficiency or security is impacting in the network performance and its technological and architectural limits. It is time of thinking in a Future Internet. This document aims at contributing to give a coherent vision of the Spanish ICT actors about Internet in the upcoming future by the provision of new ideas, convergence between the technical and non-technical perspectives, providing recommendations on policies and roadmaps that could foster the active participation of the Spanish industry, academia and a broad scope of organizations in the development of the infrastructures and services for the future networked society.

Content

1. Concept of Future Internet

1.1. Introduction

Future Internet is conceived as the required communication infrastructure including devices, networks, services, knowledge and contents to serve a future networked society and to accommodate, in a sustainable way, its communication needs, ever unanticipated ones. But the Future Internet is not a prediction but a goal to be attained in response to the current limits of the Internet to meet complexity and sufficient quality standards. And the stakeholders of this research effort are responsible for enabling the technologies, the standards and the methodologies. They are responsible for adopting the new attitudes and for realising the catalysing new projects that will make the Future Internet happen. From the technical point of view, this future Internet should be global, ubiquitous, accessible, trustable, sustainable, omni-media, scalable, adaptable, and personalized.

As a result, it is not a simple evolution of the current concept of Internet. Conversely, it is a new telecommunication network concept, relying on a full convergence of technologies, networks, services, media, etc, everything built around the user as its centre, its behavior, its reactions, and its wishes within the socio-economic environment. This concept represents a pervasive Internet. The Future Internet reaches the whole Information Society and particularly answers the demands to enhance the performance and the socio-economic behaviours of individual users, SMEs and the Administration. Hence, the future telecommunication network arises as something that will exist as part of our future world, embedded in our lives, with no need to undertake any specific action to access to it, to its contents, or to other people through it, because we will be intrinsically part of the network; social entities, people, will be the centre of the network.

1.2. Future Internet Perspectives

The SE-centric (Social Entity - centric) approach is central in the configuration of the future Internet. That means Internet will be the place where services, contents, things and even the network evolve around the person; that is, Internet must pervade every aspect of the life of the individuals (social relations, work, leisure, economical activities, life at home etc.).

Therefore, the long term objective will be that people can be connected "anytime, anywhere and with any device" what must contribute to enhance his/her quality of life applied in many aspects, such as:

- Life at Home.
- E-Entertainment and leisure.
- Transport and tourism.
- Digital Enterprise.

- New relations among citizen and public administration.
- Ambient Assisting Living, including e-Health and e-Inclusion.
- Social Networks.
- Security
- Workplace

The following picture depicts the Future Internet vectors

Figure 1: Future Internet Vectors

The analysis of the different elements constituting the future of internet is usually made considering the different technologies, as depicted in the following figure.

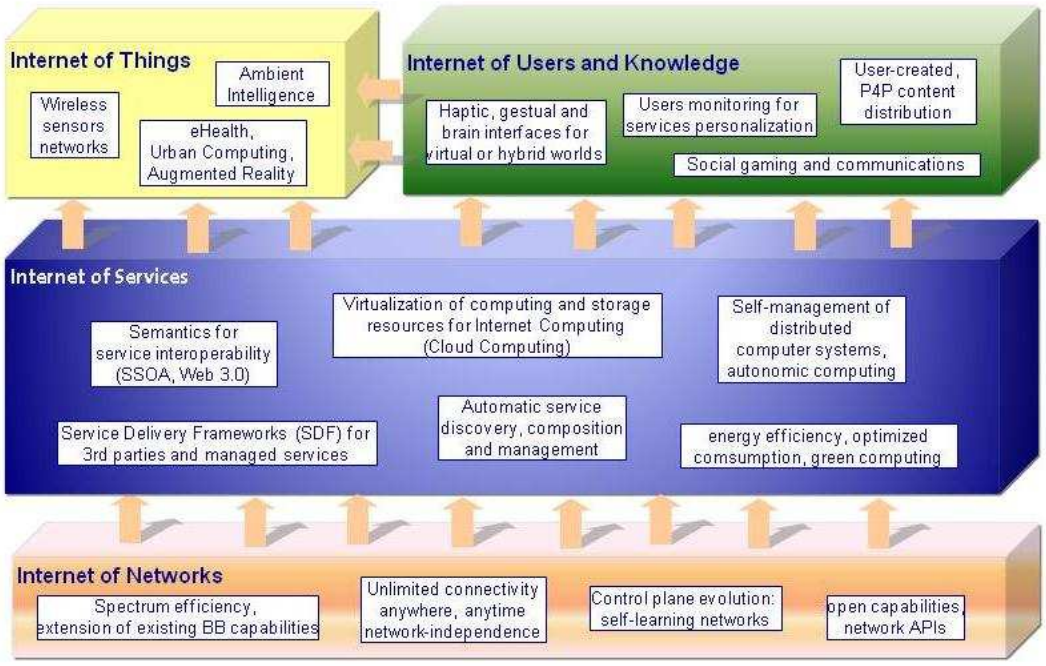

Figure 2: Elements of the FI

Internet of Users, Content and Knowledge

In the last three decades, the Internet has developed from a network for scientists into the global hub for information and communication where different actors, including citizens, share their contents and connect with each other. People are using mails, blogs, micro-blogs, and instant messaging as communication means. They are connected to social networks and virtual worlds, sharing pictures, music, and knowledge within a given community. They want all those features to be accessible anywhere, anytime and on any device. In other words, a new definition of Internet is at stake: "Internet is the people". Last but not least, all these principles have been imported inside companies, leading to a revolutionary change on the notion of how employees interact with ERP, business and operation support systems.

As the Future Internet is evolving to an Internet of people, efforts should be put in the following user issues, many of them related to evolution of the Web, from Web 2.0 to Web 3.0:

- **User profiling.** Future applications should be adapted to the profile, background, preferences, language, space-temporal location and even current mood of the user in a dynamic way. This also includes the development of new applications that will allow users sharing their knowledge within a given community, and structuring information based on the existing profiles and points of view ("anyone can say anything about any topic").

- **Context and User awareness.** This area is focus on recommendation systems, particularly for mobile web and location-based services, as well as technologies supporting a smarter interaction by means of exploiting semantics linked to context and content/services being accessed. It should also include new ways of personalized and contextualized advertising.

- **User generated content/services.** The evolution of users towards "prosumers" (consumers and producers of new content and applications) will allow breaking the barriers/boundaries between content/service producers and content/service consumers, allowing the creation of new types of relationships. These new kinds of relationships will require empowering professional and amateurs users to foster with real-time tools the collaboration among them (creation, annotation, sharing and retrieving).

- **User Experience.** There is a need to design and develop novel multidirectional interfaces and interaction mechanisms, including multimodality and "presence", between people and infrastructures and both directions. Multimodal interactions should provide the users with new modes of interfacing with a system behind the traditional visual and voice modalities, such as pen-based input or haptic input/output.

- **Accessibility (e-Inclusion).** A pervasive Future Internet means overcoming prejudices at every single step of its deployment; and placing wider perspectives of human-machine interactions instead of these prejudices. Technologies, methodologies and certification models should be developed to ensure the Future Internet as a universal right not excluding anyone and, furthermore, making the Information Society even wider.

- **Social communities and Virtual Society.** New specialized and contextualized social networks should be created to more and better support key social activities:

e-Education, e-Health, e-Government, etc.

The vision of user-centric Future Internet reinforces the emergence of a Future Information Society in which all citizens access the contents or services they are looking for wherever they are in a very natural and technology transparent way. These ease to access any needed service will help dramatically to bridge the digital divide and will boost new economical relationships.

To build the Internet of Users, Content and Knowledge, further work is needed on:

- **Innovative media contents:** the migration from the current 2D media contents towards a 3D Internet, generating a fully immersive multisensory environment to the user. Thus, these new formats should allow higher quality of experiences to the user, going beyond the products of the traditional media industries.

- **3D coding:** Adapted methods to describe and encode 3D pictures (or scenes) have to be designed, or adapted from the current state of the art in 2D picture coding. Those methods will have to interface easily to a variety of terminals, each of them being offering different qualities in terms of scene rendering, according to the application (and the cost of the terminal) concerned.

- **Virtual Worlds:** They will provide a sense of enriched experience for the user by the addition of new reality (new sounds, images, vibration, odors ...). Those virtual environments will be both immersive and adaptative in such a way that they will encompass the ability to become highly adaptative to user preferences and expectations, learning from previous experiences. Immersive high definition 3-D 'displays' (including transducers for audio, and for other senses as they become available) will create the illusion of presence in a virtual or distant world as an immersive and integrated experience for users.

- **Innovative interaction:** Innovative interaction will be based on natural user interaction: voice, gestures, eye-sight, movements, etc. Interaction with virtual worlds will not be unique, in the sense that many actors might create their own world (enterprises, entertainment entities, professionals or even amateur people for enjoyment). This feature is one of the most important challenges due to the advantages it provides to the final user in terms of the freedom to choose different environments where they could act with no changes in terminals or ways to operate.

- **Augmented Reality:** Augmented reality will be a fundamental component of the Future Internet where the reception of more enhanced information will bring an enriched experience for the consumers: indications in travel, additional information while observing reality, assistance while driving, enriched information when carrying out a surgery operation etc.

- **Multimedia search engines:** Dynamic and adaptive access to content is very tedious because of the tremendous amount of multimedia data online, in multiple formats and structures. New type of search engines, indexing and cataloguing contents or specialized in the identification of objects within images, need to be developed. The challenge is to access easily those content items that the users may appreciate, in a contextualized manner that suit their (business or private) information needs, their entertainment wants and their personal tastes.

- **Recommendation systems:** These kind of systems should help people finding the required content, taking into account the context, emotional data, community interests, language and other personalization criteria. Context reasoning paradigms and methods should enable the context interpretation and adaptation inference process.

- **New P2P/P4P services:** Since the appearance of Peer-to-Peer file sharing networks, many internet users have chosen this technology to share programs, films, songs, documents, etc. The increasing number of legal P2P content distributors along with the deployment of High Speed Residential Access (HSRA) networks will bring new and more P2P/P4P-based services.

A cognitive society goes beyond information and content accumulation and consumerism by involving conscious intellectual activity (as thinking, learning, reasoning, or remembering). For this purpose, the Internet should support and promote mechanisms for information storage, processing, knowledge creation and dissemination. Knowledge and culture must be opened worldwide to break down barriers and to promote dissemination and learning.

In practice, this means that in order to achieve real social progress, the Future Internet shall provide, beyond information access, adequate processing means and involve conscious intellectual activity. That includes intelligent ways of storing data and contents, searching mechanisms to capture just the required information, systems to recommend and guide users or even generating knowledge in the intellectual sense the humans usually do.

2. Internet of Things

The term "Internet of Things" has come to describe a number of technologies and research disciplines that enable the Internet to reach out into the real world of physical objects.

It consists of the management of information about real world objects and their surroundings provided by a number of sensors and wireless communications devices mounted in different environments, embedded in systems, worn by users, etc. The ambient intelligence paradigm builds upon ubiquitous computing and human-centric computer interaction design and is characterized by systems and technologies that are: embedded, context-aware, personalized, adaptive and anticipatory.

This poses a number of challenges both in the network and in the treatment of the information coming from those devices. The challenge is to handle the large amount of information coming from things and to combine it to provide useful services.

Integrating "things" into the network is one of the major expected growths of the future network. This is why the integration of object networks within a general purpose network is just one of the goals. For instance, some challenges are to ensure protocols adapted to object characteristics, to offer greater security to afford ubiquity and daily nature of network use, to integrate small low capability devices, etc.

Some of the application domains are:

- **Wireless Object Networks.** The connection between different sensors and actuators may require special purpose networks able to handle low throughput but with very high reliability and resilience. Wide area coverage, low consumption and low cost are some of the challenging research directions.
- **Ambient intelligence and smart spaces.** A very promising area is related to the management of great amount of data from different smart objects (sensors and actuators) and the capacity to handle massively distributed networked devices (based on RFID or similar technologies).

3. Internet of Services

The term service would include a broad variety of applications that will use communication infrastructures. Of particular importance, the concept of Software as a Service has to be analyzed and extended to include all capabilities related to cloud computing and cloud storage. The following elements may need further research:

- **Service Delivery Platforms.** The present concept of global Service delivery platform should go beyond the client service model to support mechanisms of global service supply where third parties, or even final users, will have the capability to create and aggregate services, publish and act as intermediaries for service delivery and provide new channels. In fact, Service Delivery Platforms should evolve to become Service Delivery Frameworks (SDF) and services should evolve to become Managed Services.

- **Next-Generation SOA.** The open platform will be extended to include SOA (Service Oriented Architecture) for value added services. Semantics is a very good tool to enhance service descriptions allowing automatic composition. EDA (Event Driven Architecture) and autonomic principles will complement the way processes can be orchestrated in SOA, creating sophisticated means for sensing and reacting to situations typical of compliance, logistics, infrastructure management or finance services. Last but not least, SOA will evolve so that interaction with the user will support all the features listed in "Internet of Users" section. This trend of incorporating new functionalities as required by the applications will lead to the new SOA/Web 3.0 that will include new features that have to be fully developed and used:

    - SOA for things
    - Indexing of internal applications
    - Semantic services
    - Automatic behavior

The above mentioned vast amount of information, coupled with the incorporation of data coming from the huge amount of sensors being deployed (the "sensor web") will preclude human processing; therefore at the application space, it is increasingly becoming a game of machine-to-machine communication. A great share of the future Web will consist of systems talking to systems, not to humans, but following user orders and criteria.

- **Semantics** is widely thought to be the "unifying glue" that will put together all the bits and create the overall intelligent interconnected network, hence the vision of the Semantic Web.

- **Cloud computing.** This area includes the virtualization of infrastructures through

more flexible and granular optimization of processing and storage resources. Those "on the net" resources shall also be used by enterprises, using on demand models, that would allow dynamic and intelligent accounting.

- **Autonomic computing.** Its ultimate aim is to create computer systems capable of self-management, to overcome the rapidly growing complexity of computing systems management, and to reduce the barrier that complexity poses to further growth.

4. Internet of the Network

This constitutes the basic element on top of which the previous "internet" shall be built. There are several elements to be considered:

- **Advanced radio interfaces and mobile solutions.** The convergence of future radio interfaces and the interdependency with fixed networks. This item also includes the evolution of Cognitive Radio toward Cognitive Networks, in which Cognitive Wireless Mesh Network (e.g. CogMesh) is considered as one of the enabling candidates aiming at realizing this paradigm change.

- **Advanced connectivity.** The objective is the connectivity everywhere, at anytime and unlimited capacity with quality of service control. This will include suitable connectivity at work, home, office, in the private and public domains, within public and private spaces.

- **Network control plane evolution.** The paradigm of self-learning networks is to be explored. This may include new routing schemes. Other areas related to network control include delay tolerant networks, storage networks, etc.

- **New service platforms.** Service platforms will have to enable automatic service discovery, description, composition and negotiation. They will have to handle service level agreements (SLA) and manage the required quality of services. They will have also to provide information related to billing and charging.

- **Re-configurability and cognitive communications.** Aimed at making a more flexible use of the available radio spectrum. Such policies often require devices to effectively identify spectrum opportunities (cognitive behavior) and, accordingly, seize such opportunities by tuning their radio transmission (re-configurability needs).

- **Development of energy-friendly networks.** This is motivated by two different facts. On the one hand, there is a wide consensus that networks should actively contribute to reduce the carbon footprint of the industrialized society. On the other, many devices to integrate the so-called Internet-of-Things will be severely constrained in what concerns energy consumption, computational complexity and storage capacity. In addition, a pervasive use of efficient Internet networks and services will have to assist to other sectors (transport, …) to reduce their own energy consumption.

- **Research on scalability issues** The number of devices and terminals in the FI is likely to increase by several orders of magnitude. These protocols (e.g. mobility, routing, addressing, etc) should be carefully designed in order to guarantee that their behavior scales well with the network size with the minimum additional investment.

- **Business convergence.** As indicated in the Internet of Services, the new network platforms will be, in some cases, open to third parties who shall be able to interact through open API (Application program interfaces) based on standard solutions.

- **Broadband devices and networks.** In order to cope with the unprecedented demand for higher data rates and the dramatic increase of the number of networked devices (i.e. Internet of Things), substantial research work is needed towards the design of truly broadband devices, in particular at the wireless access level, and towards the definition of networking protocols suitable for optical networks which are likely to be used at the core network level.

- **Satellite component.** Satellite communications have had a strong and continuous evolution, from the initial concept of an active repeater high in the sky, to become a complex key node interconnecting users, beams, services, etc., in a very intelligent and efficient way.In this sense, satellite systems are the perfect element to provide the **Ubiquity concept** and **Universal Access** to the Future Internet.

5. Cross-domain issues

Among the many questions that may be raised in the context of cross-domain research, the following issues have been identified as the most relevant:

- **Trust security and privacy.** Future Internet should be a secure and trustworthy internet. It includes many different working areas such as preventing illegal access to private content, hindering identity tampering, promoting collaborative security, guaranteeing digital identities, ensuring privacy and integrity in transactions and anonymity of access to contents and applications.

- **Resiliency and trustability.** Software is one of basic elements that is meant to evolve as part of this Future Internet evolution. Consequently, the sustainability and the success of the concepts conceived for the Future Internet rely on the resilient and trustable nature of the evolved software components.

- **Software quality and process improvement.** The quality gap between prototype approaches and commercial-off-the-self technologies must be bridged on time. Suitable methodological frameworks for software process realization will play a major role on meeting this requirement to ensure fruitful research outcomes.

- **Business models.** This area considers optimizing business objectives and includes dynamic pricing, billing and charging of internet services, models for automatic price determination, secure and fast mobile payments, real-time billing and charging, etc.

- **Green computing.** The need for optimized consumption and efficiency of future platforms is also a significant factor for new platform development. This part is also closely related to the infrastructure part as covered in the internet of the network

- **Rights management.** In a content growing environment with a convergence between "professional" and "amateur" content generators, IPR should be easily handled.

- **Governance for an open and neutrally accessible FI.** Internet governance must not be understood as any political agreement for Internet surveillance and control, but as a management of the Internet basic functions: addresses, protocols, domain names, etc… Hence, this is not a technological pillar but it is just necessary for a successful Internet use, and even for the co-existence of objects and their movement through the network. Some work is also expected in the challenge of net neutrality and its implications.

5.1. The strategy of experimental research

Together with the concept of Future Internet, it has appeared the need of experimentation network for Europe and beyond Europe. Any technological development affecting Future of Internet may have multifaceted and even unexpected consequences, at any technological, social or economic level. Therefore, new proposals for Internet architectures, protocols and services should not be limited to theoretical work, but also include early experimentation and testing in large-scale environments.

Besides the currently available means (e.g., GEANT system for Europe), all actions are oriented towards a structure of experimental testbeds, as FIRE, PANLAB, ONELAB, etc…, managed by European entities. These labs will allow to make tests with new protocols and services, as well as to generate solutions for new network architectures. As a result, it is convenient to grant the greatest possible relevance to the participation of RTD Future Internet infrastructures in these shared use projects, with the sponsoring of the European Commission, coordinated with initiatives in USA, GENI/FIND, and other countries.

These infrastructures must be prepared to test the advanced concept of Future Internet, and to validate new developments, concepts and services. As the CERN exists for research on advance physics, it is required a similar infrastructure regarding to the Future Internet, where all researchers could test there advances in an adapted and adaptable environment to the new paradigms.

6. Analysis of opportunities and mechanisms for implementation

6.1. Strategy

The area of the Future of Internet is considered to be a center topic, both for industry, research centers and Academia. It is therefore essential to put in place an adequate strategy that would assure that Spain is actively participating at European and Worldwide scales, exploiting those areas where Spanish companies have critical mass to assure a good position that will bring not only economical returns, but much more important new products and applications that will generate wealth and jobs.

This strategy must be underpinned by the Focus, Methodology, Differentiation and Dissemination pillars:

- **Focus:** due to the dimension of the problem space at hand, it is required to carefully select and prioritize the research topics to be pursued, so as to ensure the effectiveness of actions in those areas which already constitute a competitive position, or which bear the potential for developing leadership in the mid-long term. The strengths of existing businesses, the social and cultural characteristics of the country, the economic and educational structure, and other policies, such as sustainability, should serve as drivers in this focusing approach. In addition, this prioritization is needed to improve the efficiency and impact of the limited investment in R&D compared to those countries with higher R&D investments.

In that direction, the present Spanish industry outlook seems to be more focused towards service creation, both "within the network" and "using" the network. There is considerably less focus to the implementation and design of new devices and sensors. It is a "service oriented" sector. This means a strong focus towards the integration of media and electronic and the software part, always in relation to the network.

There are, at present, several major platforms relevant to the objective: eISI, eNEM, eMOV, eSEC, eVIA, INES and PROMETEO. Clearly, a more focused and integrated action will be required, and this is why the coordination effort of Es.Internet is necessary. Common (or at least coordinated) projects have to be defined and a more integrated agenda for the different platforms has to be designed.

- **Methodology:** "experimental" and "disruptive" approaches should be adopted, promoting cross-domain research among currently separated disciplines and convergence between the supply- and demand-side, and supporting the development, through cooperation, of an Advanced Service Sector. Experimental research will serve to demonstrate the viability of the proposed concepts and business models. Particular attention should be paid to the integration and alignment of research centres and academia to the future industry needs. Development of a Common Strategic Research Agenda of all the above Spanish

technology platforms is highly recommended.

- **Differentiation:** through recognition and differentiation of national achievements in a global interconnected context with other actors and technology poles, the movement around the Internet of the Future will serve to position our ICT hyper-sector in the global landscape and to connect it with other related international initiatives. This would require a specific effort from the different actors to find "activity niches" with clear agenda and expertise that would clarify the image. This could also be achieved through a regional approach, in a similar way as done in France though the regional "poles de competitivite".

- **Dissemination:** at international level, an adequate dissemination strategy will contribute to the acceptance, adaptation and reuse of Spanish technology. At national level, success stories can be the inspiration for other Spanish companies to achieve competitiveness through the use of the developed methodology. Also, focused/specific training for Spanish companies will help improving their competitiveness potential

- **International cooperation:** As complement to dissemination, international cooperation should be also promoted in those fields previously identified as strategic for Spanish industry. International cooperation in these fields will help Spanish industry to position internationally and lead these areas. Particular attention should be paid to foster cooperation with Latin American researchers.

6.2. Instruments and procedures

In terms of instruments, there are some doubts about the validity of the current JTI model. There are several reasons for that:

- The JTI may take some time before becoming a reality. In the ETP leaders meeting in September was clear that the Commission would not be proposing any new JTIs until after the mid-term review of FP7 and its instruments has been completed.

- The new European Parliament does not become active until quarter 3, 2009 meaning that we can only start building support for a possible JTI late next year.

- The division of the budget for Phase 3 of the ICT area of the Framework Programme will be completed by around quarter 1 of 2010, and it will probably be completed before the mid-term review is officially released. There is a timing problem to get a budget allocation in the ICT area Phase 3 budget of FP 7 (covering 2011 to 2013). Then we would be talking about a potential JTI in FP 8, starting in 2013 at the earliest.

- The financial and contract negotiations model used by Artemis is very unattractive from the industrial perspective. The conditions of FP 7 projects are much more attractive.

- Member states are limiting the funding in JTIs so that participants get to the same maximum as organizations would get in their own national programmes.

This means 30% or 35% funding in many countries and not the funding of close to 50% that we get in FP7 projects. They are not allowing the 16%. EU funding to be added to the 30 % national funding - they simply subtract the 16% from the normal national funding to keep down the maximum funding to the national level.

- The funding level in different countries does not correspond well to the requests of the consortium proposers.
- This means that in some countries the oversubscription level is 8 to 1 while in other countries it is 3 to 1. This means that many partners in proposals that were accepted by the JTI will receive no funding (in countries where there is high oversubscription) and will either have to drop out of the consortium, or work with the 16% funding provided by the European Commission, or fund the work internally from their organization. The end effect is that the consortium of a successful project is likely to be smaller than that originally proposed and parts of successful projects will have to be replanned. The whole negotiation process is very long in duration because of the need to consult the national authorities over which proposals they individually fund, after the JTI evaluation phase has ended.

Nonetheless, and once explained which are the main hurdles that the JTI model presents, it is necessary to remarks that a competitive tool/instrument should be made available.

Therefore, a specific new instrument should be made available in order to be able to recover from this situation. This new instrument should be dynamic and flexible enough to deal with current scenario in the Future Internet field. Particular aspects related to JTI structure that has been related before should be taken into account in the design of this new instrument.

It is also important to remark that different instruments can be necessary, since there are different scenarios in the short, mid and long term research. While long term research can be implemented through traditional FP7 tools, it may be necessary to create new instruments capable of offering an appropriate response for those areas identified as urgent-critical research areas.

Consequently:

- At European level, we see the launch of a new Action within FP7 work programme: "the Short-Medium term Future Internet Perspective", asking European Commission to identify possible additional funding available within the European Union budget period (2007 – 2013) and not constraining to FP7 current budget, but exploring other sources of funding, like Structural Funds.
- At Spanish level, including Ministries of innovation and Industry as well as Autonomous Communities research programmes, we see the need of promoting a specific "Spanish Strategic Action" within the Avanza R&D Programme, to ensure the accommodation of small and medium size R&D projects, complemented with a set of CENIT, TRACTOR, SINGULAR projects, bearing in mind a general coordinated approach, to ensure the Spanish Future Internet research impact is well covered.

7. Proposed Actions and Recommendations

7.1. Short Term

As a consequence of that, we propose to continue using and perfecting existing instruments to direct current research on FI, but considering that it may be still necessary to create better and more flexible instruments for the urgent and critical research areas, as well as for different R&D approaches, such as classical, cross-domain and experimentally-driven research.

INGENIO2010 and its instruments, such as CENIT and CONSOLIDER programmes, are providing very good tools to assure adequate industrial and Academia participation in preparatory and medium term activities. Those projects should be continued and promoted. The existing Spanish platforms, eISI; eNEM; eMOV; eSEC; eVIA, INES and PROMETEO are very good discussion fora and their recommendations and endorsement should be carefully taken into consideration. The participation in AVANZA R&D projects should be a first step to a larger European involvement (through Eureka and FP7 actions).

es.internet actors recommend the following actions:

1. Spanish instruments should promote more and larger Spanish consortiums around focused research nation-wide programmes to assure global impact and, at the same time, to facilitate the access to other research funding sources such as FP7.

2. Existing pan European collaboration instruments besides FP7, essentially Eureka, must be promoted and enhanced. Particular attention should be paid to CELTIC and ITEA2 Clusters. It is recommended to make an effort in order to assure greater participation of Spanish industries in those programmes. A good possibility would be the adoption of rules similar to those of Eurostar program in those clusters. That approach may assure a greater collaboration and a more effective scheme for medium term projects and, properly managed, could be even more effective than JTI. It would also allow greater strategic control from the Spanish authorities and greater efficiency.

3. National activities around FI should be promoted and disseminated to assure the active participation, involvement and cooperation of Spanish actors, both enterprises and academia, in existing ETP, particularly NESSI, NEM, e-Mobility and ISI, and to contribute in the development of dynamic road-maps for specific Spanish challenges.

4. A set of measures are required to facilitate the development of qualified skills, the attraction of talent and the enhancement of training programmes with regards of FI.

7.2. Long Term

In the long term, measures should be taken in order to make existing or new Spanish ICT related firms more powerful and to foster the creation of new business and market niches by:

1. Ensuring coherence of action and avoid fragmentation of efforts thus gaining economies of scale that allows the Spanish companies having a sound competitive position in the Internet field.

2. Promoting the collaboration between industry and academic actors for ensuring better planning, timing and alignment of the current value chains, with special focus on SMEs, who could benefit of the "tractor" effect generated by bigger corporations as well.

3. Guaranteeing continued funding from the public administration which might allow a long-term investment in R+D+i activities by the firms, thus reducing the associated risks. An intelligent combination of all kind of funding/investment might leverage the effect on the creation of innovative service around Internet.

4. Raising awareness of the importance of the development of Internet among people by showing the applicability of the net in many social services which might greatly enhance their quality of life.

5. Improving the regulatory framework, and policies that promote innovation and investment.

6. Ensuring interoperability of systems, terminals and networks by facilitating the standardization work.

7. Promoting internationalization of Spanish industry through the participation in international R&D programmes.

The development of these recommendations will serve to create a "momentum" in the Spanish ICT super-sector around a first priority theme, the Future Internet, by building a solid knowledge base, able to position Spanish actors in the international context and to anticipate them to take full advantage of the economic opportunities that this development will bring about.

7.3. Expected impact

It is foreseen the R&D efforts devoted to put in place the Future Internet will bring benefits in increasing European productivity and competitiveness along with a more social and territorial cohesion by means of reducing the digital divide.

In terms of economical benefits from the achievement of the technological objectives the following could be cited:

- A more focused research, with a set of balanced and well-defined areas, will avoid the current fragmentation of efforts; thus reducing the cost of innovation and the increasing likehood of achieving the pursued aimds
- The cooperation among industry, academia and SME might provide the necessary scale to cope with great project whose ambition and complexity cannot be carried out by individual entities.
- The focus and efficiency gained will reduce, in general terms, the development lifecycles, and specifically the product and service time to market.
- Contributing to the creation of more and better jobs, characterized for the requirement of qualified skills that could be disseminated all over the enterprises and academia.

- Common technologies developed under the umbrella of Future Internet can be applied to the dairy working methods of the organizations, thus obtaining productivity gains. Possibility of transferring technologies across multiple sectors thus harnessing of the Future Internet research in a variety of cross-environments.
- More efficient R&D spending by public authorities as those supported project will be well oriented towards a common objective and goal.
- Leverage effect of the private-public partnership investment in the innovation process as well as the mobilizing of further resources.
- Real creation of a digital economy based on the knowledge.
- Unification of markets, dismantling artificial barriers that could provide scale to have better performance as well.

An impact assessment to quantify these advantages must be performed, in parallel to the proper technological process of research and development, to adjust and maximize, in monetary terms, these capabilities.

In respect to the social benefits, the followings might be mentioned:

- The products and services derived from this area have clearly a potential to help Europe challenges either social (such as aging, security, safety and welfare etc.) or economical (loss of enterprises competitiveness, low productivity etc.)
- Capability to increase social and territorial cohesion by means of e-Inclusion.
- Chances to enhance people quality of life
- Potential benefits in education, relations among people and the administration, training etc.

8. Analysis of Focus Areas / Programmes

The main purpose of the definition of a set of common Research Programmes / Scenarios is to maximize the impact of the R&D investment taking into account the structure and potential of the Spanish ICT sector, both for the business and academic actors. Potential funding instruments should focus on these common objectives.

The analysis is performed following a three step approach.

1. A number of possible technologies (as indicated in the vision part) are briefly described.

2. A list of selection criteria are proposed

3. As a consequence, a selection of technologies, to be proposed for specific action in different programs are obtained

8.1. Program proposal

Internet of Users and Knowledge

- Program: Web 3.0 / Next-generation Web Front Ends

The main goal of this program is to research and develop advanced web technologies that will support interaction of users with the future internet of services and contents. Technologies enabling modeling, capture and management of context (which not only comprises delivery context and location, but information about user profile and social networks) will support full context-awareness during interaction. Users have to be fully empowered as to be able to configure their personalized access to contents/services as well as share both knowledge and new content/services they generate on their own, becoming prosumers (i.e., not only consumers but producers of both contents and services). It should be stressed that, accessibility and e-Inclusion aspects turn out to be a key problem to be addressed within the scope of this program.

- Program: Web 3.0 / Semantic Web

The main goal of this program is to create and implement new tools that will allow breaking the barriers and boundaries between information producer and information consumer. Both structured data and even unstructured or semi-structured content such as Web pages or documents will be widely available in RDF and OWL semantic formats.

Moreover, intelligent applications such as natural language processing or machine learning will support the vision of Intelligent Web.

Internet of Content

- Program : 3D communication

This program will aim at developing 3D environments where contents will be interactive, reactive and intelligent. It means that they will have independent behavior with the environment, with other elements and even with end users. Concepts like user-centric, immersive and sensory experiences are strongly related to 3D environments and other topics like ubiquitous, ambient and context-sensitive, personalized and customized specify the characteristics of such environments.

- Program : Search engines

This programme will work on providing access by advanced search means and interact with multimedia content that can be created and manipulated by professionals and non-professionals, and will be distributed and shared everywhere on any terminal. Standard technologies that allow semantic annotation, indexing and retrieval of contents in an automatic or semiautomatic way will be key within this program. Recommendation systems that provide relevance feedback will also be crucial for the personalization of multimedia networked search.

Internet of Things

- Program: Global Standard for Objects Communication.

The main goal is to build a global standard for wireless object (sensor & actuator) networks in a similar way that was done with GSM regarding personal communication: from operator-less systems to mixed operator / operator-less structures able to provide nation (and beyond) wide coverage, capilarity and the required QoS in terms of throughput, reliability, robustness, etc.

- Program: Connected Car & Road

The main goal is to achieve efficient, cooperative vehicle-vehicle and vehicle-road infrastructure systems. This program will encompass two activities: the networking of surface transportation vehicles for safety and efficiency purposes, commonly known as cooperative safety and relying on vehicle-to-vehicle communications (V2V), and the design and development of communication infrastructures for road transport, both along the roads and in the management infrastructure, including the operator networks (i.e., cellular, core), which are enabled with communication- and service-related capabilities. These infrastructures relay on vehicle-to-roadside (V2R) and vehicle-to-infrastructure communications (V2I), sometimes generically grouped into V2I for simplicity. These connected cars and connected roads will require stringent quality of service for most of the applications, especially in terms of performance (latency, throughput and availability), reliability and security/trust, and notably for quality-critical applications (e.g., safety). In the long term, these two activities will set the grounds towards automatic transport managed

road systems.

- Program: The Internet of Things for improved business productivity and energy efficiency

This research program will explore application scenarios where a network of tiny devices and actuators (the so-called IoT) might lead to increased productivity levels in current business (logistics, retailers, etc) and reduced energy consumption (e.g through accurate natural resource monitoring and supervision). Whereas the business application scenario has received some attention over the last years, energy efficiency aspects have recently emerged as a priority focus at the EC level, where ICT technologies have been called to play a leading role in attaining the reduction of a 20% of the green-house gas emissions by year 2020. This program is by definition transversal in that it encompasses activities on physical devices and technologies (sensors, RFID tags, etc), network protocols (multiple access, routing, etc), application and services, etc.

Internet of Services

- Program/scenario : Innovative Mobile Service Platforms.

The main goal is to build business scenarios based on innovative mobile service platforms: mobile super prosumers, mobile service front-ends, searching and recommendation engines for distributed, mobile service platforms (both for services and contents), real time collaborative service provisioning (including full digital lifestyle), etc. It may also include issues related to advertising

- Program/Scenario: e-health and Home applications

This line will explore the use of advanced service process orchestration as well as 3D user interface technologies at home and scenarios related to health. It will include all aspects related to terminals, transmission technologies and user behavior

- Program: Evolution of Service Oriented Architectures

This program includes the development of new technologies which lead to evolution of Service Oriented Architectures (SOA). Main aspects of this evolution have to do with integration of backend services with web front-end architectures (see programs related to Internet of Users) as well as the introduction of new techniques for service orchestration, applying both autonomic and event-driven principles. Results will be applicable to both Service Delivery Platforms and Business/Operation Support Systems at companies.

- Program: Cloud services

Cloud services refer to the virtualization of processing and storage resources, providing application the necessary runtime support to be provided "as a Service" under certain SLA constraints and with no limitations of scale in terms of number of accesses. This support will be offered in a cost-effective manner, enabling flexible on-demand provisioning as well as flexible charging and billing models.

Internet of Networks

- Program Scenario: Advanced Radio interfaces

This program will analyze future radio interfaces able to high capacity networks, including the interaction and interdependability to the fixed network. It will also include re-configurability and cognitive radio solutions and spectrum efficiency and re-use

- Program Scenario: Advanced fiber connectivity

This program will focus on economic solutions for fiber optic deployment that will facilitate the introduction of internet at all levels

- Program Scenario. Trust security and dependability on the network

Including all areas related to preventing illegal access to content, collaborative security, digital identities, etc.

- Program Scenario. Nobel architectural solutions including new control plane evolution

Analyze new internet architectures that could solve the saturation problem in Internet. Also evolutionary approaches shall be analyzed

- Program scenario : Broadband Commodities

The main goal is evolve the value chain of current telecom operators wholesale business model. The idea behind would be to let service providers buy and sell connectivity resources on demand and real-time (broadband commodities), enabling service creation as simple and fast as possible.

Cross-pillar programme: Internet-based System of Systems

In a great variety of IT-intensive sectors, systems do not work anymore in isolation. They constitute systems of systems that work collaboratively forming eco-systems to achieve common missions. Examples of such systems of systems include:

- Health systems, including systems from social security, hospitals, pharmacies, ambulances, etc. that must work together to provide a service to a person the suffered an accident.
- Air transportation systems, including reservation, ticket issuing, travel planning, luggage management, airport services, etc. to ensure that an efficient transportation service is offered.
- Car navigation systems, including traffic information services, route planning, GPS, entertainment systems, motorway services, etc. to provide effective breakdown service on road.
- Enterprise systems, including resource planning, purchasing systems, customer management systems, etc. that need to accomplish a business process.

In each of these cases, we find **the collaboration of autonomous systems to accomplish a mission in a changing environment**. This is a field in which the Future Internet will play a key role as a vehicle for enabling **Internet-based Systems of Systems**. The distinguishing characteristics of Internet-based Systems of Systems are:

- There is **no central authority** that controls the overall system of systems. This has important consequences in the development and evolution of these systems, since it cannot be mandated as the vision of one single party, but it must accommodate the independent evolution of autonomous elements.
- The **boundaries are unknown** or not clearly defined. The participant systems may dynamically come in or leave and the overall behaviors must accommodate to this changing situation.
- There may be latent **incompatibilities or emergent behaviors** not initially anticipated as a consequence of lack of shared semantics.

Internet-based system of systems is a rapidly growing area with a very high economic potential. It will constitute the canonical way of building systems in the future out of existing elements, based on a philosophy of build-as-you-go rather than planning everything up-front.

Internet-based system of systems poses new research challenges that span over the different pillars of Future Internet. It requires a new set of skills, technologies and practices; the definition of new frameworks and infrastructures with more flexible methods and processes. Some of these topics are identified as follows:

- Internet of Things

  Networks of sensors and actuators that enable the identification of changes in the context.

- Internet of Users/Knowledge/Content

  User-based and role-based profiling. Context awareness. Privacy. Identification.

- Internet of Services

  Service modeling: standards for modeling functional and non functional features, semantics, quality of service, explicit security features.

  Virtualized resources

  Virtualized services: high level management services in which technology converge

  Predictable service quality levels. SixSigma service delivery. Context awareness

  Self-awareness: reflective properties providing a self-conscious net that is capable of transforming itself through learning.

  Dynamic quality of service negotiation according to stakeholders' policies.

- Internet of Networks

Advanced interconnection involving ubiquity and continuity.

- Cross Domain topics

  Building trust is systems: trust modeling

  Adaptive security support

  Identity management

  Security needs specified explicitly in business processes and ensured by design

  Make security observable

  Resilient internet: ensuring business continuity in the presence of failures

  Bridging the gap between business processes and IT infrastructure

8.2. Program analysis

This section outlines a number of possible elements to be considered for the filtering of Programmes / scenarios.

- **Attractiveness**

  1. Technological leadership. Novelty
  2. Technological impact on the architectural design of the Future Internet.
  3. Social impact
  4. High return
  5. Transversality

- **Factibility**

  1. Favorable environment
  2. Techno scientific knowledge either currently available (in companies, universities and research centers) or needed in the years to come for a better positioning at the international level

9. Index of figures