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COAST

D2.1 - Service Requirements Specification

Author(s): P. Plaza, J.L. Gonzalez, V. Cruz (TID), L. Celetto, E. Quacchio (STM), Th. Zahariadis, A. Brokalakis, I. Koufoudakis, M. Perdikeas, A. Platskos (Synelixis), F. Junqueira, I. Kelly (Yahoo), A. Wolisz, S. Rein (TUB), T. Schierl, K. Grüneberg (HHI), S. Niccolini (NEC), B. B. Cambazoglu, M. Serafini (BM), G. Pau (UCLA)

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Abstract:

This deliverable contains the requirements specification for the services to be delivered by the COAST framework. The requirements have been obtained through the analysis of the needs of the different stakeholders and the definition of service scenarios. Additionally, the business perspectives are analyzed and the resulting business models are draftly introduced.

Disclaimer

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1	ST Microelectronics	STM	Co-ordinator	Italy
2	Synelixis Solutions Ltd	Synelixis	Contractor	Greece
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05/6/2011	7.1	TID	Revisiosns
05/6/2011	FF2	Synelxiis	Fixing version

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Abbreviations

ADSL	Asymmetrical Digital Subscriber Line
ALTO	Application Layer Traffic Optimization
API	Application Programming Interface
CF	COAST Core Functionality
CS	COAST Core Service
DTV	Digital Television
DPI	Deep Packet Inspection
FCCN	Future Content-Centric Network
FCDN	Future Content-Delivery Network
FTTH	Fiber To The Home
GPS	Global Positioning System
HD	High Definition
HTTP	Hyper-Text Transfer Protocol
HTTPS	HTTP Secure
IPTV	Television over IP
ISP	Internet Service Provider
LAN	Local Area Network
MDC	Multi-Description Coding
MVC	Multi-view Video Coding
NAM	Network Aware Module
P2P	Peer to peer
PDA	Personal Digital Assistant
PQoS	Perceived Quality of Service
QoS	Quality of Service
R&D	Research & Development
RG	Residential Gateway
SaaS	Software as a Service
SD	Standard Definition
SLA	Service Level Agreement
SME	Small and Medium Enterprises
SSL	Secure Socket Layer
STB	Set Top Box
SOA	Service Oriented Architecture
SVC	Scalable Video Coding
MVC	Multi-view Video Coding
MTBF	Mean Time Between Failures
MTR	Mean Time to Repair
MTTR	Mean time to recovery
TAT	Turn-Around Time
TAM	Terminal Aware Module
URL	Universal Resource Locator
VoD	Video on Demand

VPN	Virtual Private Network
WAN	Wide Area Network
WP	Work Package
WSDL	Web Service Definition Language

Executive Summary

While the current Internet architecture is designed based on the client-server communication paradigm, the Future Media Internet is expected to be dominated by content-oriented traffic. The inconsistency between the Internet design and the real usage is expected to increase further, as the Future Internet is envisaged to provide the means to share and distribute (new) multimedia business and user-centric services, with superior quality and striking flexibility from everyone to everyone. In consequence, it is necessary to redesign the Future Internet based on a content-centric paradigm to provide data/content to the users in an efficient manner.

The COAST project aims to build Future Content-Centric Network (FCCN) overlay architecture able to intelligently and efficiently link billions of content sources to billions of content consumers and offer fast content-aware retrieval, delivery and streaming, while meeting network-wide Service Level Agreements (SLAs) in content and services consumption. This will be achieved by combining intelligent network caching, searching and network, terminal and user context awareness.

In short, we may specify the COAST functionality as a FCCN that:

a) will find where the content resides and

b) identify/analyse what content and traffic is flowing through the network routers,

c) replicate and cache the content efficiently at the "*best*" place in the network,

d) dynamically identify what is the "*best*" host/cache and the end-to-end path (in terms of both efficiency and network-friendliness) for content delivery and streaming to a user, and

e) provide the "*best*" Perceived Quality of Service (PQoS) to the user by interactively adapting the content based on the user and the terminal capabilities, requirements and context.

This functionality will accelerate or enable innovative services like network aware searching, context aware/personalised/interactive (3D) Video on Demand, network friendly TV or live events with enhanced PQoS, efficient user generated content sharing and IP application (including SOA applications and web-site) acceleration.

The need and the benefit of such services, along with the methodology that led us to these conclusions are explained in details in this deliverable. Moreover, we give some insights on the system design that will lead to the realisation of these services.

1. Introduction

While the current Internet architecture is designed based on the client-server communication paradigm, the Future Media and 3D Internet is expected to be dominated by content-oriented traffic. A recent report [1] shows that most of the Internet traffic is characterized as P2P traffic, which does not conform to the client-server paradigm and generates unnecessary indirection overheads when users try to retrieve the desired data. The inconsistency between the Internet design and the real usage is expected to be further increased, as the Future Internet is envisaged to provide the means to share and distribute (new) multimedia business and user-centric services, with superior quality and striking flexibility from everyone to everyone. In consequence, it is necessary to redesign the Future Internet based on a content-centric paradigm to provide data/content to the users in an efficient manner.

In the foreseen "Future Internet" age, where everyone may be a content producer, manager/mediator and consumer, COAST aims to build a Future Content-Centric Network (FCCN) overlay architecture able to intelligently and efficiently link billions of content sources to billions of content consumers, and offer fast content-aware retrieval, delivery and streaming, while meeting network-wide Service Level Agreements (SLAs) in content and services consumption. In short, COAST is expected to deliver an FCCN overlay network, **where the users will just specify which content or service they need, and the COAST framework will find the desired or the most relevant data and forward it to the users in an efficient, timely and network-friendly way**.

In order to better explain COAST's content delivery approach, let's start by reviewing how content discovery, retrieval and delivery take place in today's Internet and where COAST is innovating. Today, the vast majority of Internet usage is data retrieval, data delivery and streaming and Web services access, where the user cares about content and is oblivious to their location. **That is, the user knows that he/she wants news from CNN, videos from YouTube or weather information regarding a place that he plans to visit from the weather service of Yahoo, but does not know or care on which host the desired data or service reside.** This host may be around the corner or at the other side of the planet. What the user really cares about is the accuracy and reliability of the content and the quality that this service is provided. On the other hand, the service and network providers/telecom operators care about improving their added valued services (e.g. better QoS, faster response to a request, increased reliability, better/adapted streaming quality) and increasing their profit by increasing their customer base and lowering their (administrative, management, infrastructure) costs.

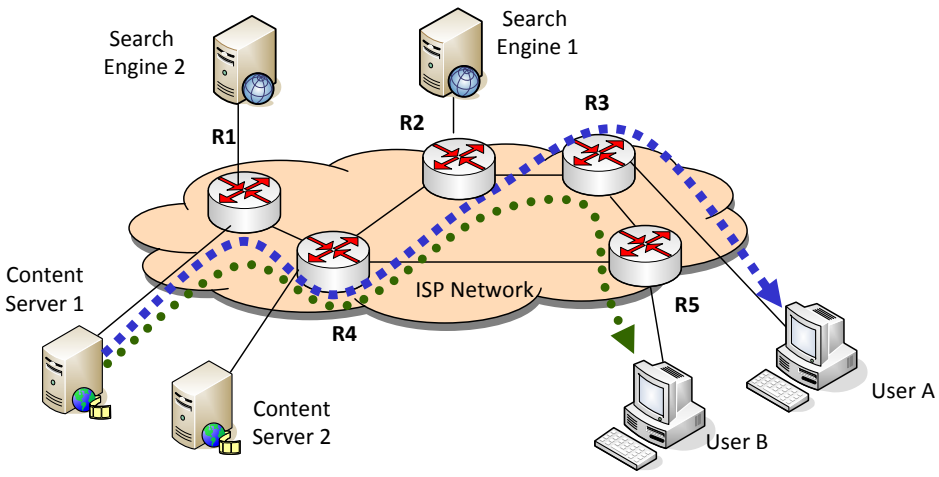

Figure 1: Today's Network Architecture, Content Discovery, Retrieval and Streaming

Now, let's assume that 10,000 users get a link from a social network that recommends them a new video at YouTube. This would results 10,000 people hitting YouTube at the same time for the same content, and that's being shipped 10,000 different times. COAST aims to follow a content-centric

networking approach, and build intelligence in the network in such a way that would allow the most accessible route to the content to be achieved. This would allow higher performance by more closely associating the need of the individual user with specific content. The user would not go back to YouTube for the same content, but would go to where it resides cached on the network.

In order to better explain what COAST aims to offer and how we will achieve it, let's review Figure 1. The figure shows how content retrieval and streaming is realized today. The network consists of:

a) *Content Servers* or *Content Caches* (either professional or user generated content and services),

b) Centralised or clustered *Search Engines*,

c) Core and edge *Routers* and optionally *Residential Gateways* (represented as R1 to R5) and

d) Users connected via fixed, wireless or mobile terminals.

The initial step is ***Content Discovery by the Search Engines***: the Search Engines crawl the Internet to find, classify and index content or services. Alternatively, users may publish content and manually inform the search engine. The second step is ***Content Discovery by the User***: the user queries a Search Engine and gets, as feedback, a number of URLs, where the content is stored. The last step is ***Content Delivery/Streaming***: the user selects a URL and the content is delivered or streamed to him.

In the above scenario, if both User A (UA) and User B (UB) ask for the same content to the same Search Engine, they will both get as an answer that the content is stored at Content Server 1 (CS1). Then the content will be delivered via the routers' (Rx) path: for example CS1-R1-R4-R2-R3-UA and CS1-R1-R4-R2-R3-R5-UB respectively. Yet, all three steps of content discovery and delivery can be significantly improved:

- If the ***content could be stored/cached closer to the end users***, not only at the end-points as local proxies, but transparently in the network (routers, servers, nodes, data centres) then content delivery would have been much more efficient.
- If the ***routers could identify/analyse what content is flowing through them*** and are able to ***replicate*** it efficiently, the search engines (supported by additional mechanisms/network overlays) would gain much better knowledge of (even the streaming) content location and other features such as popularity, and provide enhanced information (even on "live" video streams).
- If the ***network could dynamically identify what is the best end-to-end path*** (less congestion, lower delay, more bandwidth), it would have provided a better way to deliver the data. For example the path R2-R4-R5-UB may be much better than R2-R3-R5-UB.
- If the ***content could be interactively adapted***, not only statically based on the network and terminal capabilities, but also based on the interactive content selection by the user (e.g. instantly changing the point of view, zoom-in/zoom-out at a streaming session), the user experience would be much better.

In short, we may specify the COAST functionality as a FCCN that:

a) will find where the content resides,

b) identify/analyse what content and traffic is flowing through the network routers,

c) replicate and cache the content efficiently at the "*best*" place in the network,

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e) provide the "*best*" Perceived Quality of Service (PQoS) to the user by interactively adapting the content based on the user and the terminal capabilities, requirements and context.

The benefits of the realisation of the above services are very important:

- The ***end-user*** will benefit from simpler services, faster content delivery/smaller start-up time, new features (e.g. service adaptation, personalisation and interactivity) leading to better PQoS.
- The ***Service Provider*** will benefit from lower start-up and operational costs, enhanced scalability & availability with smaller equipment investments, faster IP connectivity, new added-valued services.
- The ***Telecom Operator/ISP/Network provider*** will benefit from the lower infrastructure costs, the new business and the new added-valued services that may offer.

1.1. Definitions/Clarifications

In many cases, a number of terms are used by different research communities and stakeholders with different meaning. In order to avoid confusion, we provide in this section some clarifications:

- **Searching (for what).** This is the common definition of the word "searching" from the users' point of view. A user visits a Search Engine (or in an even broader sense a database) and makes a query, which contains a number of criteria (e.g. name, type, date, …). The system performs a "searching" on the metadata and indexes that has already prepared and returns links to the components/objects that better mach the criteria set by the user. For example, I am looking for a video film with Angelina Jolie and Johnny Depp and the system (may?) return to me the film "Tourist". COAST targets distributed searching (for what) using a number of techniques (described in details in WP3), but this is not the only focus of the project.
- **Searching/Crawling.** This is another definition of the word "searching", which is commonly replaced for clarity by the word "crawling". The Search Engine searches for new content by crawling to the various web sites following every known hyperlink. Within COAST, this is also called "active crawling". Additionally to active crawling, COAST also supports "passive crawling" via Deep Packet Inspect (DPI). Content/services active/passive crawling together with publishing is the methods considered in COAST for informing the search engine for new content.
- **Searching (for where).** This is an alternative definition of the word "searching" from the COAST point of view. In this case, the user already knows the content that s/he wants to watch/ download, and the COAST system is searching for the "best" location that the content (as a unity or in the form of parts/segments) is located. For example, searching for the "Tourist" from my iPod (where also my profile is stored), the system should return the location where the "Tourist" film in low resolution and black&white (because this is the info stored in my profile) is stored or cached.

  It is worth to note that this kind of "searching" may not be done by the Search Engine per se but by other components of the COAST network architecture. A typical example would involve the use of the COAST Entry Points (CEPs) for that purpose as described in [21].

Within COAST we also use the words "Content Storing" and "Content Caching":

- **Content Storing** is the process of permanent copying a content file as a unity. Following the previous example, the system may store the complete film "Tourist" in one server per involved city.
- **Content Caching** is the process of temporary copying a content file or a segment/part of the file to a system cache. Following the previous example, the system may cache the complete film "Tourist" or various segments of the file on multiple locations. The time period that the file cache segments will remain valid may depend on the content age, popularity, size and network architecture.

COAST supports both content storing and caching, though emphasis is mainly given to content caching.

1.2. Document structure

The purpose of the document is to specify the service requirements to be taken into account by the technical workpackages of the COAST project in order to design the elements and functionality of the FCCN. The document is structured as follows:

1. ***Analysis of user needs and market trends.*** The success of COAST depends on providing the right set of functionalities and services to meet the market demand. In order to ensure this in Chapter 2 we analyse the market trends, and the technological environment which COAST must face. We also consider the needs and expectations of the users and other stakeholders regarding content access and delivery.
2. ***Definition of service scenarios.*** In Chapter 3 we present a number of scenarios showing some possible ways of use of the COAST framework. The scenarios cover all the functionalities to be addressed by COAST as well as identify the relevant stakeholders.
3. ***Definition of the COAST core functionalities and core services.*** Taking into account the information from Chapter 2 and the scenarios from Chapter 3, the core functionalities and core services to be provided by the COAST framework are defined.
4. ***Definition of the service requirements.*** The requirements of the COAST core functionalities are defined in Chapter 5. Both functional and non-functional aspects are considered.
5. ***Analysis of business aspects.*** In Chapter 6 we introduce a preliminary analysis of the business aspects regarding COAST and its stakeholders. This analysis will be further expanded in WP 8.
6. ***Conclusion.*** Concluding specification remarks.

As compared to the first version of the document, this version additionally includes:

- §1.1 “Definitions/Clarifications”, which provides a definition/clarification of the words searching and storing/caching
- § 2.1.4. “Content/Service Consumption SLAs”, which clarifies the term service level agreement (SLA) in the context of COAST, and gives some examples for SLA metrics and SLAs associated with COAST (Backbone Internet providers, Web service level agreement Cloud computing SLAs).
- Chapter 3 “COAST Service Scenarios” has been modified in order to include more details on the SLAs (where ever applicable) in the service scenarios analysis.
- Core Functions CF1 and CF4 have been extended to clearly include the SLA monitoring, negotiation and enforcement functionality.
- Various typos and missing figures have been corrected.

2. Analysis of the User Needs and Interests

In order to extract the service requirements, COAST has applied a methodology based on the innovation process defined by Synectics [2], a company from the French group Altran. This methodology is geared towards modifying innovation processes to take into account the user perspective early, before the service design phase. A close look to the user and market trends is given a very special attention. The main goal is to design services that are needed by the society (customers) and not to design a service and then see if it matches what the user really needs, as often happens.

As a preliminary work, the first 3 phases sketched on the figure below, with a focus on residential users and the Digital Home were analyzed. The end result of this analysis was the definition and extraction of user insights. These and other additional insights based on project partners' experience were further analyzed in order to extract service requirements. Insights considered are related to searching and retrieval trends, network architecture design, content adaptation, network awareness and network overlays and streaming.

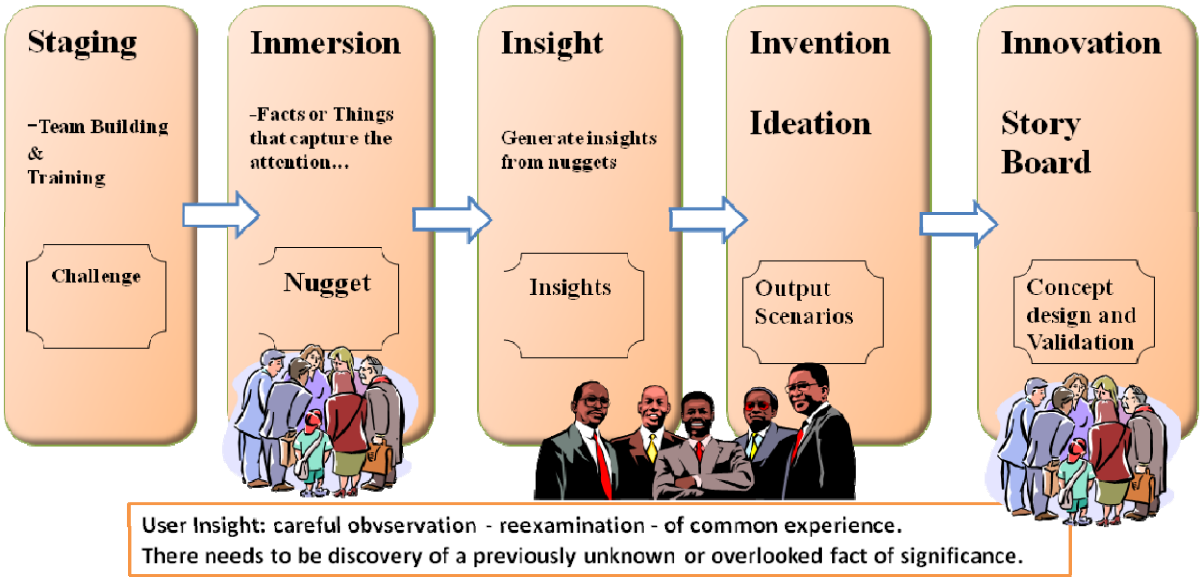

Figure 2: Synectics Innovation Methodology applied in WP2

In this deliverable, we have taken up these inputs and applied the invention process and the innovation process. In WP2, the innovation process is tackled by defining possible scenarios from which the services and their corresponding requirements are listed in this document. These requirements will lead to system specifications, which will be realised in WP3-WP6.

In WP7, the story board process will be taken over, in order to design a concrete concept from the drafted scenarios and implement the services first as mock-ups that will be evaluated with the help of the user experience design team at operators (e.g., Telefonica).

In the latter process, real users will take a very important role. Once the mock-ups are validated, we will proceed with the prototyping and further feedback process. The methodology that will be employed in WP7 is sketched in Figure 3.

However, COAST also aims to provide services that directly tackle the needs of the service provider, the network provider and the enterprise markets. These services are mainly considered as improvements to existing services, in order to meet new efficiency criteria. Descriptions of these services are directly provided based on the partners' experience.

In the following section, we describe the social and the consumer trends as they were analysed during the evaluation process. From these trends, we extract the user insight, which are later mapped into COAST technological scope.

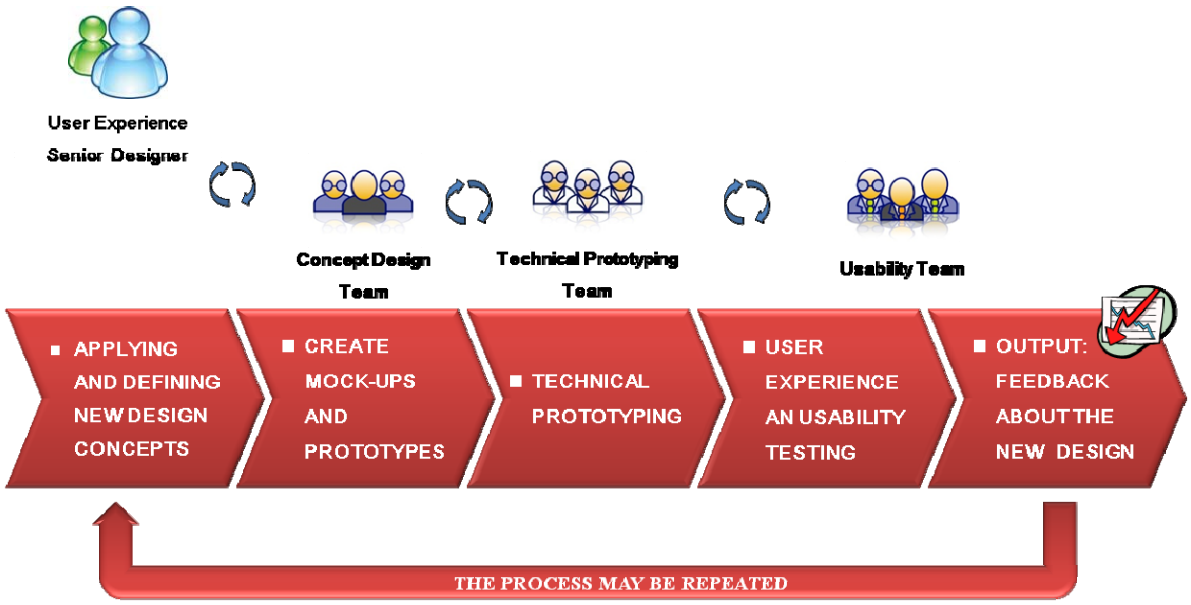

Figure 3: User Experience Service Design Methodology

2.1. User Trends

We are dividing the user trends in two groups, in a) *general social trends*, related to the technology, and in b) *customer trends* related to the user habits.

2.1.1. General Social Trends

Cities are growing, populations are expanding and homes are getting smaller and less private. Based on a rather recent market study, by 2030, developing countries alone will need to build the equivalent of a city of 1 million people every 5 days to accommodate them, while by 2050, an estimated 80% of the world's population will reside in cities. And while people are spending less time in their home, they are demanding more from it. It is important to highlight that for residential users the computer and the mobile phone are now becoming the focal point in most families nowadays. As it is shown in Figure 4 the result of a poll carried by Telefonica all around the world to a selected number of interviewees (28-35 Years old) the user technological focus at home is by far the computer (44%) followed by the mobile phone (31%), leaving well behind the white and brown goods. It must be noticed that TV was not considered as an option in this polling. The objective was to get an insight of what type of technology represents an opportunity for the future.

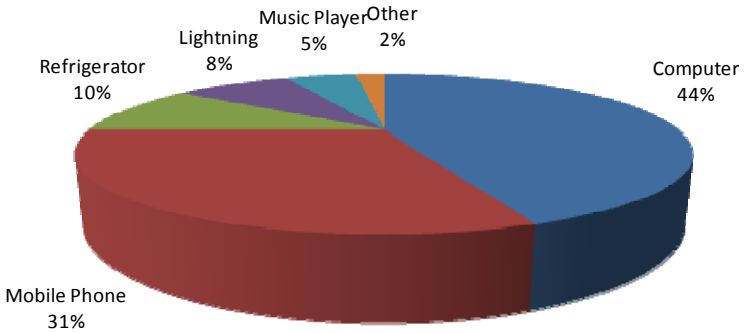

Figure 4: User technological focus at home[1]

[1] Teleconica, Mole Poll, 2009

Focusing just on content search, there are already a number of factors that clearly show the great potential of search frameworks for large audiovisual content. First of all, the IP content stored in home systems is growing exponentially. As it is shown in Figure 5, the percentage of users/subscribers having IP-content (personal or commercial available) has already reached 16% by 2009. The trend indicates that this with continue to increase rapidly.

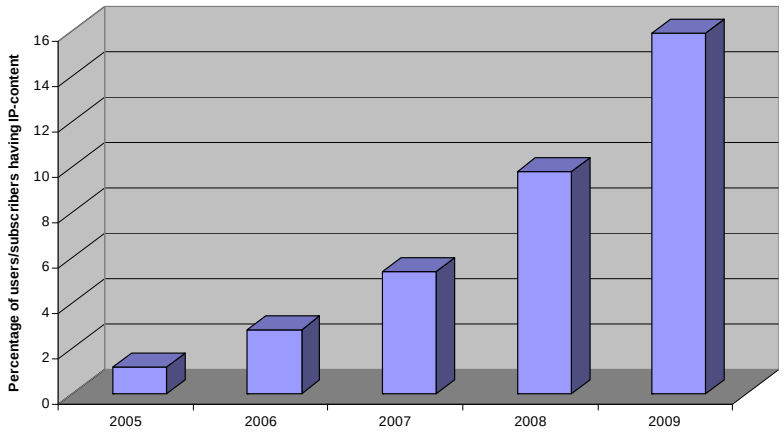

Figure 5: Grown of IP-based Content

Moreover, the type of the stored content is also very important to define the future services and applications. As it is shown in Figure 6, digital pictures are available in the vast majority of home/personal storage devices, followed by music[2]. Yet, personal videos and movies even today result in a significant percentage (26% and 17% respectively).

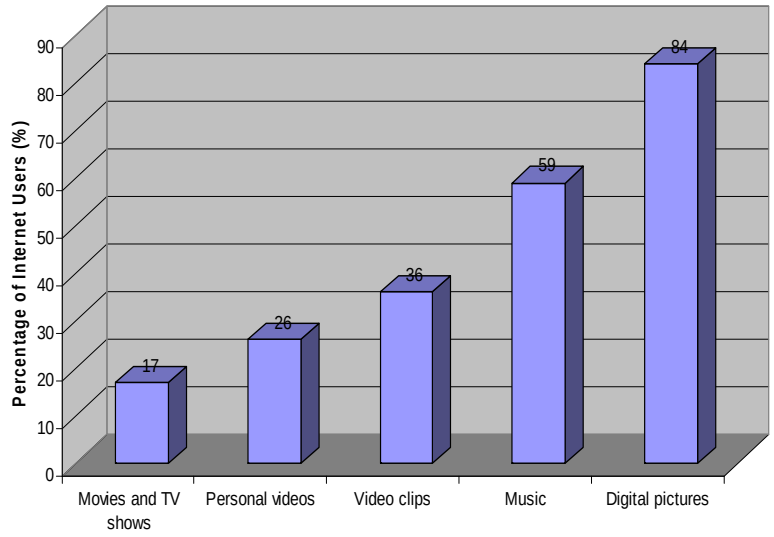

Figure 6: Digital Content on Home Computers

It is also important to see how digital content production has evolved. As shown in Figure 7, in 2006, digital content, produced by either professional or amateur users, reached the capacity of 160 exabytes, while it is expected that by 2010 it will reach the capacity of 990 exabytes, a 6 fold increase[3]. In 2011, the amount of digital information produced in the year will be almost 10 times that produced in 2006.

[2] PARKS ASSOCIATES, "Profile of PC Usage, a survey of 2682 PC Users with Internet", 2007

[3] IDC consultancy report,"The expanding Digital Universe" March 2007

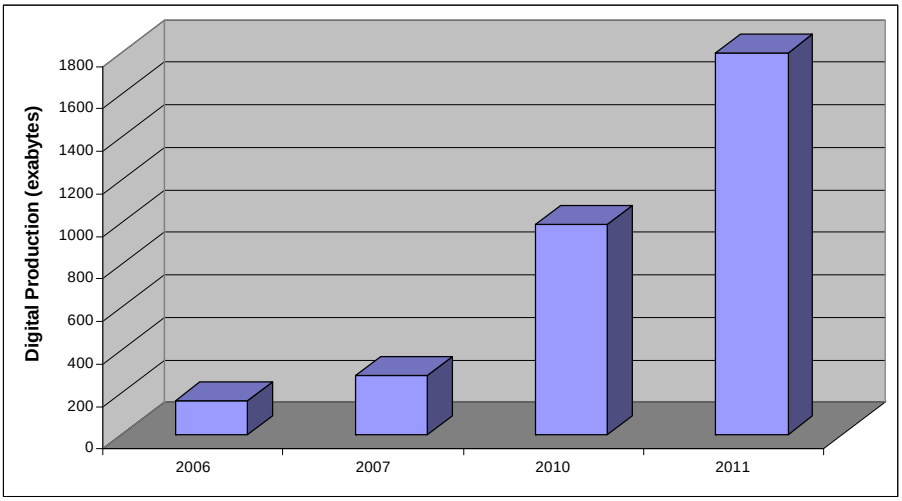

Figure 7: Audiovisual Content Production (professional or amateur)

In parallel, the user habits start to change. Social networking sites have become a global phenomenon since the number of users who are members to them are increasing rapidly. It is estimated that there are more than 1 billion subscribers in social networking websites world wide, more than 154 million people accessing a social networking website every day, more than 1 billion minutes spent on social networking every day and more than 8 billion pages are accessed on social networking websites every day[4]. Moreover social networks are spread throughout the globe (Figure 8).

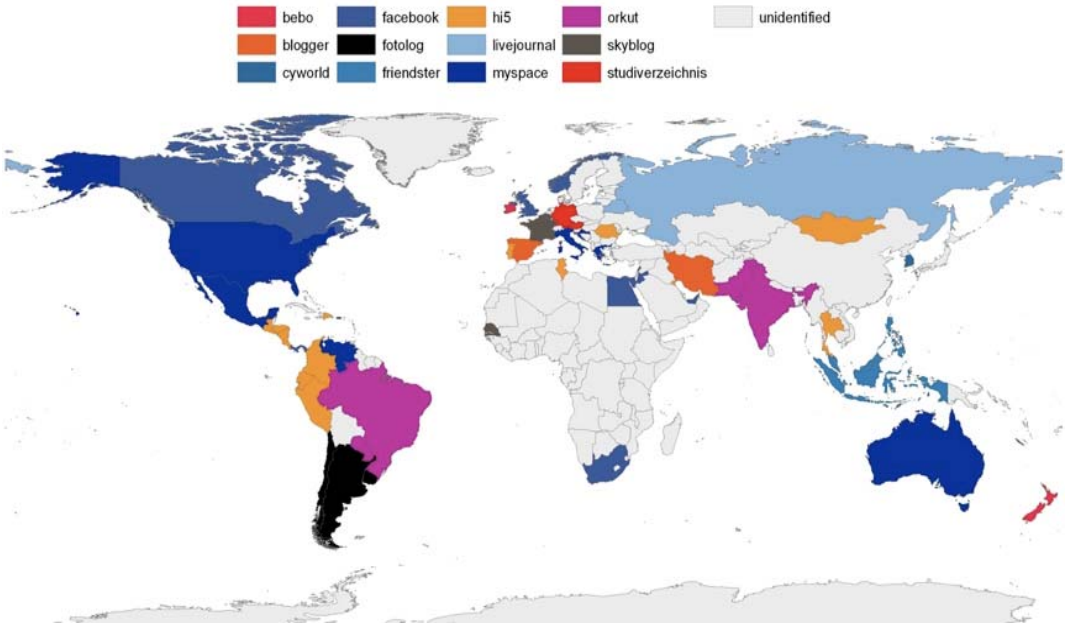

Figure 8: The world map of social networking

The changing behaviour of the user is also shown in Figure 9. Compared to other online communications and social media platforms, users are moving from plain emailing and social networks, towards synchronous communications and immersive applications like Immersive Environments, 3D Chats and 3D Virtual Worlds.

[4] Joao Da Silva, CHORUS Event, Geneva, 10 October 2007

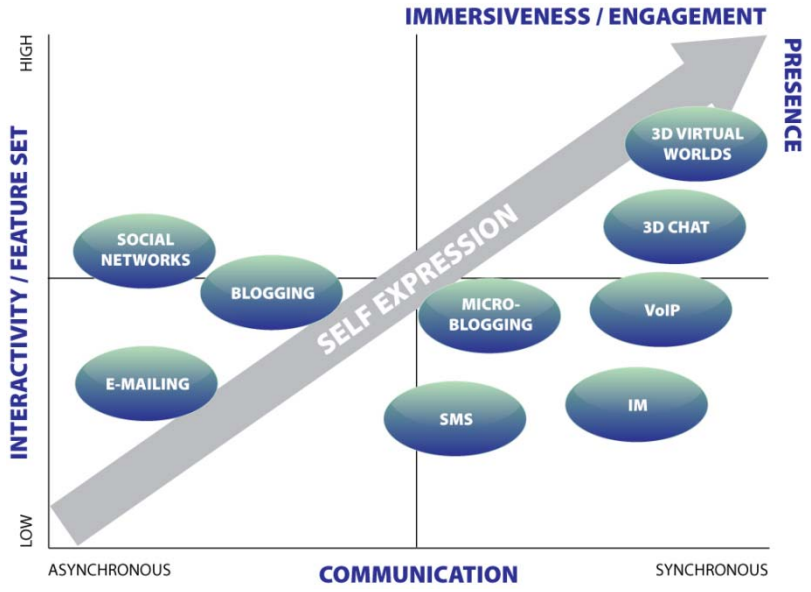

Figure 9: Virtual Worlds Compared to Other Online Communications Tools

It is clear that Internet is really shifting the habits of people. It is gaining more and more acceptance and is shifting the attention of users away from television. This fact is reflected in the figure below that represents what users are doing when they are not working.

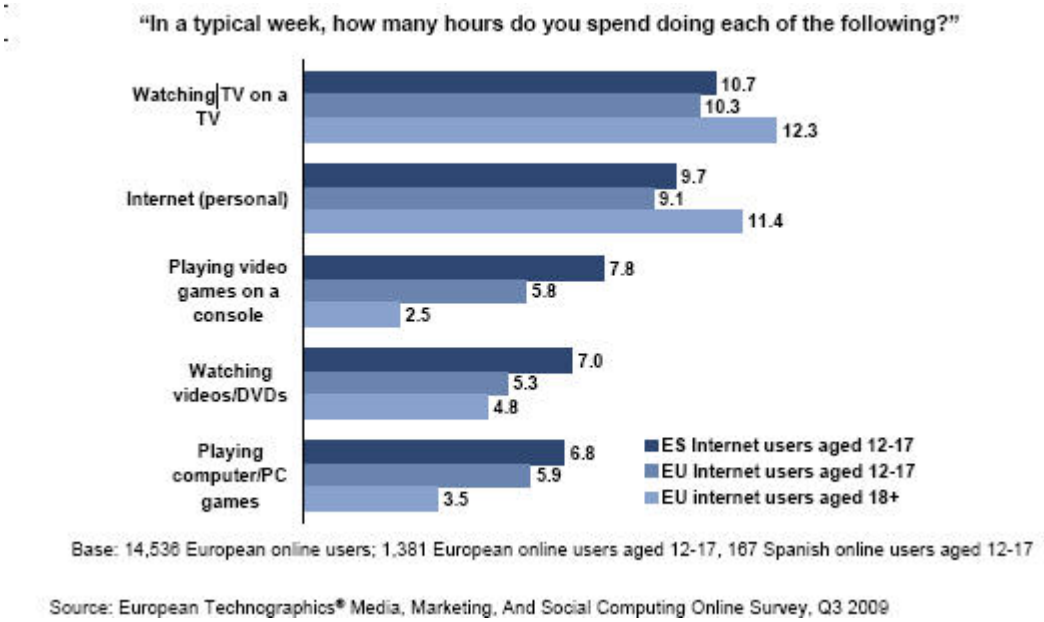

Figure 10: User Habits with respect to services.

The above considerations are really showing that COAST is tackling a need that comes from the actual societal service consumption pattern illustrated above. Video streaming is a key issue and certainly impacts the TV and the PC world. Users need to be connected and have access to content from the Internet in a timely manner, regardless of the type of content or service accessed. Quality is also key and it has to be automatically calibrated depending on the context of the user (considering the network conditions and the user conditions).

It is also worth noting that the mobile communication users' habits are changing. Since 2008, nearly 90% of mobile phones have been camera phones. Service providers have been offering attractive prices to entice their customers to purchase a camera phone, as camera phones provides them an opportunity to sell services associated with this advanced feature. Subscribers have also shown an

increasing interest in these phones and have a high willingness to pay for new services (Figure 15). With the introduction of mega-pixel camera phones, with video recording and playback capabilities, the demand has further increased and provides additional opportunities for operators to offer complimenting services.

2.1.2. User trends via the Market Evolution

The changing user trends are also shown from a number of market statistics. For example, the penetration broadband access, in particular ADSL, has reached in some countries in Europe a very important value and is continuously increasing. The values of ADSL penetration in Europe range from 78.3% in Malta down to a 27.8% in Portugal. The market is still developing, and what is important to note, is that users that are connected to Internet are switching from narrowband to broadband in most of the cases. In many cases, today's home (Home at 2010) already has access for speeds of up to 50 Mbps (many large telecom operators have already launched commercially the FTTH solution).

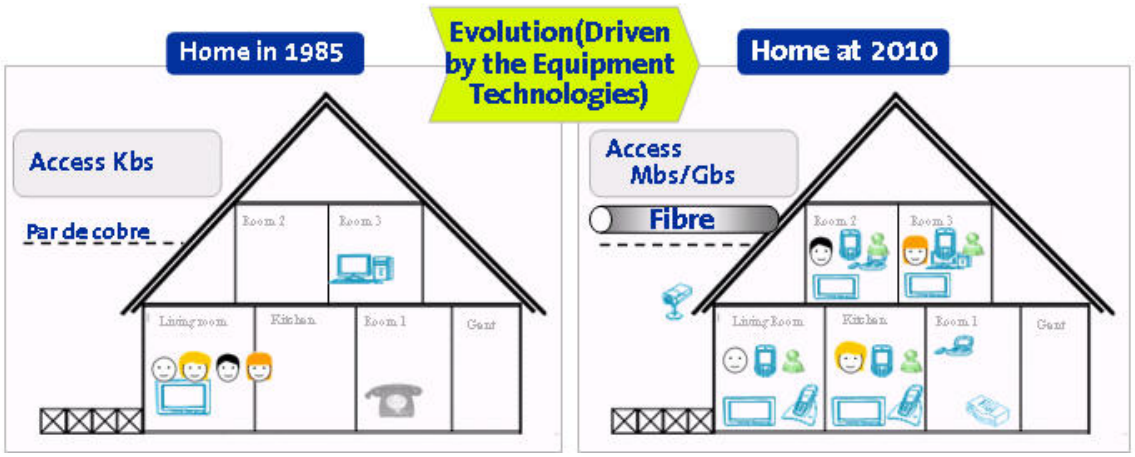

Figure 11: The Evolution of the Digital Home from 1985 to the home of today

Yet, in order to not only return the huge investment, but also turn FTTH solution profitable, new broadband services are required. One of these services is IPTV. As already shown in Figure 12, the number of IPTV subscribers is increasing rapidly.

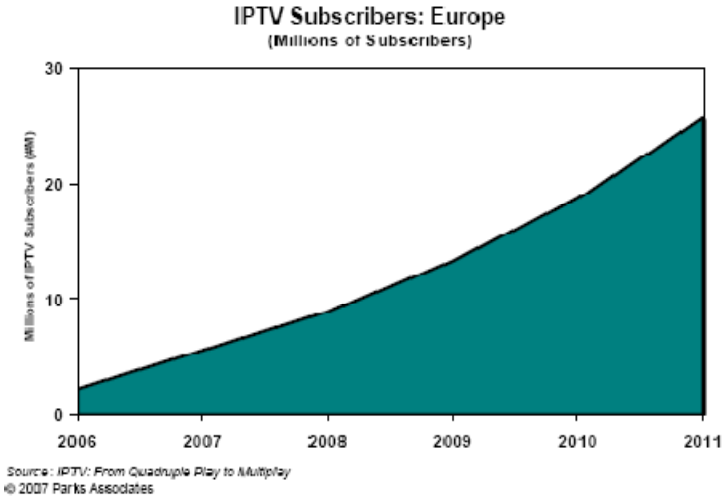

Figure 12: IPTV Subscribers in Europe

As it is shown in Figure 13, value-added service providers and telecom operator should move towards more innovative, bandwidth hungry services e.g. HD video and HD video Calls. It is then important to highlight that COAST is directly targeting the provision of a Future Content Distribution

Network (FCDN) that will enable users to consume video contents coming for the Internet in a timely manner, suiting their needs.

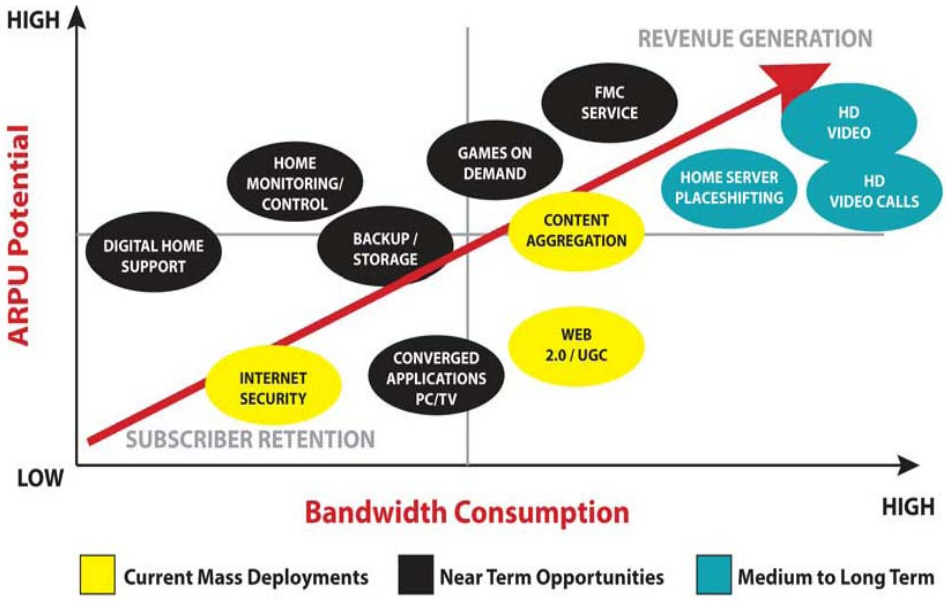

Figure 13: Bandwidth consumption versus ARPU

In general, value-added services represent a huge market potential. In 2007, the EC broadband value-added services industry generated approximately $409 million in total revenue (Figure 14). Premium technical support and broadband entertainment services represented the largest categories, with $327 million and $78 million, respectively. The total service provider value-added services market has grown to almost $1.3 billion in 2009. The willingness to pay for new mobile added valued services shows also the changing behaviour and habits of the users.

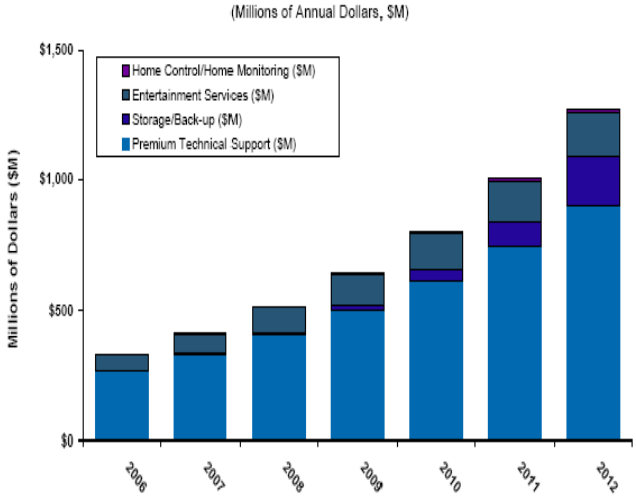

Figure 14. EU Broadband Value-added services revenues[5]

[5] Parks Associates, "Customer Analysis to drive value-added services," June 2008

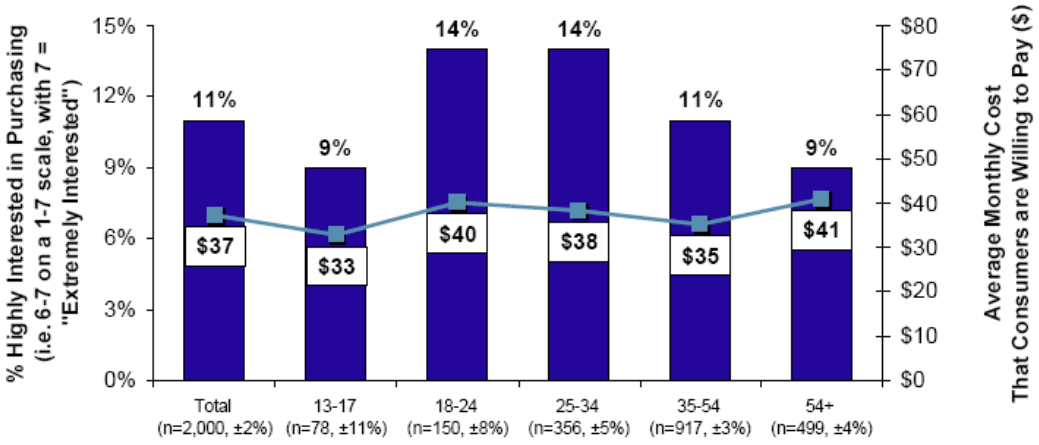

Figure 15. Mobile Data Purchase & Willingness to Pay [6]

Nowadays, digital content is almost on every terminal or consumer equipment that can be found at home. In Spain, for example, the digital consumption of media measures in traffic has increased from 60,000 Terabytes in 2000 up to 1,000,000 Terabytes in the last few years. Therefore, users now have an increasing need for home networking solutions in order to share or stream their digital content among terminals and are willing to share this content with others in many formats (Figure 11). As it also shown in Figure 16, A/V consumer electronic devices (LCD TVs, Home Audio systems, Digital Set-top boxes, Digital Cameras) are among the top 8 revenue areas in the Digital Home, while the DTV chipsets shipment world-wide is another large market area.

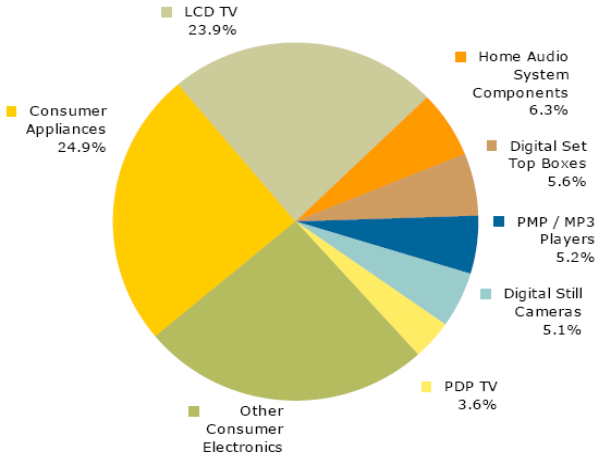

Figure 16: Top Revenue product areas by Application (2007-2012)

Some of the major challenges that Telcos are envisaging for the future include:

- Massive broadband: The fourth utility
- On demand bandwidth: End of 'one size fits all'
- Guarantee the experience quality
- Simplify the devices management
- Content distribution network: On demand-content
- Advertising as a content-funding mean
- The voice becomes another broadband application
- Single sign-on in services and devices
- Intelligent search capabilities through multiple platforms

[6] PARKS ASSOCIATES, "Mobile Phone Market Intelligence", 2008

- Horizontal integration of the home network and services.
- Automatic storage and synchronization for multiple contents and devices
- Invoicing and payments in one-click and on-line on multiple platforms

2.1.3. Consumer Trends

Understanding consumer trends and customer insights are crucial to capture new growth opportunities in the different areas where new services are to be designed and possibly exploited. Moreover, what we want to do in COAST is to adapt product and service offerings to new customer needs in the technological area addressed by COAST. After spotting and analysing general emerging and future consumer patterns and trends, several customer insights on social macro and micro trends from across the world have been identified. The findings are below summarized and analyzed, pinpointing the trends that are to be considered and addressed in COAST.

1. **Consumer power:** Nowadays consumers are experienced and well informed on the new services and the competition. They trust mainly on their peers recommendations and have increased requirements. Companies have to adapt to these new type of consumer, but their willingness to be transparent, to participate, to collaborate and co-create also represents a big opportunity as it is now easier to involve users in the innovation processes.
2. **Interest & Uniqueness:** People want to be special and unique, so consumers will want to buy products and services as long as they provide them status and make them more interesting to others.
3. **Tribe:** Uniqueness needs to be confirmed and admired by one's peers, or even one's tribe, so there is an increasing demand for products and services manufactured to answer tribal needs. And what humans want most of all is to communicate, to interact and to integrate.
4. **Now & Faster:** Nowadays there is an obsession with the here and now, with getting instant gratification and with collecting as many experiences and stories as soon as possible. And time has become precious, so people don't want to waste their time. This is a crucial trend to take into account in the project.
5. **Life on the go:** Consumers live a mobile lifestyle, they expect accessibility from virtually anywhere and at anytime (24/7 connectivity), they want to know what's around them and want to use their mobile phone for everything.
6. **100% online:** Everyone is online, or will soon be. There is even a generation of consumers that is "always connected even when offline", by getting updates via SMS to their mobile phones or via email from services likes twitter, facebook etc. In fact, the offline world is adjusting to and imitating the increasingly dominant online world.
7. **Raw & Real:** Consumers' language is becoming more transparent, opinionated, conversational, direct, outspoken, risqué, fun, honest and in your face, and companies have no other option than speaking their customers' language if they want to survive.
8. **Sustainability & Eco-awareness:** Green is the new status quo, for people's lives, their tech and the companies they trust. And more and more consumers are looking for eco-friendly options. So being an eco-company is a must nowadays. Moreover, there is also an opportunity for offering devices and services that help consumers make the most of energy saving options.
9. **Care:** Consumers have never before considered themselves as important or as entitled as they do now, therefore they demand from brands to be generous and caring, to assist them in smart, generous, relevant ways, making the most of their products.
10. **Humanizing tech:** Technologies are becoming more personally valuable as they are relevant to people's everyday lives. But technology needs to become more ubiquitous, seamless, smart and meaningful. Consumers demand products and services that enrich their lives and anticipate their needs and behaviour. People also expect communication technologies to be at the forefront of

change in the future. Telefónica has the opportunity of offering technology that helps fulfilling everyday consumers' necessities with easy to use, usable, reliable and ubiquitous services.

11. **Privacy, Safety & Security:** People need to feel that they and their family (especially children) are safe; therefore they want and expect guarantees from companies. This trend also provides network and service providers the opportunity for offering products and services that help consumers and their families feel safe, especially in the online world.
12. **Here (locality)**: Although we are surrounded by globalisation, there are an increasing number of consumers that demand locally produced products, local information services and ways to connect to fellow residents.

2.1.4. Content/Service Consumption SLAs

In many cases, the customers (i.e. enterprises, business or individuals) request Service Level Agreements (SLA) for the services that they get. A SLA is a contract between a network service provider and a customer that specifies, usually in measurable terms, what services the network service provider will furnish. As an example, many Internet service providers (ISP) already provide their customers with an SLA. Some metrics that SLAs may specify/include are:

- The contracted delivery time (of the service) or performance
- What percentage of the time services will be available by measuring for e.g. Mean Time Between Failures (MTBF), Mean Time to Repair (MTR) or Mean time to recovery (MTTR)
- The number of users that can be served simultaneously and dial-in access availability (performance versus denial of service)
- Specific performance benchmarks to which actual performance will be periodically compared (as a set of performance criteria which the service is expected to meet). For example data rates, throughput, jitter, TAT (Turn-Around Time) or similar measurable details.
- The schedule for notification in advance of network changes that may affect users
- Help desk response time for various classes of problems
- Usage statistics that will be provided.

Some examples of specific SLAs are summarized:

- **Backbone Internet providers**. It is not uncommon for an Internet backbone service provider (or network service provider) to explicitly state its own service level agreement on its Web site. The Telecommunications Act of 1996 does not expressly mandate that companies to have SLAs, but it requires that ILECs negotiate in good faith regarding things like resale, access to rights-of-way, and so forth.
- **Web service level agreement** (WSLA) is a standard for service level agreement compliance monitoring of web services. It allows authors to specify the performance metrics associated with a web service application, desired performance targets, and actions that should be performed when performance is not met. WSLA Language Specification, version 1.0 was published by IBM on January 28, 2001.
- **Cloud computing SLAs.** The underlying benefit of cloud computing is shared resources, which are supported by the underlying nature of a shared infrastructure environment. Thus, SLAs span across the cloud and are offered by service providers as a service based agreement rather than a customer based agreement. Measuring, monitoring and reporting on cloud performance are based upon an end user experience or the end users ability to consume resources. The downside of cloud computing, relative to SLAs, is the difficultly in determining root cause for service interruptions due to the complex nature of the environment. Any SLA management strategy considers two well-differentiated phases: the **negotiation** of the contract and the **monitoring** of its fulfilment in real-time. Thus, SLA

Management encompasses the SLA contract definition, the SLA negotiation, the SLA monitoring and the SLA enforcement.

2.2. User Insights

Based in the various user trends, TID have conducted the SYNECTIC's processes using real users in order to get valuable user insights to be taken into account under the 2010 innovation project portfolio. On the other hand, COAST industrial partners have also provided insights based on their experience on user requirements. The major user insights are summarized in the following sections.

2.2.1. Digital home users

During the process of SYNECTICs, TID performed interviews and group discussions with real users. The demographic sample chosen had the following characteristics.

- Family parents between 35 and 45 years old.
- Living with a partner.
- At least one child below 13.
- They have PC and a Broadband connection.
- They have also digital TV services
- They have different professions.

This sample was based on the analysis of demographic trends of one representative market (i.e., Telefonica's market). In this analysis process, the following diagram (Figure 17) was produced.

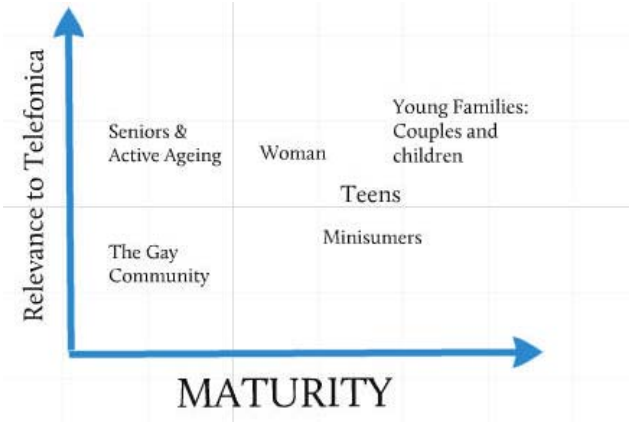

Figure 17: User Demographic trends for Telefonica business profitability

Below, the result of the three processes, staging, immersion and insight, is summarized. A group of Telefonica professionals have participated in compiling this result. This group was comprised of R&D engineers from TID's Digital Home group and experts from the User Experience Group, who were the facilitators and drivers of the use of Synectics methodology.

Below is a list of the major insights that were found in the above process. The list is ordered following an importance criteria for the interviewees.

Code	INSIGHT
DHI-1	My Content is Mine
DHI-2	My life with me
DHI-3	Knowing me is changing me
DHI-4	One device to control all
DHI-5	My mobile always at hand
DHI-6	Our TV

DHI-7	Technology that enhances
DHI-8	Entertainment for Children

Below each one of the above insights is explained better.

2.2.1.1 DHI-1: My Contents is mine

Parents are aware that their personal contents (photographs, videos, audio files, documents) are not safe since backup is a tedious job, not implemented in most cases. A virus or hardware failure may cause the irrecoverable loss of their valuable memories.

Nowadays, with the extensive use of digital devices, the volume of personal content has multiplied. Classification and organization is very difficult, making it hard to find and access a particular content. Therefore solutions for classification and search facilities for complex private networking environments are truly needed (of course it is assumed that permission is granted).

2.2.1.2 DHI-2: My Life with me

Parents demand a remote access service to their personal and purchased content. This service must be simple. Parents don't like the idea of storing their content out of the home but they want to have access to it wherever they are.

Possible scenarios are: listening to their music at work, watch the kids' favourite films while at the grandparents' home or showing their latest holidays photographs without carrying them around.

2.2.1.3 DHI-3: Knowing me is changing me

Family parents are worried about home expenses (electricity, water, gas, phone, Internet, pay TV). They would love to save money without sacrificing convenience, while being able to do whatever they want whenever they want. They need to know they have control over all activities going on in their homes. They think the best way to make their children value ecology and energy savings is through education, but they lack the tools to do it. They want to change their consumption habits, but in order to do that, they need to know what their consumption is, how they consume and realize that the efficient use of resources has a real reward.

2.2.1.4 DHI-4: One device to control all

Family parents dislike having a different remote control for every home device. They want to control all devices from a small remote, tactile easy to use and configurable to their likings. The user interface must be simple, unlike those complex remotes full of buttons. The mobile phone is a good candidate as they always carry it with them and every family member has one.

2.2.1.5 DHI-5: My mobile always at hand

The mobile phone has become an inseparable personal device. It is used not only out of home but at home as well. Users would like to use new mobile services or evolutions of existing ones. The mobile phone is also regarded as a concentration point of useful information such as reminders, alerts and alarms. However, the receptions of non-requested information such as SMS ads, or repetitive reminders are found to be irritating. The mobile's address book is highly valued by users, who are terrified by the idea of losing it. Often, users prefer to use their mobile phones instead of the fixed line just for the convenience provided by the address book. Users would like to have a more flexible access to the address book information, even from other devices.

2.2.1.6 DHI-6: Our TV

Family parents want to access free content from the Internet on the TV. They also want an on demand pay TV service which offers quality and varied programs for all the family. In this case, some degree of interactivity is desired when selecting content in order to value and check the valuations from other users for that content.

2.2.1.7 DHI-7: Technology that enhances (+ parental control)

Family parents are willing to let their children use the Internet for education and entertainment, but only if they can be sure that the kids will make a good use of it. Nowadays many parents only allow their children to use the Internet when they are present to monitor their activity in real time. Parents demand mechanisms to control the contents their children are able to access and to restrict contact with unwanted people.

2.2.1.8 DHI-8: Entertainment for children

Family parents need to provide entertainment for their children both at home and out of the home. Sometimes they need educational content while in other occasions they just want to have the children entertained. Technology is very attractive for kids but it is hard to find applications adapted for them.

2.2.2. Evolution of Web Search

In this section, we give the insights of considerations with respect to the evolution of the web search.

Starting from the advent of the Internet, there were simple, yet useful services available such as e-mail, remote login, and file transfer. Over time, these services became more elaborated, and many of them are still of use, such as e-mail. On a daily basis, a large fraction of the World population exchange messages. In 2009, there were 1.4 billion e-mail users, an increase of 7% compared to the previous year, and roughly 90 trillion messages have been sent [4].

Since the late 90's, the rapid growth of the number of Web servers have made searching necessary to enable users to locate documents across the large number of servers available. Initially, searching was based on directories, and not search engines as we have today. Using concepts of information retrieval at a large scale to find documents on the Web only came out later, and such concepts were crucial to enable Web search. Directories are virtually impossible to use given the scale of documents we currently have on the Web. Estimates say that there were roughly 234 million Web sites in 2009 [5].

As access and storage technologies advanced, users changed their way to use the Web. Previously, users would produce and search for text documents, often with small figures. Currently many users make available high-quality pictures and video on the Web, typically by uploading them to sites such as Flickr and YouTube. Given the volume of information in the form text, image, video, and the different new uses for the Web (not only informational, but also recreational), made the job of search engines more difficult and more relevant. Without search engines, finding content in general by chance or even word-of-mouth became virtually impossible. Consequently, relevance of search results became even more critical.

Commercial search engines work hard to advance the current search technology so that it is possible to continuously improve the overall quality of search services. However, there are some critical limitations that prevent engines to make progress in some directions. For example, search engines do not have access to user preferences outside the context of the search engine. The estimate for the number of Internet users in 2009 is 1.73 billion [6], whereas Yahoo! has 500 million registered in 2008. This difference implies that even if all registered users are active, a search engine can not learn about the behaviour of a large fraction of users, not even in an aggregated fashion. We expect in the future that more information about user preferences in some anonymized form will be available to engines to help with the task of sifting through a large number of objects and delivering the most relevant ones.

There is also an increasing demand for personalization, and not only regarding search. In the future, more options of services will be available to users, including home set-top boxes serving content and users producing high-quality content and streaming from mobile devices. Those options will lead to even different use scenarios, and require search engines and Internet providers to adapt to this new reality. For search engines, there is a critical need to re-evaluate the techniques used in current architectures. Many of the techniques currently used related to *crawling*, *indexing*, and *query processing* require centralization in the form of a large amount of compute power (many well-

connected processors). Such a requirement leads to services that are not easy to tailor to regions. With a distribute architecture instead, it would be possible to tailor search results to user preferences at different levels of granularity. At one extreme, we can imagine a distributed architecture used at the granularity of neighbourhoods, tailoring results according to demographic. Such a fine level of granularity could also leverage the use of caching more heavily, assuming that users geographically near to each other are likely to request similar content.

To summarize these views, the following insights can be defined:

Code	INSIGHT
WSI-1	Users search for all types of content, including high resolution pictures and videos
WSI-2	New uses of the web: not only informational but also recreational
WSI-3	User preferences must be taken into account in searches
WSI-4	Adaptation of search results depending on type of device and user location

These insights are analyzed below:

2.2.2.1 WSI-1: Users search for all types of content, including high resolution pictures and videos

Videos constitute a highly demanded type of media that imposes important challenges to the network infrastructure due to the amount of bytes to be transferred and the timing constraints. The high definition and 3D varieties of video will impose even more stress to the network in the near future. Moreover, features like personalised video or interactive video (including zoom-in and out) need even more intensive searching capabilities and makes localised caches more important than ever.

In addition to video, other types of content are also popular: pictures, music and web services (travel reservation, online shopping, etc).

2.2.2.2 WSI-2: New uses of the web: not only informational but also recreational

The actual bandwidth that many Internet users are enjoying is making possible new uses of the web such as on demand and live streaming of video and music. Users are also connected between them by social networks allowing them to comment, rate and recommend content to other users. This type of immediate communication between users makes some content highly popular within a very short time frame, thus stressing the network infrastructure.

2.2.2.3 WSI-3: User preferences must be taken into account in searches

The amount of media content available for consumption on the net has been increasing rapidly, which leads to an increase on the number of available search results in a search engine. Given such a plethora of objects, it is important that users have a chance to refine search results to better match their interests.

2.2.2.4 WSI-4: Adaptation of search results depending on type of device and user location

Similar to WSI-3, adaptation of search results depend not only on the user preferences but also on the type of the device. For example, a HD video would not be well appreciated in a 3G mobile terminal, but may be preferred in a set-top box. Thus, search and content adaptation must take into account the type of the user's device. Search results may be tailored also based on the user location and at

different levels of granularity: neighbourhood, region, country, etc. This feature may be extended well beyond current services or even location-based services, based on the requested granularity.

2.2.3. Evolution of Enterprise Services

In this section, we give the insights with respect to the evolution of the enterprise services.

As enterprises and organizations expand globally, employees, partners and customers need access to critical IP-enabled, applications anywhere, anytime and over a wide range of devices. These include but are not limited to email hosting in the form of software-as-a-service (SaaS), core applications accessed over SSL VPN, real time interactive web conferencing, virtualized applications and desktops, secure large file transfers, remote desktop management or custom client/server applications. While these applications provide users with key business capabilities, poor performance or spotty availability of these applications can lead to decreased productivity, low adoption and high support costs. These applications must perform quickly, securely and reliably every time in order for enterprises to realize the full benefits of the application and the overall success of the business.

Another important parameter is the speed and the interactivity of web-sites (including on-line shops), which are growing in an increasing pace. While dynamically generated content offers an unprecedented opportunity to engage with consumers, rendering pages on the fly can lead to delays and even failures in delivering content. Web access acceleration would significantly improve the image and the visibility of companies, while generate new value-added services to the service providers and ISPs.

Web acceleration goes well beyond Internet web access. Enterprises and large organization invest heavily in developing Web-based applications that move processes like supply chain management, customer support, sales orders, and extranets online. But centrally-located applications don't always perform consistently, and when they're slow or unreliable users become frustrated or avoid using them altogether. Infrastructure build-outs require additional capex and rarely solve the problem, pushing ROI even further out of reach. On the other hand, companies delivering software electronically (such as enterprise application vendors, consumer electronics companies, anti-virus manufacturers, semiconductor companies and game developers) must overcome a globally dispersed user base, increasingly larger file sizes, and heavy traffic loads while maintaining manageable operational costs.

To summarize these views, the following insights can be defined:

Code	INSIGHT
ESI-1	Remote access acceleration
ESI-2	Web site acceleration
ESI-3	Web-based applications acceleration
ESI-4	On-line Software Delivery

2.2.3.1 ESI-1: Remote access acceleration

Remote access and in general IP application acceleration would significantly improve the performance of enterprises. Specific IP applications and software-as-as service solutions must perform quickly, securely and reliably every time.

2.2.3.2 ESI-2: Web site acceleration

The speed and the interactivity of web-sites are very important parameters of the web-site success, and thus of the corporate image of the enterprise.

2.2.3.3 ESI-3: Web-based applications acceleration

Going beyond web site acceleration, Web-based SOA applications acceleration may results in enterprises' increased productivity and ISPs' new business models.

2.2.3.4 ESI-4: On-line Software Delivery

On-line software delivery enterprises must overcome problems and restrictions generated by the globally dispersed user base, the increasingly larger file sizes and the heavy traffic loads, while maintain manageable operational costs.

2.2.4. Evolution of Mobile Broadband Services

Additional insights may be extracted also from other areas. As the most relevant and important one is considered the broadband mobile market. Mobile telephones have evolved from plain telephones to multi-media, multi-modal devices. Most telephones today are considered as intelligent PDAs, with many applications (even user generated ones), they have larger screens able to playback video, touch screens, which simplify the user interaction, at least one camera able to capture images and live video in acceptable or even good quality and facilitate multiple network interfaces, which enable instant access to the mobile broadband network or the home/enterprise wireless LAN. In this way, mobile phones are evolving to the most preferable user interaction devices.

Many of the insights in this category can be considered as variations of the previous insights. Yet, as they represent a huge market potential, some major mobile broadband services insight are summarized also here:

Code	INSIGHT
MBI-1	Internet access from the mobile
MBI-2	Streaming to the mobile
MBI-3	Infrastructure- less mobile services access

2.2.4.1 MBI-1: Internet access from the mobile

Remote Internet access and in general IP application acceleration from the mobile phone would significantly improve the user acceptance. MBI-1 can be considered as a variation of the DHI-4: "One device to control all" and DHI-5: "My mobile always at hand"

2.2.4.2 MBI-2: Streaming to the mobile

Streaming to the mobile can be considered as variation of the DHI-6: "Our TV" and DHI-8: "Entertainment for children". Moreover, it may be considered as extending WSI-3: "User preferences must be taken into account in searches", WSI-4: "Adaptation of search results depending on type of device, WSI-5: "Tailoring of search results according to user location at different levels of granularity" from searching to streaming. Yet, this insight is much stricter to user preferences and context issues like user terminal, location, network, movement constrains.

2.2.4.3 MBI-3: Infrastructure-less mobile services access

In this insight we include all the services that are not purely based on the infrastructure. As examples we include ad-hoc and peer-to-peer mobile networking, vehicular-to-vehicular based services, personal and opportunistic area networks, sensor networks.

3. COAST service scenarios

As we have already explained, COAST aims to build a Future Content-Centric Network (FCCN) overlay architecture able to intelligently and efficiently link billions of content sources to billions of content consumers, and offer fast content-aware retrieval, delivery and streaming, while meeting network-wide Service Level Agreements (SLAs) in content and services consumption. In short, COAST will deliver a framework, where the users will specify which content or service they need, and the COAST framework will find the desired or the most relevant data and forward it to the users in an efficient, timely and network-friendly way.

Having in mind the insights and the COAST main objectives, in this section we provide a number of service scenarios. From these scenarios we are trying to demonstrate the COAST added value and extract the major COAST functionality and core COAST services. These scenarios may potentially perform the basis for the COAST user cases and demonstrations in WP7.

3.1. Home Based Scenarios

This group of service scenarios mainly correspond to Internet access and infotainment consumed or generated from the home environment.

3.1.1. Internet Video Access on my TV

Scenario Title	**Internet Video Access on my TV**
Keywords	• Video Streaming • Content Searching • Effective tagging • User preferences • Content Consumption SLA
Application areas	• Residential services • Internet access from my TV
Applications	• Preferred video search • Optimized Video coding • Videoconference
Actors	• Peter, 43 years old • Jim, 12 years old Peter's son • Pierre, 24 years old, neighbour, Led Zeppelin's fan • Tutorials Inc, an SME creating tutorial videos
Storyboard	Peter is sitting on his living-room sofa at home watching on his TV a personal video of the summer holidays. To do that he is using the home server product (Multimedia disk with Internet connectivity) that allows him to access different kinds of content through his TV and even watch video streams coming from the Internet. Peter plays the guitar and is teaching his son, Jim, how to play. Jim pops in and says: "Father, I would like to play Led Zeppelin's Stairway to Heaven". To accelerate the process, Peter decides to search for a tutorial in the Internet. So, he accesses to the internet services interface from his home server (connected to the COAST Streaming Platform). "Son, look how simple it is if you watch this." The COAST search engine extensions immediately find that there are a

	number of video tutorials on how to play this song, both professional and user generated ones. Peter selects the professional video from "Tutorials Inc", an organization who creates teach-yourself music tutorials. As the video tutorial is popular, Pierre had downloaded it a few days ago. COAST decides to stream the local copy, which has been cached in the COAST-aware node, instead of streaming it from the Tutorials Inc video server. The start-up delay is minimal and the quality is amazing. Peter and Jim enjoy the video. Jim decides to continue his practise in his room. So, he turns on his PDA, and selects the same video, which is now streamed keeping only the base layer. After practicing the song for some time, following the tutorial, Jim says: "And now let's see how the real masters do it!" He searches for the last performance of the band in 2007 at the O2 Arena in London. He starts the search via the COAST platform and several versions of the video appear hosted in different servers: Flickr Photo albums, YouTube or DailyMotion Videos, etc. They then had a nice session of viewing photos and videos of the band's concert. A new fan of the band is born! As the Led Zeppelin content has been recorded with MVC, different views of the band are available. Their focus is on the guitarist. Thanks to COAST set-top box with free-viewpoint capabilities, they are able to see the artist performance from different perspectives and focus on the hands of the player. In this way they can really understand how the action is progressing and mimic the performance live. It is like the artist is there and they are playing together! This is an experience that very hardly could be able to have had in the real life.
Analysis	To support this scenario, the following requirements are necessary[7]: • COAST platform discovers the content (CF1.1), the network topology (CF1.2), the traffic (CF1.4), the popularity (CF1.5), the terminal type (CF1.6) and the user context (CF1.7). • Popular content is cached in the network (CF2.1) • Peter's Home Server accesses the Internet and searches for the content (CF3.1) and the best delivery path (CF3.2). An SLA negotiation process starts in order to select the most appropriate delivery path. • The content is adapted and personalised to Peter's and Jim's terminals (CF4.1, CF4.2) • The video is optimally streamed to Peter's and Jim's terminals (CF5.2). During the video streaming the content consumption SLA is monitored. • The home server provides the COAST API and user interface (AF1) • Peter's and Jim's terminals (set-tops or home video server) are able to decode SVC and MVC contents and support free viewpoint (AF2). • Peter's & Jim's terminals are able to manage the users' profiles (AF3).

3.1.1.1 Stakeholders

Stakeholder	Description	Quality Goals
Peter, Jim (users)	Accesses his preferred Videos on the Home Server	The quality of the videos is optimized by the COAST platform depending on the user context

[7] The different requirements are extracted from the scenarios, but are summarized in the next session.

		(Device, networking,…) and on the Internet sources.
Tutorials Inc	An SME creating tutorial videos. It is able to provide high quality videos in various formats, but can't afford the cost of creating a distribution network.	The company takes advantage of the COAST platform to distribute the content, by using various video caches in the network.
COAST Platform provider	He is able to connect to the home Servers. He has an agreement with the home server equipment provider and the service/connectivity provider.	Able to handle user preferences and context and profile in order to adjust the quality and meet specific SLAs. Depending on the sources, a coding engine will allow to optimize the video streams using the above criteria. A COAST subsystem will support SLA negotiation and monitoring, and specify the measures to be taken in case of deviation and failure to meet the asserted service guarantees (for example, a notification of the service customer).
Internet Service Provider	Provides the Internet connectivity and the network infrastructure. Provides APIs in some of the cases.	Best effort. Can optimize network load and enforce SLA by differing the transfer of content in a different time from peak hours.

3.1.2. Publishing my own videos

Scenario Title	**Publishing my own videos**
Keywords	• User generated content • Content searching • Streaming • Effective tagging • Peer-to-peer
Application areas	• Residential services • Content sharing
Applications	• User content search • Content publishing • Optimized Video coding
Actors	• Alex, 35 years old • Social Group of internet users
Storyboard	Alex is a do-it-yourself (DIY) enthusiast. Whenever he starts a new project, he always resorts to the Internet for information on materials, tools, procedures and inspiration. He has learned from experience that the most useful information usually comes from other enthusiasts. That is why he likes to use the COAST enabled search engine to retrieve all kinds of DIY information. Normally a search engine would only index content once its crawler has found it. However with the COAST platform, Alex's videos will

	be inserted into the index soon after he creates them. This time Alex wants to contribute back to the DIY community with a video showing the construction of a solar powered swimming pool heater. He carefully shoots every step of the process using his HD video camera. Then he edits the video on his PC. When the video is finished, Alex puts it in his home server, which is connected to the COAST platform. Using the home server GUI, Alex marks the video to make it publicly available to all Internet users. He also tags the video with the most appropriate keywords to ensure his file is found by searches related to DIY and solar projects. Alex is concerned about privacy issues, but he is confident that the COAST platform will strictly limit public access to only the content he has explicitly marked for sharing. Alex's video is a big success. Thanks to COAST his video is easily found and played. In spite of the high number of hits, Alex's Internet connection is not overloaded due to the effective content caching mechanism provided by COAST. The clarity of the HD video delivered by the COAST platform makes it easy for people to follow Alex's instructions. He receives many congratulations and gratitude messages from fellow DIY enthusiasts. More surprisingly for Alex, he receives many requests to buy the system from him. All this positive response encourages Alex to start a small business to sell his solar pool heater as a kit. A small community is growing. Once a week, Alex delivers to his most enthusiast friends a live message where he addresses his week experiments to improve performances of the system. Initially, when only a tenth of them where connecting to his ADSL set top box in videoconference, the bandwidth was enough, but now his business is becoming too big for an ADSL service and too small for a huge IPTV infrastructure. Alex does not want to give up his weekly rendezvous with his fans, because he feels it is a real plus for the customers to have a direct contact with the producer, they perceive him more close to their needs. COAST helps to keep him in touch with his fans, because thanks to the peer-to-peer streaming technology some of them rely the conference to the other connecting peers.
Analysis	To support this scenario, the following requirements are necessary: • Alex is subscribed and has access to the COAST platform that allows him to publish his own content and search for other user's content. No upload is needed. COAST platform discovers of the content (CF1.1), the network topology (CF1.2), the traffic (CF1.4), the popularity (CF1.5), the terminal type (CF1.6) and the user context (CF1.7). • Effective caching of user generated content. Popular content is cached in the network (CF2.1) • The content is adapted and personalised to receivers' terminals (CF4.1, CF4.2) • The video is optimally streamed users' terminals using peer-to-peer streaming (CF5.2) • The home server provides the COAST API and user interface (AF1) • Access and privacy control on user content (AF4).

3.1.2.1 Stakeholders

Stakeholder	Description	Quality Goals
Alex (user)	Makes his own content available to other users. Searches and accesses other user's content.	Content sharing should be easy and allow feedback from other users. Home Internet connection should not be overloaded with content sharing traffic.
Social Community	Receive user generated content and communicate with the owner/creator in a simple and efficient way.	Search results should include user generated content if relevant. Content sharing should be easy and allow feedback from other users.
COAST Platform provider	Provides searching and streaming of user generated content.	Published user generated content must be indexed and included in search results when appropriate. Content coding and stream should be done efficiently and take into account the user context and preferences.
Internet Service Provider	Provides connectivity	Best effort. He provides extra services with peer-to-peer streaming technologies for dedicated user channels.

3.1.3. Media Box TV

Scenario Title	Media Box TV
Keywords	• Video streaming & decoding • Video aggregation and Tagging • User context • Searching with parameters • Video meta information • Video on demand • Content Consumption SLA
Application areas	• Residential services
Applications	• TV streaming • Indoor user localization • Media discovery • Easy search and retrieve TV interface
Actors	• Alice and family • Xtrim Inc, a innovative broadcasting company

Storyboard	The entertainment market is changing continuously with regard to the content offered, but delivery mechanism remained basically unchanged. Until today, there were several ways of offering video content to customers: - Regular TV with unmanaged TV channels where viewers can only decide to view or not to view the broadcast. - Pay-Per-View where viewers can decide to subscribe to certain content and control the delivery. New technologies open new markets and close obsolete ones. The entertainment company Xtrim Inc. knows it, and launched a new concept of entertainment based on COAST technology. Combining the power of search engines, automated profiling, and extensive social and automated tagging, Xtrim creates the Xchannels. *Xchannels* is a customer's Internet portal displayed on TV screens by a residential gateway. It presents a collection of content, classified and ordered to be watched sequentially. Xchannels is fulfilled with all Internet video provider's content, and ordered depending on video's meta information, user's profile and many other parameters, managed mainly by the residential gateway. But not only the automated skills of Xchannels improve user experience, also easy controls displayed on the screen allows viewers to enhance the search results to match even more their likes. In other words, Xchannels offers you exactly what you want to see each time you turn it on. Alice is about to spend some time watching TV after a busy workday. She goes through all TV channels, but nothing of interest to her. She decides to try the new provider, which her neighbours are talking about. She knows that the new channel is delivered via the Internet, but her last generation gateway is able to handle it. At the first glance Xchannels seems to be really different, and the main screen shows several videos, films and TV programs with some graphical information attached. Alice is amazed that everything seems to be interesting: Xchannels offers the next chapter of all the TV series she is following and several films of her favourite actor. On a closer look, Alice realizes that the information displayed about the sub channel is actually information about people that is also watching it. She is amazed about how much information comes from other viewers, such as how many people is watching the channel, how long they stay, how close to her home they are or how they are assess the program. Surprisingly, there is a meter that also tells her how much she is going to like each option, and most of the time it is right. Xchannels is easier to watch, than regular TV programs. It starts playing the first classified content just when she tunes the channel, but she can skip the program to go to the next one. Little by little, Alice discovers a new way to watch television, where traditional channel hopping is substituted by selecting those parameters that she appreciates more. When she increases the weight of the proximity of viewers, she discovers local channels she never heard about; even her children's school TV is there; on the contrary, highly viewed content is less interesting for Alice than those highly valuated by others. Now, Alice and her family are accustomed to managing the flood of meta information to search for content, channels and live shows, because they spend less time searching for something interesting. Day after day, the new entertainment is becoming more familiar. The

	content and quality is tuned depending on who is watching it, depending on the hour of the day, previous choices or place from where the Xchannels is seen; and each configuration looks more accurate than previous ones. Now Alice is wondering why they waste so much time hopping channels in the past.
Analysis	To support this scenario, the following requirements must be covered: • Service provider's application must store user's search and play history • Service provider's application must interface with COAST API • COAST platform must discover the content (CF1.1), the network topology (CF1.2), the traffic (CF1.4), the popularity (CF1.5), the terminal type (CF1.6) and the user context (CF1.7). • Effective caching of user generated content. Popular content is cached in the network (CF2.1) • COAST must deliver video content to get best user experience based on content closeness, number of sources, etc (find the best delivery path (CF3.2), and start an SLA negotiation process in order to select the most appropriate delivery path). • The content is adapted and personalised to receivers' terminals (CF4.1, CF4.2) • The COAST aware gateway must gather user's context (location, time, day) via an automatic API and/or a user interface (AF1) • The COAST aware gateway must discover TVs and media servers in the home network (CF1.2) • The COAST aware gateway must discover media content, tag it and generate search pattern for available similar content on the provider (CF1.1 and CF3.1) • The video is optimally streamed to users' terminals via peer-to-peer streaming (CF5.2) • The home terminals (set-tops or home video server) are able to decode SVC and MVC contents and support free viewpoint (AF2). • The terminals are able to manage the users' profiles (AF3).

3.1.3.1 Stakeholders

Stakeholder	Description	Quality Goals
Media provider	Provides the media content	Be able to provide as much content as possible for all search parameters, and deliver an "endless" streaming.
COAST Platform provider	Provides network management to improve search, caching and delivery of videos.	Prepare the network to guess the best results on "best effort" broadband connections. A COAST subsystem may also support SLA negotiation and monitoring, and specify the measures to be taken in case of deviation and failure to

		meet the asserted service guarantees.
Internet Service Provider	Provides “best effort” broadband connections between Media Provider and Customers	He provides extra services with peer-to-peer streaming technologies for dedicated user channels.

3.2. On-the-move scenarios

This group of scenarios describe the COAST functionality that target mobile devices such as laptops, PDAs or mobile smart phones (with calendar and sensory support). The COAST user does not need to care about the given wireless infrastructure as the options for his connectivity are discovered and exploited automatically. It is made sure that the COAST user can retrieve content which is streamed with stable quality or downloaded to his device in a short time.

The content can be video including video, audio only (e.g. music) or pictures. It is further possible to distribute high-quality content by streaming it to the COAST platform using the mobile device or by uploading content to the COAST platform from the mobile device in a short time. The COAST subscriber can perform a search that takes the limitations in his (future-) connectivity or in his mobile device into account such that he is provided with useful and stable quality content.

3.2.1. Context sensitive search and delivery on the move

Scenario Title	**Context sensitive search and delivery on-the-move**
Keywords	• Mobile device • Context relevant content • Support of stable quality
Application areas	• Services offered through mobile devices (laptop or smartphone) • Tourist/Social/Cultural services
Applications	Mobile user who is provided / offered context-sensitive (3D-video) content with stable quality and search services
Actors	• John and Marry, Tourists • Advert Inc, Advertisements' Service Provider • MyShoes.com, A modern shoes store
Storyboard	John and Marry are moving towards the Victory Column in Berlin. When they arrive at the monument, a list of video streams is offered on John's mobile device. As John's mobile device is a rather low-end mobile phone, only content that can be played by John's mobile is proposed. John selects a video from the different options that he has and they both enjoy the selected video stream with stable quality (they listen to the audio stream explaining the history of the victory column while they are walking around it). Marry takes some pictures of the Victory Column and uploads them to the COAST platform to be offered to other users, who are potentially interested in it. As the weather is nice, they decide to roam in the shops centre. As they pass by MyShoes.com shop, Marry receives a small advertising message to her mobile phone regarding today's special MyShoes.com discounted sales and promotions, personalized according to her preferences. Marry finds an excellent pair of shoes, and she is happy that she had subscribe to that service offered by Advert Inc.
Analysis	To support this scenario, the following requirements must be covered: • COAST platform must discover the content (CF1.1), the network topology (CF1.2), the traffic (CF1.4), the terminal type (CF1.6) and the user context (CF1.7). • Effective caching of user generated content. Popular content is uploaded and cached in the network (CF2.1) • The content is adapted and personalised to receivers' terminals (CF4.1, CF4.2)

	• The COAST aware terminal must gather user's context (location, time, day) via an automatic API and/or a user interface (AF1) • The COAST aware terminal must discover media content, tag it and generate search pattern for available similar content on the provider (CF1.1 and CF3.1) • The video is optimally streamed to users' terminals via peer-to-peer streaming (MDC could also be an additional option) (CF5.2) • The home terminals (set-tops or home video server) are able to decode SVC, MVC or MDC contents and support free viewpoint (AF2).

3.2.1.1 Stakeholders

Stakeholder	Description	Quality Goals
John & Mary (users)	Tourist, people on-the-move. They are provided with relevant content and can upload content while on-the-move.	Content is provided with stable quality They may subscribe to new services
MyShoes.com (Content provider)	A modern store that uses the COAST platform to promote sales	New sales opportunities/business models
Advert Inc, (Service provider)	Service providers. They offer the push content service and they refer to the user's context and optimal delivery	The offered results fulfil the user's needs and can be provided in time / with stable quality
Internet service provider	Provides access to the Internet via the different access technologies	Best effort

3.2.2. E-learning platform

Scenario Title	On-line university degree
Keywords	• Live Streaming • VoD • IP acceleration • Adaptation • P2P
Application areas	• Internet enabled devices • Residential services
Applications	• E-learning platform
Actors	• Anne, 35 employer

Storyboard	Anne is working as a designer for a multinational company, with many years of experience in her field of competence. Even if she likes a lot her job, since she joined the company she hadn't progressed a lot in her career. One of the main reason is that compared to other colleagues, she doesn't hold a MS degree. She started a university degree in industrial design, but she didn't conclude the program of the exams. Ann is well motivated to enrol in a university and accomplish the courses. Nevertheless, Anne is married and has a small baby; so she can't afford leaving the job and studying full time. On the other hand, there are no universities close to her home city, and she would have to relocate the whole family to attend classes. Furthermore, she is also a very active and dynamic person and she loves doing a lot of sport indoor (spinning, cycling, jogging in a fitness centre etc.), and outdoor (long walks in mountain). She thinks she cannot sacrifice all her relaxing activities. In order to be able to manage family life, job and hobbies with the studies, Anne starts to look for universities offering eLearning system, as she thinks that could be her unique option. Most of the universities offer standard eLearning platform, that can be used only with a powerful PC at home or in a lab, and require high bandwidth IP connections. On the other hand, by looking some examples of eLearning platforms, she also thinks that the quality of the provided services (on demand download of recorded lessons, live streaming of seminars, shared desktop etc.) seems very poor, compared to the high enrolment costs (video and quality resolutions are low, video in streaming suffer from continuous interruptions etc.). One day while browsing the web she discovers that one of the best and renowned universities is promoting a novel eLearning platform. Thanks to the COAST network infrastructure, they claim of being able to provide to each student innovative and high quality services and a much more realistic remote participation to classes, seminars, discussions, etc. The contents (live lessons, on demand download of pre-recorded classes, seminars, download of documents, etc.) can be accessed everywhere, using any type of IP enabled device, and connecting through any kind of network. Quality of the service in fact is always high (up to HD for video lessons delivered in streaming), and continuity of service, that is particularly critical for live sessions, is ensured. The COAST infrastructure takes care of selecting, on the fly, the best network path to deliver the selected content, avoiding congestion or bottlenecks. At the same time the content is automatically adapted to the user preferences or to the capabilities of the device that the user is using, or the network bandwidth available. The possibility to access the e-Learning service almost everywhere attracted Anne so much that she decided to select the on-line courses offered by that university. Furthermore the enrolment costs were lower with respect to other similar courses offered by other universities, as the COAST platform heavily reduces the infrastructure costs for the content/service providers. After only one year of on-line classes, Anne got the degree, and after some months she was also able to change her position, becoming team leader. Anne thinks that the success of her studies is mainly due to the high quality of the service provided by the University, and the technologies deployed in the COAST. In fact she was able to download or receive in streaming classes almost from everywhere (at home using her IPTV STB, in the kitchen while preparing dinner on her iPad, while driving or travelling in bus to reach the office on her iPhone, while doing sports in the fitness

	centre listening lessons with her iPod etc.). Every time it was only necessary for Ann to log in the e-learning platform using a common web browser, search and select a stored content, or a live session; immediately and automatically she was able to receive the content in best format (reduced size/frame rate, reduced quality), and according to the context (mobile, residential environment) and preferences (only audio).
Analysis	To support this scenario, the following requirements must be covered: • COAST platform must discover the content (CF1.1), the network topology (CF1.2), the traffic (CF1.4), the terminal type (CF1.6) and the user context (CF1.7). • Effective caching of user generated content (CF2.1) • The content is adapted and personalised to receivers' terminals (CF4.1, CF4.2) • The COAST aware terminal must gather user's context (location, time, day) via an automatic API and/or a user interface (AF1) • The COAST aware gateway must discover media content, tag it and generate search pattern for available similar content on the provider (CF1.1 and CF3.1) • The video is optimally streamed to users' terminals via peer-to-peer streaming (CF5.2) • The home terminals (set-tops or home video server) are able to decode SVC, MVC and MDC contents and support free viewpoint (AF2)

3.2.2.1 Stakeholders

Stakeholder	Description	Quality Goals
Anne (user)	Wants to obtain a MS degree, but can't move closer to the University. So eLearning is the only option.	She can watch the lessons, in real-time or on demand. When connected to the service, she has just to select the content this is always delivered at the maximum quality and adapted to her preferences and her context.
Service Provider (eLearning service providers)	Can offer services with a lower infrastructure cost and with high delivery quality	Deliver audio/video lesson with HD quality. QoS and Continuity of Service guaranteed. Low infrastructure costs
University/Private education institute	Can offer many courses on-line/attract more students	Students satisfied of the received service

3.2.3. Always Best Content Scenario

Scenario Title	Always Best Content
Keywords	• Varying Connection • Caching, Location aware • P2P
Application areas	• Internet on the move • Video on Demand/Streaming
Applications	• Location aware search • Local content caching • Load Balancing
Actors	• Group of friends going to Paris • Content Providers
Storyboard	8 friends, Jim, Peter, Benjamin, Garret, Jenny, Jessica, Monica, Derek and Irina are split in 3 cars and are driving from Brussels to Paris. On the way, they are enjoying iTV the next Generation of Interactive Internet TV which allows them to select any music video ever produced and to see it at anytime, anywhere, with any device. Each vehicle uses the COAST platform to fetch the playlist from the content provider that is located in the Internet. GPS information is used to identify the location of the best replica and to forecast the type of wireless coverage along routes. Different video layers are downloaded by different vehicles taking advantage from MDC, MVC and SVC techniques, the layers are then exchange locally using the WiFi technology between the cars. The video and audio quality is so good that when Guns N' Roses start the notes of "Knocking at Heavens Door" Jenny, Jessica and Monica start singing with the band. Peter likes the performance and activates the in-vehicle camera broadcasting the content to the rest of the group in the other cars. Jim then decides to save the event and publish it on the network. The COAST server takes care of locally save the performance and uploads it on YouTube, while on the go, using the spare upload bandwidth from all the vehicles in the group.
Analysis	To support this scenario, the following requirements must be covered: • COAST platform must discover the content (CF1.1), the network topology (CF1.2), the traffic (CF1.4), the terminal type (CF1.6) and the user context (CF1.7). • Effective caching of user generated content (CF2.1) • The content is adapted and personalised to receivers' terminals (CF4.1, CF4.2) • The COAST aware terminal must gather user's context (location, time, day) via an automatic API (GPS) and/or a user interface (AF1) • The COAST aware gateway must discover media content, tag it and generate search pattern for available similar content on the provider (CF1.1 and CF3.1) • The video is optimally streamed to users' terminals via P2P streaming (CF5.2) • The home terminals (set-tops or home video server) are able to decode SVC, MVC and MDC contents and support free viewpoint (AF2) • Multi-homed Internet connection (i.e. HSDPA/LTE/WIFI/WiMax).

3.3. Social Networks/Enterprise Related Scenarios

3.3.1. Web Acceleration

Scenario Title	Web Acceleration
Keywords	• Web Access • Caching • Terminal aware • Content/Service Consumption SLA
Application areas	• Web browsing • Internet on the move
Applications	• Web server acceleration • Local content caching • Load balancing • Added valued web hosting
Actors	• Peter and John, founders of Small-ISP.com • Large-ISP.com, a Large ISP
Storyboard	Peter and John are two Telecom engineers. They do an excellent job as subcontractors. Yet, they want to start their own business as an ISP, mainly offering added-valued services (e.g. web sites management, service creation platforms etc). However, the available capital is minimal and they can't afford a huge network link rental. On the other hand, if access to the web sites they host is slow, they have little chance of competing on the open market. After checking out various options for outsourcing, they found that Large-ISP is offering access to the COAST Content-aware platform, with a very competitive price. Instead of renting a fat uplink, they will offer their services via the COAST platform. At first the Small-ISP server receives some traffic and their uplink is congested. After a couple of days however, the case has changed completely. Text, images, videos, 3D models are not downloaded from the server directly anymore. All content is already cached in the COAST network and all requests are redirected to the cached content. Moreover, the web pages they offer are automatically adapted to the user terminal and connection context.
Analysis	To support this scenario, the following requirements must be covered: • COAST platform must discover the content (CF1.1), the network topology (CF1.2), the traffic (CF1.4), the terminal type (CF1.6). • Effective caching of user generated content (CF2.1). • COAST platform must provide IP traffic accelerated routing (CF5.1) • COAST platform must provide video stream accelerated streaming in order to support web content (CF5.2)

3.3.1.1 Stakeholders

Stakeholder	Description	Quality Goals
Peter & John, (Small-ISP.com)	They want to start a business (e.g. a small ISP) with minimal	They can take advantage of the COAST platform to offer added

	capital	valued services with small cost.
Large-ISP.com	A Large ISP that offers the COAST platform	Can provide alternative services, with low cost and increased quality. SLAs including Mean Time Between Failures (MTBF), Mean Time to Repair (MTR), Mean time to recovery (MTTR) or data rates and throughput may also be applied.
Users	Users of the Small-ISP.com	The users take advantage of the better and cheaper services, and ISPs competition.

3.3.2. IP Acceleration

Scenario Title	**IP Acceleration**
Keywords	• Faster Internet Access • Network awareness
Application areas	• Web browsing • VPN services
Applications	• VPN • SSL, SOA • Software as a Service
Actors	• Peter and John, founders of Small-ISP.com • Large-ISP.com, a Large ISP
Storyboard	Based on COAST platform, Small-ISP is progressing well. Now, Peter and John are considering new services e.g. VPNs, SSL, SOA, Software as a Service (SaaS). Yet, they still can't invest in a huge link pipe. They contact the Large-ISP and they get advantage of a new offering. The COAST platform (with some small fee) offers the capability to accelerate access to some IP addresses. The platform collects statistics of the different network routers, and automatically adapts the routes in order to follow the lowest congested and more economic path.
Analysis	To support this scenario, the following requirements must be covered: • COAST platform must discover the content (CF1.1), the network topology (CF1.2), the traffic (CF1.4), the terminal type (CF1.6). • COAST platform must provide IP traffic accelerated routing (CF5.1)

3.3.2.1 Stakeholders

Stakeholder	**Description**	**Quality Goals**
Peter & John, (Small-ISP.com)	They want to add new services to their small ISP with minimal capital	They can take advantage of the COAST platform to offer added valued services with small cost.

Large-ISP.com	A Large ISP that offers the COAST platform	Can provide alternative services, with low cost and increased quality. A COAST subsystem will support SLA negotiation and monitoring, and specify the measures to be taken in case of deviation and failure to meet the service guarantees.
Users	Users of the Small-ISP.com	The users take advantage of the better and cheaper services, and ISPs competition.

3.3.3. Protect my privacy

Scenario Title	Protect my privacy (massively remove illegal or not authorized content from the network caches)
Keywords	• User privacy • User rights • Content deletion • Caching
Application areas	• Content hosting • Caching infrastructure
Applications	• Deletion of illegal content • Customer care
Actors	• Anne, 26 years old • Internet users • Customer care representative
Storyboard	Anne is a popular TV newscaster. She is not only a very good journalist but also she is very pretty. Her photographs have appeared in numerous magazines. She has many fans on the Internet and her images are one of the most demanded content. One day, a video showing Anne getting undress at a hotel room appears on an Internet site. The video receives a big number of hits in a very short period of time. Unaware of the dubious content of the video, the COAST platform detects the popularity of the file and starts caching it in order to provide a faster access to it. The video was illegally taken, without Anne's knowledge or agreement. As soon as she knows about the existence of this video, she requests the immediate deletion of the file to all Internet sites carrying it. A customer care representative of one of the sites notifies the COAST platform that the video must be deleted. The video is immediately removed from all COAST caches. Further access to the video is systematically denied and the content is no longer returned by COAST search engines.
Analysis	To support this scenario, the following requirements must be covered: • COAST platform must discover the content (CF1.1), the network topology (CF1.2), the traffic (CF1.4), the terminal type (CF1.6). • Effective caching and deleting of user generated content (CF2.3). • COAST platform must provide IP traffic accelerated routing (CF5.1) • Users should be able to request the deletion of content (AF4).

3.3.3.1 Stakeholders

Stakeholder	Description	Quality Goals
Anne (person)	Her privacy has been violated by a content which the COAST platform has helped to distribute.	Requests for deletion of illegal content must be easy to make and quickly executed.
COAST Platform provider	Provides searching and streaming of content, but also content removal.	The content must be able to be deleted from all caches, removed from search results and further streaming must be blocked

4. COAST Core functionality and services

From the analysis of the methodology used to explore the users' needs and interests, the extracted user insights and the COAST scenarios, some COAST core functionalities (CF) are extracted. Moreover, we group the different scenarios into COAST core services (CS). The CFs are then mapped into the different insights to show how COAST aims to meet some of the project beneficiaries' business targets.

4.1. Core Functionality

From the analysis of the methodology used to explore the users' needs and interests, and the COAST scenarios, some COAST core functionalities (CF) are extracted:

- **CF1: Discovery.** The COAST framework should find where the content and the services reside, including servers, caches and hidden web-sites. Within COAST, the discovery functionality is extended to go beyond the content and services and to identify/analyse what content and traffic is flowing through the COAST network nodes (e.g. routers, residential gateways, etc), via inspection of packets or signalling messages (Deep Packet Inspection). In this way, in the discovery functionality we consider also end-to-end network-awareness and network traffic-awareness per network link or at least at certain network paths.

  Besides COAST operation, this core functionality is also significant as it embodies the initial steps of ***SLA monitoring***. Based on the information gathered at this stage and monitored latter, the SLAs may be negotiated and enforced respectively.

  We may define the following subgroups:

  - **CF1.1: Content discovery in servers and caches.** This core functionality includes discovering of named content (e.g. text, images, html/php etc. web pages, video files and video chunks etc) in different locations of the network (servers, RGs, routers, etc.) and reporting to the search engine. In case supported by the RG, this functionality may be extended in the home network.
  - **CF1.2: Service discovery in servers and hidden web-sites.** This core functionality includes discovering of named web services (based on WSDL etc) in different locations of the network (servers, hidden web-sites, etc). In case supported by the RG, this functionality may be extended in the home network.
  - **CF1.3: Network topology discovery.** This core functionality includes discovering of the network topology including servers, caches, search engine proxies, routers, RGs and communication links between them. Network topology information can be reported to a network server (e.g., ALTO server) that will provide on-demand traffic optimization based on network awareness. In case supported by the RG, this functionality may be extended to also discover the in-home network. The discovery can include the estimation of available capacity of the involved wireless cells and links to be exploited for optimization of content delivery.
  - **CF1.4: Network traffic discovery.** This core functionality includes discovering of the traffic volumes between the different nodes and discovering the level of congestion. Monitoring of the agreed SLA is significantly based on CF1.4.
  - **CF1.5: Content and services popularity discovery.** This core functionality includes discovering the popularity of specific content and services. It will be a combination of traditional popularity discovery methods at the search engine site (by counting the clicks at each hyperlink) and innovative methods at content-aware nodes in the network (based on DPI).

- **CF1.6: Terminal type discovery.** This core functionality includes discovering the terminal type (PDA, laptop, netbook, STB, home server etc). It will be reported back to the network overlay (for content adaptation and enrichment) and at the search engine (for proper discovery of content).
- **CF1.7: User context discovery.** Similar to the previous one, this core functionality includes discovering of the user context (based on combining sensory data e.g. accelerometer. It will be reported back to the network overlay (for content adaptation and enrichment).
- **CF1.8: User location discovery.** This core functionality includes discovering of the terminal and user location, by using location information e.g. from a GPS. It will be reported back to the network overlay (for content adaptation and enrichment) and at the search engine (for proper discovery of content).

- **CF2: Caching**. The content may be efficiently replicated and stored in the network. The COAST framework should be able to replicate and cache the content efficiently at the "*best*" place in the network. Content popularity is also an important factor, while provision for live streaming should also be provided.
  - **CF2.1: Content caching.** This core functionality considers intelligent content caching in the network (including content storage, refreshing and replacement methods). In order to enable VoD or live streaming services the video objects will be split in small chunks that could be replicated and cached separately in network nodes
  - **CF2.2: Cached content removal.** This core functionality considers removal of content as a result of either a normal procedure (information for content expiration) or for administration reasons (e.g. illegal content).
- **CF3: Searching.** The COAST framework should not only find the content that best fits the user query, but also dynamically identify what is the "*best*" host/cache and the end-to-end path (in terms of both efficiency and network-friendliness) for content delivery and streaming to a user. This may also include issues like adaptation of searching, and context (terminal, network, location) awareness.
  - **CF3.1: Content and services finding**. This core functionality is the result of a query, taking into account location, content and service popularity, etc.
  - **CF3.2: Content and services delivery path finding.** This core functionality takes into account the user location (mainly based on IP analysis or any other relevant information) and information related to the content location/cache, service location, network topology and traffic, to discover the "best" delivery path. This discovery is not done by the search engine; instead the search engine queries an external oracle to get guidance on this matter. Additional information (e.g. cost) may also be taken into account.
- **CF4: Adaptation & Personalisation.** The content may need to be "*best prepared*" (adapted) before delivered to the user or even interactively or dynamically adapted. The reason for that may be the user preferences or the context (e.g. the user terminal, network, location, time of the day etc).
  - **CF4.1: Context based adaptation.** Based on a number of parameters (e.g. content type, user terminal, network traffic, user location, etc.), the content may be adapted to "best" fit the user context. For example, in case the user terminal is a low-end PDA and the content is coded using the Scalable Video Coding (SVC) format, the COAST platform may decide to deliver only the base layer, as the terminal may not be able to decode the enhanced layers.
  - **CF4.2: Personalisation**. Based on user preferences (e.g. I want to watch films only in HD), a number of content adaptations may take place.

- **CF5: Routing & Streaming.** Finally COAST should provide for routing and streaming functionality, in a way that achieves the best Perceived Quality of Service (PQoS) based on the content, the user preferences, the terminal capabilities, requirements and context.
    - **CF5.1: IP traffic accelerated routing.** This core functionality takes advantage of the network topology and network traffic awareness in order to route IP packets via the best alternative way. Packets routed towards different IP addresses may receive different priorities at the content aware network overlay.

      This CF also applies to the COAST content/service ***SLAs enforcement***. The system via CF1 acquires knowledge of the network topology, the caches availability and the expected traffic conditions and via CF5.1, it negotiates IP traffic accelerated routing.
    - **CF5.2: Video accelerated streaming.** This core functionality supports efficient video streaming, taking into account different P2P overlays and content types/ encoding formats (e.g. Multi-Description Coding). Similar to CF5.1, CF5.2 also applies to the COAST content/service ***SLAs enforcement***, as it will negotiate video accelerated streaming and perform corrective actions in case the SLA is not met.

4.2. Additional Functionality

Besides the COAST Core functionality, from the COAST service scenarios we may additionally extract additional functionality:

- **AF1: Collect User preferences.** COAST platform should be as transparent as possible. Yet in some cases, the home server or the user terminal should provide a method (API or User Interface) for collecting user requirements and/or preferences.
- **AF2: Video Encoding/Decoding/Adaptation**. Terminals (set-tops, home video servers, mobile terminals) should be able to decode SVC and MVC contents, support free viewpoint or be able to switch between HD and SD, or in general switch between video qualities, resolutions, frame rates etc.
- **AF3: User profile management.** Similar to AF1, the COAST platform should provide a method for collecting and managing more permanent user preferences and store them in a historical user profile.
- **AF4: Access and privacy control.** The COAST platform should provide methods and control for protecting user content (either when it is on the user terminal and home server, or as caches in the network). Moreover, users should be able to request the deletion of content.

These functions may be considered as beyond the COAST main objectives. Yet, proper implementation will facilitate COAST deployment.

4.3. Mapping of insights to COAST technological scope

Before we proceed into the definition of the COAST services, it is worth to see how the different insights are mapped into the COAST technological scope.

INSIGHT	COAST technological scope	COAST Functionality
DHI-1: My Content is Mine	This implies an efficient remote access of personal content wherever the user is. By developing the discovery, search, routing and streaming, one could get accelerated instant access to all his published content. Moreover, via caching, a similar backup functionality could be applied.	CF1.x CF2.1 CF3.x CF5.1 AF4

DHI-2: My life with me	This implies access to personal content through the Internet in a timely manner. By developing the discovery, search, and routing & streaming functionalities, one could get accelerated instant access to all his published content, and via caching, the COAST FCCN will be able to index private content that will reside within the home network.	CF1.x CF2.1 CF3.x CF5.1 AF4
DHI-3: Knowing me is changing me	This implies providing adapted searching and adapted streaming based on the user profile and context. This is also related to the COAST adaptation functionality.	CF1.x CF4.x CF5.x
DHI-4: One device to control all	Context awareness for the user to access efficiently content form which ever terminal he uses. The strength of COAST in this case is to detect which terminal the user has chosen, having the possibility of delivering content to a very wide portfolio of devices.	CF1.x CF4.2 CF5.x
DHI-5: My mobile always at hand	Similar to DHI-4, COAST will deliver the content efficiently to the device, taking into account the type of device and the networking context the user is accessing the Internet from.	CF1.x CF4.x CF5.x
DHI-6: Our TV	COAST can really influence on the quality of accessing content form the Internet on the TV by having better quality streamed to the user and in a timely manner. E.g. accessing preferred content without really caring about the service that provides it over the Internet, search for the newest family videos that are available on other family related networks, devices, home servers etc.	CF1.x CF2.1 CF3.2 CF4.x CF5.2
DHI-7: Technology that enhances (+controls)	By getting the information of the context (who, terminal, network), COAST can access the content that parents really think is appropriate for their children.	CF1.x CF4.x CF5.x
DHI-8: Entertainment for Children	Similar to DHI-7, COAST will be able to provide a much better experience by accessing rapidly and efficiently the content that the user is typically trying to view.	CF1.x CF2.1 CF3.2 CF4.x CF5.2
WSI-1:Users search for all types of content	COAST must consider the wide range of content that Internet is able to offer to the users now (images, music, text, video) and in the future (HD video and live streams, 3D varieties).	CF1.x CF2.x CF3.x
WSI-2: New uses of the web	New uses of the web such as on demand and live streaming of video and music, and social networks. COAST must address this usage patterns to provide a more efficient searching and delivery mechanism.	CF1.x CF2.x CF3.x CF4.x CF5.x
WSI-3: User preferences in searches	COAST must address the mechanism to learn about user context and preferences.	CF1.x CF3.x CF4.2
WSI-4: Search depending on type of device	COAST should address the issue of searching and content adaptation taking into account the type of the user's device.	CF1.x CF3.x

		CF4.1
WSI-5: Search depending on user location.	COAST should address the issue of distributed search engines in order to allow the tailoring of the search results to the user location	CF1.x CF3.x CF4.1
ESI-1: Remote access acceleration	Remote access and in general IP application acceleration is mainly based on network and network traffic knowledge and adaptation issues. Moreover it is mainly related to advanced routing functionality.	CF1.x CF4.x CF5.1
ESI-2: Web site acceleration	This insight requires on the one hand knowledge of the network and the network traffic and on the other hand caching (in case of dynamic rendering in the network), adaptation and routing functionality.	CF1.x CF2.1 CF3.x CF4.x CF5.x
ESI-3: Web-based applications acceleration	This insight is a variation of ESI-1 and ESI-2 combining the required functionality.	CF1.x CF2.x CF3.x CF4.1 CF5.x
ESI-4: On-line Software	This insight is based mainly on the knowledge of the network and the network traffic and on the other hand caching and routing functionality.	CF1.x CF2.1 CF3.x CF5.1
MBI-1: Internet access from the mobile	MBI-1 can be considered as a variation of the DHI-4: “One device to control all” and DHI-5: “My mobile always at hand”	CF1.x CF2.x CF3.x CF4.1 CF5.1
MBI-2: Streaming to the mobile	MBI-2 can be considered as variation of the DHI-6: “Our TV” and DHI-8: “Entertainment for children” and as extending WSI-3, WSI-4 and WSI-5 from searching to streaming.	CF1.x CF2.1 CF3.x CF4.x CF5.2
MBI-3: Infrastructure-less mobile services access	This insight requires on the one hand knowledge of the content location, the network and the network traffic and on the other hand adaptation and routing functionality.	CF1.x CF2.x CF3.x CF4.x CF5.x

4.4. Mapping of user trends to COAST technological scope

On important issue to better position COAST is to compare the COAST technological scope with the different user trends as described in the previous chapter. As we may see in Figure 18, COAST is mainly focusing on users that want high quality services, customised and personalised streaming content in a faster and more efficient way.

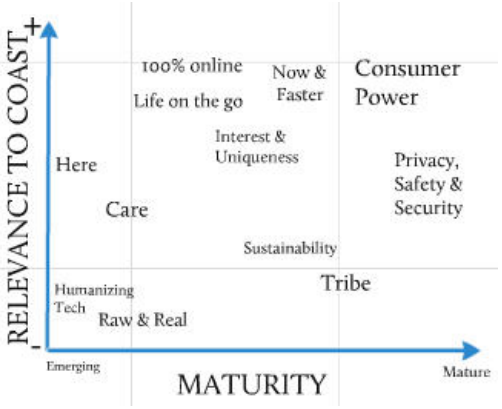

Figure 18: User Trends mapping to COAST relevance

4.5. Core Services definition

Based on the different insights, the user trends and needs and the identified COAST core functionality, we define the following COAST Core services (CS):

- **CS-1: Network-aware Search**. The user is visiting a search engine site and initiates a query. The search engine results are enhanced and more targeted, taking into account network information (e.g. returning search results with content caches that are faster accessed by the user location), and potentially even more sophisticated criteria (e.g. user's context, user's physical movement and operator's costs optimisation).
- **CS-2: Context-aware Video on Demand (VoD).** The user is able to watch his favourite video/film adapted to his/her context (e.g. user's terminal, network path). Only the end-user terminal is fixed, while COAST selects the content that *best* matches user terminal, is cached at the *best* network location, and dynamically selects the *best* alternative end-to-end path for video streaming.
- **CS-3: Personalised/Interactive (3D) VoD and Progressive Download.** The user is able to download and at the same time watch his favourite video/film, which is not only context optimised, but it may also offer personalised and interactive features e.g. the video will be *best* adapted to user's preferences, the user may select the view of a multi-view video, select between 2D and 3D, select between SD or HD and interact in real time with the video.
- **CS-4: Network friendly TV or live events streaming.** The user is able to watch live events and TV over the Internet with enhanced quality, very good continuity and very small start-up/zapping delays, while COAST offers network friendliness by selecting the *best* network anchor for video delivery.
- **CS-5: User generated content sharing.** Besides the traditional ways (uploads to a server like YouTube), the user may utilise the COAST platform features to share or stream his/her own content (e.g. photos, music, videos or even live surveillance) to many recipients, though the available uplink is rather narrow.
- **CS-6: Optimized content mirroring.** COAST platform features may be used to accelerate large files by selecting the *best* network cache and path. Example applications may include on-line software delivery and software updates on-line.

- **CS-7: Web-site acceleration.** COAST platform features may be used to accelerate dynamic web pages rendering on the fly by selecting the *best* network cache and path for different objects' (text, images, videos) downloading.
- **CS-8: IP Application Acceleration.** Enterprises and service providers may utilise COAST platform content, traffic and network awareness to accelerate IP applications. Example applications may include email, core applications accessed over SSL VPN, remote desktop management or even SOA-based service mash-ups.

As can be seen, the COAST core services are defined in such a way that most of them include all COAST core functionalities and cover as many as possible user insights. Of course, this is a small set of services, while the list of potential COAST services may be endless. On the other hand it should be underlined that COAST, as a targeted research project, is not intended to cover all user insights, but to create the baseline technology to facilitate many of them.

COAST Core Services vs. Scenarios	CS-1: Network-aware Search	CS-2: Context Aware VoD	CS-3: Pers./Int. (3D) VoD	CS-4: Network friendly TV	CS-5: U.G. content sharing	CS-6: Optimized mirroring	CS-7: Web-site acceleration	CS-8: IP Acceleration
Video Access on my TV	X	X	X			X		
Publishing my own videos	X	X			X	X		
Media Box TV	X	X	X	X		X		
Context-based search & delivery	X	X	X		X			X
E-learning platform	X	X	X		X	X		X
Always Best Content		X		X				
Web Acceleration	X	X		X		X	X	X
IP Acceleration								X
Protect my privacy	X				X	X		

Table 1: Service/Scenarios matrix

COAST Core Services vs. Functionalities	CS-1: Network-aware Search	CS-2: Context Aware VoD	CS-3: Pers./Int. (3D) VoD	CS-4: Network friendly TV	CS-5: U.G. content sharing	CS-6: Optimized mirroring	CS-7: Web-site acceleration	CS-8: IP Acceleration
CF1.1: Content discovery	X	X	X	X	X	X	X	
CF1.2: Service discovery	X					X	X	
CF1.3: Network topology discovery	X	X	X	X	X	X	X	X
CF1.4: Network traffic discovery	X	X	X	X	X	X	X	X
CF1.5: Popularity discovery	X	X	X	X		X	X	
CF1.6: Terminal type discovery	X	X	X	X		X	X	X
CF1.7: User context discovery	X	X	X	X	X	X	X	

COAST Core Services vs. Functionalities	CS-1: Network-aware Search	CS-2: Context Aware VoD	CS-3: Pers./Int. (3D) VoD	CS-4: Network friendly TV	CS-5: U.G. content sharing	CS-6: Optimized mirroring	CS-7: Web-site acceleration	CS-8: IP Acceleration
CF1.8: User location discovery	X	X	X	X	X	X	X	X
CF2.1: Content caching		X	X	X	X	X	X	
CF2.2: Cached content removal	X	X	X	X	X	X	X	
CF3.1: Content/services finding	X	X	X	X	X	X	X	
CF3.2: Delivery path finding		X	X	X		X	X	X
CF4.1: Context based adaptation		X	X	X	X	X	X	
CF4.2: Personalisation		X	X	X	X	X	X	
CF5.1: IP accelerated routing		X	X	X	X	X	X	X
CF5.2: Video accelerated streaming		X	X	X	X	X	X	X

Table 2: Core Services/Core Functionalities matrix

5. Requirements Specification for the COAST Framework

The following sections contain the specification of the requirements for the COAST framework. Each section focus on a particular Core Functionality as described in 4.1 and 4.2.

The following naming has been used:

- ***Rx.y.z*** corresponds to a functional requirement ***z*** of Core COAST Function ***x*** subcategory ***y***
- ***NFx.y.z*** corresponds to a non-functional requirement ***z*** of Core COAST Function ***x*** subcategory ***y***
- ***ARx.z*** corresponds to a functional requirement ***z*** of Additional COAST Function ***x***
- ***ANFx.z*** corresponds to a non-functional requirement ***z*** of Additional COAST Function ***x***

CF1 Discovery		
ID	Title	Summary
CF1.1: Content discovery in servers and caches		
R1.1.1	Content crawling/ distributed content crawling	The search engine should try to locate the content located in its area of responsibility. The search engine will crawl the web for hypertext, image, video and audio content. The web crawl must be split across multiple search sites.
R1.1.2	Content aware node (CAN) active content crawling	A CAN should analyse the content (text, web page, video, signalling, music) and try to compare it with well known descriptors or information included in the content file in order to identify the content ID.
R1.1.3	CAN send information to the search site	A CAN will send access information to the search site. This information will inform the search sites which objects are being accessed by the traffic, which the CAN is being applied to.
R1.1.4	Use of content awareness information	The search site will incorporate the access information it receives from CAN into its index and crawl seed list.
CF1.2: Service discovery in servers and hidden web-sites		
R1.2.1	Web service crawling/ distributed service crawling	The search engine will crawl the web for web services specification files (WSDL). The web crawl must be split across multiple search sites.
R1.2.2	CAN active service crawling	A CAN should analyse the web pages and extract web services (based on WSDL).
R1.2.3	CAN send information to the search site	A CAN will send access information to the search site. This information will inform the search sites which web services are being accessed by the traffic, which the CAN is being applied to.
R1.2.4	Use of service awareness Information	The search site will incorporate the access information it receives from CAN into its index and crawl seed list.

CF1.3: Network topology discovery		
R1.3.1	CAN node to search site assignment	A CAN node will be assigned to its "closest" search site, "closest" being a function of some metric(s) to be defined, such as geographical proximity or number of network hops. Cost could also be a decision parameter.
R1.3.2	Network topology discovery	Discovery of the underlying networking infrastructure, based on traffic, underlying physical and wireless links and interconnections or management information.
R1.3.3	Home network topology discovery[8]	Discovery if the underlying home network topology is being part of the content delivery end-to-end path.
R1.3.4	Use of topology information	Estimation of the link qualities and optimization of the content delivery path. Cost could also be a decision parameter. This functionality will also be utilised during SLA negotiation.
CF1.4: Network traffic discovery		
R1.4.1	Network traffic discovery	Discovery and prediction of the network load in dependency of the time, area and location
R1.4.2	Traffic information	This information will be sent to a traffic optimization server (e.g. ALTO) for further process.
R1.4.3	Use of traffic information	Prediction of the network load and the achievable throughputs. This functionality will also be utilised during SLA negotiation and monitoring.
CF1.5: Content and Services popularity discovery		
R1.5.1	Content popularity Info	A CAN node will send popularity information to the search site. This information will inform the search site as to how often certain objects are accessed by the traffic, which the CAN (via DPI) is being applied to.
R1.5.2	Service popularity Info	A CAN node will send popularity information to the search site. This information will inform the search site as to how often certain services are accessed.
R1.5.3	Use of popularity Information	The search site will incorporate the popularity information it receives from CAN into the relevance calculates for search results. The popularity will also be used for proper content caching.
CF1.6: Terminal type discovery		
R1.6.1	Terminal type discovery	Identification of terminal type and characteristics. In order to deliver content to the end-user in the “best” way, COAST shall discover the type of end-user terminal and its characteristics. Thereby COAST can select the “best” suited content for the end-user regarding improved PQoS and optimized resource consumption.

[8] Though Home Network is private and in most cases not accessible, in order to offer streaming services, sometimes knowledge of the home topology may be important. So the user may either allow COAST to perform home network topology discovery (given some minimum privacy and security) or this is performed by a COAST RG.

R1.6.2	Terminal type information	The discovery includes the detection of type of terminal: mobile phone, set-top-box, computer, etc., screen characteristics: size, resolution, etc., type of user agent: browser, specific COAST plugins, etc., video codecs, audio codecs, type of network interface, type of access technology, connectivity.
R1.6.3	Use of terminal information	Side-information to optimize the content delivery to the terminal.
NF1.6.1	Terminal discovery plugin	The end-user is required to install the COAST plugins to exploit the complete functionality of the content delivery.
CF1.7: User context discovery		
R1.7.1	User context discovery	COAST shall be able to discover information about the circumstances surrounding the user in the moment of the content request and delivery. Such discovery shall be done in a completely transparent way for the user e.g. discovery and prediction of the user context via smartphone sensory and calendar.
R1.7.2	User context information	The user context discovery can estimate and predict user activity, user location, type of suitable content and connectivity requirements. In particular the following information may be part of the user context: • Terminal type and capabilities. • Network access characteristics. • Location information: Geographical coordinates, Qualified location: at home, on the move, etc.
R1.7.3	User context update	User context may vary from request to request or even during content delivery. COAST shall dynamically detect changes in the User context and react accordingly.
R1.7.4	Use of user context information	The end-user context is employed in COAST as a side-information a) to optimize the content delivery and b) to improve the search results. For search result improvement the context information is provided as additional input to user query (e.g. attached to the user query)
NF1.7.5	Terminal support for context discovery	The end-user has to employ sensory equipped devices that are supported by COAST in order to exploit the advanced features of the “on-the-move” content delivery. Additional software has to be installed to enable the full functionality of context discovery.
CF1.8: User location discovery		
R1.8.1	User location discovery	Estimation of the location via smartphone sensory
R1.8.2	Location information	GPS coordinates
R1.8.3	Use of location information	Prediction of mobility and user needs; provision of the required connectivity; additional information in order to improve the search result
NF1.8.4	Terminal support for location discovery	The end-user has to employ sensory/GPS equipped devices that are supported by COAST in order to exploit the advanced features or enter manually the location information.

CF2 Caching		
Identifier	Title	Summary
CF2.1: Content caching		
R2.1.1	Content identification/naming	Specify a methodology that will identify content and content caches uniquely.
R2.1.2	Content caching	This includes creation of copies of named content at the search engines' data centres, at the proxies and in the network equipment (e.g. routers, servers, RGs etc). Moreover, it includes reporting of the content caching to the most relative (local) search engine.
R2.1.3	Cache policies and management	This includes the mechanisms and methods for intelligent content caching, refreshing and replacement (selecting "what" to store, "where" to store it and for how long). Several optimization schemes could be taken into account, in order to replicate the objects in the strategic network points, reducing latency for accessing the content but without duplicating unnecessary data. Caching strategies will also consider video objects that will be totally or partially distributed in multiple nodes. In particular in order to enable the VoD or live streaming services the video objects will be split in small chunks that could be replicated and cached separately in network nodes
R2.1.4	Cache virtual server	This includes the functionality of a server mechanisms (e.g. a web server), which will act as a virtual content server, distributing the cached content and replicating the original server.
CF2.2 Cached content removal		
R2.2.1	Normal content removal	This considers removal of content as a result of a normal procedure (e.g. information for content expiration or information for the content very low popularity). The result of this action is to free storage space and increase the system efficiency.
R2.2.2	Forced content removal	This considers removal of content as a result of a forced procedure (e.g. information for illegal or dangerous content – virus or Trojan programs).

CF3 Searching		
Identifier	Title	Summary
CF3.1: Content and services finding		
R3.1.1	Closest content selection	The search engine must return the "closest" copy of an object to the user, "closest" being a function of some metric(s) to be defined, such as geographical

		proximity or number of network hops (or even cost if this information is available). Popularity (if available) should also be taken into account.
R3.1.2	Closest web service selection	The search engine must return the "closest" replica of a service using similar metrics as above. Stability, user preferences and cost (if available) should also be taken into account.
R3.1.3	User to search site assignment	The user must be transparently assigned to their "closest" search site, "closest" being a function of some metric(s) to be defined, such as geographical proximity or number of network hops.
R3.1.4	User interface / results	Query interface, results return the closest copy to the user. The results returned must be in a form usable by the user. i.e., the returned identifier for each result must be understood by the user's client software (e.g. web browser).
R3.1.5	Search engine distribution	The search engine must be distributed over multiple geographically distinct sites.
R3.1.5	Search space partition	The search space must be partitioned across multiple sites. The majority of content should have one site assignment, while popular content should be assigned to multiple sites.
R3.1.6	Search engine resiliency	The search engine must be resilient to some nodes becoming unavailable and new COAST nodes being added to the search network.
R3.1.7	Links to search site assignment	While crawling, a search site must transfer links it finds to a search site according to some assignment function.
NF3.1.8	Capacity scalability	The solution must enable capacity increase without having to build larger data centres.
NF3.1.9	Performance scalability	The solution must maintain QPS (Queries Per Second) proportionally to increasing traffic.
NF3.1.10	Latency target	The solution must preserve search latency independent of traffic (no greater increase than 200ms).
NF3.1.11	Load balancing	The solution must distribute load over multiple search sites.
NF3.1.12	User attributes	Search results must take into account the attributes of the user making the search. These attributes could include: geographical location, native language, trending topics on COAST nodes local to the user, information received from DPI.
NF3.1.13	Quality of search results	The distributed nature of the search engine should

		have a minimal impact on the quality of search results.
CF3.2: Content and service delivery path finding		
R3.2.1	Content delivery path finding	Based on R3.1.1: "Closest Content selection" and Core Functions CF1.3: "Network topology discovery" and CF1.4: "Network traffic discovery" this function should calculate the "best" path to deliver the "best" content copy to the user. The term "best" varies from technical issues (e.g. traffic load, links capacity and number of intermediate nodes) to administrative issues (e.g. historical data, trust models, cost etc.)
R3.2.2	Web Service delivery path finding	Based on R3.1.2: "Closest Service selection" and Core Functions CF1.3: "Network topology discovery" and CF1.4: "Network traffic discovery" this function should calculate the "best" path to deliver the "best" web service to the user. The term "best" varies from technical issues (e.g. traffic load, links capacity and number of intermediate nodes) to administrative issues (e.g. historical data, trust models, cost etc.)

CF4 Adaptation & Personalisation		
Identifier	Title	Summary
CF4.1: Context based adaptation		
R4.1.1	Context description	Based on a number of parameters (e.g. content type, user terminal, network traffic, user location, etc.), the content may be adapted to "best" fit the user context. For example, in case the user terminal is a low-end PDA and the content is coded using the Scalable Video Coding (SVC) format, the COAST platform may decide to deliver only the base layer, as the terminal may not be able to decode the enhanced layers. COAST will explore the standards providing tools for a complete description of the different context in which the user can operate.
R4.1.2	Adaptation parameters	Several adaptation parameters will be taken into account. Some of theme are more related to the user device capabilities (screen size, CPU, codec supported, battery status etc.) or the connectivity status (available bandwidth, channel quality indicator, average BER) Other parameters will instead characterize a more generic consumption environment (mobile/static environment, surrounding illumination, noise etc.), or will be related to the user preferences (language, genre, presentation of content, media composition), and the usage history.
R4.1.3	Context based adaptation	Based on context information, COAST context-aware system will have the capability to prepare and present

		the content in the best way for the user. This will be possible by implementing intelligent modules (named adaptation decision and execution engines) that analyze contextual information and dynamically lead to a variation of the content, trying to satisfy a given utility (it may be PQoS, bitrate or a generic user preference) In case of rich-media contents (SVC, MVC, MDC) the result of the adaptation process will directly act on the video bitstream. By means of low-complexity operations involving the parsing video data packets headers only, it will be possible for example to reduce on the fly the resolution of scalable video contents in order to match the lower capabilities of a mobile terminal.
R4.1.4	Dynamic adaptation	Significant changes in the adaptation parameters during the content delivery session shall produce a re-adaptation dynamically. For example changes in capabilities of the terminal (i.e. reduced battery level), or in connection quality (increase of BER in the wireless link) that may degrade the quality of service, will automatically start an adaptation action intended to change the composition of the content (i.e. reduction of scalable layers) to meet again the minimal quality requirements or the constraints defined by the users.
NF4.1.5	Automatic preparation / presentation of the content	The COAST contents and services will be prepared and adapted in an automatic and transparent way for the user (no need of interaction with the system). The implementation of encoders in the COAST hardware platform will introduce format constraints in case of real time processing. Therefore, offline encoded content will be used for most investigations within this project. It can be assumed that future implementations will overcome current restrictions due to technology advancements
NF4.1.6	Continuity of service and smooth playback	Context adaptation will drive the tools able to guarantee PQoS and continuity of service for high resolution and 3D video contents, in particular for delivery over wireless link, that are more prone to high PER and congestion. For such media contents the user will experience a smooth streaming service without interruption.
CF4.2: Personalisation		
R4.2.1	Implicit personalisation	The COAST functionalities which may be subjected to personalization are: • Content consumption and adaptation: users shall have control over how content is presented on their terminals.
R4.2.2	User preferences (explicit	COAST shall allow users to explicitly set a number of

	personalization)	configuration parameters. Some of these possible parameters may be: • Content consumption and adaptation: the presentation of content on the user terminal may be configured according to parameters like: Preferred content format (SD, HD, 3D, etc.), screen orientation (portrait, landscape, automatic, etc).

CF5 Routing & Streaming		
Identifier	Title	Summary
CF5.1: IP traffic accelerated routing		
R5.1.1	Accelerated routing	This core functionality takes advantage of the network topology and network traffic awareness in order to route IP packets via the best alternative way. Packets routed towards different IP addresses may receive different priorities at the content aware network overlay.
R5.1.2	Routing strategies	Taking into account the physical links to define the "always best connected" or "always available" scenario.
R5.1.3	Quality metrics	One way delay, round-trip delay, loss, bandwidth, etc. This functionality will also be utilised during SLA monitoring and enforcement.
CF5.2: Video accelerated streaming		
R5.2.1	Streaming efficiency	It needs to be investigated to what extend the capacity of storage devices and the access speed is a limiting factor of the streaming chain.
R5.2.2	Communications (signalling, transport) protocols backwards compatibility.	Backward compatibility regarding communication protocol would be a major requirement. E.g., well-established protocols such as RTSP need to be supported for session set-up. Transport protocols for scalable and multi-view content formats need to either follow existing standards or be standardized in order to allow interoperability. On the other hand, legacy streaming involves RTP/ UDP which can create issues with NAT (Network Address Translation). Advanced approaches such as HTTP streaming have to be designed carefully in order to fulfil near real time delivery requirements wherever applicable.
R5.2.3	New signalling protocols requirements	New features (e.g., view selection) require new or at least extended protocols. Protocols for high level signalling of connections via proxies need to be specified.
R5.2.4	Video multicasting	Some features require multicast capabilities.

R5.2.5	Streaming strategies	Efficient video streaming, taking into account different P2P overlays and content types/encoding formats (e.g. Multi-Description Coding).
R5.2.6	User interaction	Depending on the required user interaction, protocols need to be selected and/or specified.
NF5.2.7	New content	Appealing media contents is needed (3D, multi-view, high resolution). Moreover, rich structured media will be considered: SVC, MDC, combined SVC-MDC, MVC video contents
NF5.2.8	Non-functional quality metrics	Quality metrics for system assessment needs to be specified. Start-up delay, continuity, bandwidth, etc. This functionality will also be utilised during SLA monitoring and enforcement.

Additional Functionality		
Identifier	Title	Summary
AF1: Collect User preferences		
AR1.1	Collect user preferences	COAST shall provide a mechanism to let the users set the available user preferences. SW modules able to collect terminal and user preferences will be installed in user devices (as part of the COAST SW plug-in) This mechanism shall not prevent the operation of the COAST services if the user decides not to set any preference or if the terminal does not support this functionality.
AR1.2	User interface	Easy to use, adapted to TVs and mobile phones, etc. The user interface for setting the user preferences shall be: • Easy to use: inexperienced users should have no problems to operate the user interface. • Adapted to a wide range of terminals, with special attention to mobile phones and TVs. • Consistent across different terminals. • Easy to access but without interfering in the normal operation of the services.
ANF1.3	Location of the User Interface	Depending on technical constraints, COAST may provide either a single user interface to set all available preferences or separate User Interfaces for different sets of preferences. For instance, search preferences might be set on the search engine while presentation preferences might be set on the terminal.
AF2: Video Encoding/Decoding/Adaptation		
AR2.1	Pre-encoded content	Content shall be encoded offline since real time hardware encoders are not yet available.
AR2.2	Backwards compatibility	COAST streaming servers shall support well-

		established protocols such as RTSP for session set-up. Transport protocols for scalable and multi-view content formats need to either follow existing standards or be standardized in order to allow interoperability.
AR2.3	Adaptation to the terminal capabilities	Real-time processing capabilities of the terminal may impose constraints with respect to content formats, e.g. video encoding, resolution and frame rate. COAST shall adapt the content to these constraints.
AR2.4	Transparent adaptation	Content adaptation shall be transparent for the user.
AR2.5	Preferred decoding terminal capabilities	Support for SVC, MDC, combined SVC-MDC, MVC video contents
AF3: User profile management		
AR3.1	User profile information	COAST shall be able to store user related information in the form of a user profile. The user profile may include the following information: • User credentials. • User preferences. • User history: search requests, delivered content, sessions and associated context information, etc. • Information derived from the analysis of the user history: user interests and likings, preferred types of content, usage patterns.
AR3.2	User profile management	COAST shall use the information contained in the user profile for the implicit personalization (by using the user history information). However, explicit personalization should also be available including user preferences update.
AR3.3	User registration	COAST shall provide the users the opportunity to be registered into the system. User registration allows COAST to create and maintain a user profile and thus provide personalized services. Non-registered users shall also be able to use all COAST services but will not enjoy a personalized experience.
AR3.4	User authentication	COAST shall provide a mechanism for the authentication of the registered users. This mechanism shall be as transparent as possible.
ANF3.5	Privacy of the user profile	COAST shall protect the privacy of the users regarding the information stored in the User Profile. For this purpose COAST shall prevent that the User Profile can be traced to a particular person.
AF4: Access and privacy control		
A4.1	Privacy control	COAST shall not access any content stored in the user's terminal unless explicitly allowed by the user.

A4.2	Access control	COAST shall allow access to user content only to those users who have been authorized by the content's owner.

Before we close this chapter, we would like to emphasize the requirement of **backwards compatibility**. Though this requirement puts many obstacles in the system design, it is critical as it guarantees progressive deployment and realistic exploitation of the system.

6. Business Aspects

This chapter analyses the business aspects affecting to the different COAST stakeholders. First we give an overview of the business perspectives for the COAST services and then we explore the business models resulting from the COAST framework.

This is a preliminary analysis that shall be further expanded in Task 8.1.

6.1. Business Perspectives in COAST

6.1.1. Residential Broadband Services

Below we summarize the relevant challenges related to the COAST objectives in Figure 19 and thus the COAST consortium will focus its effort in order to pave the way and surpass the pinpointed challenges.

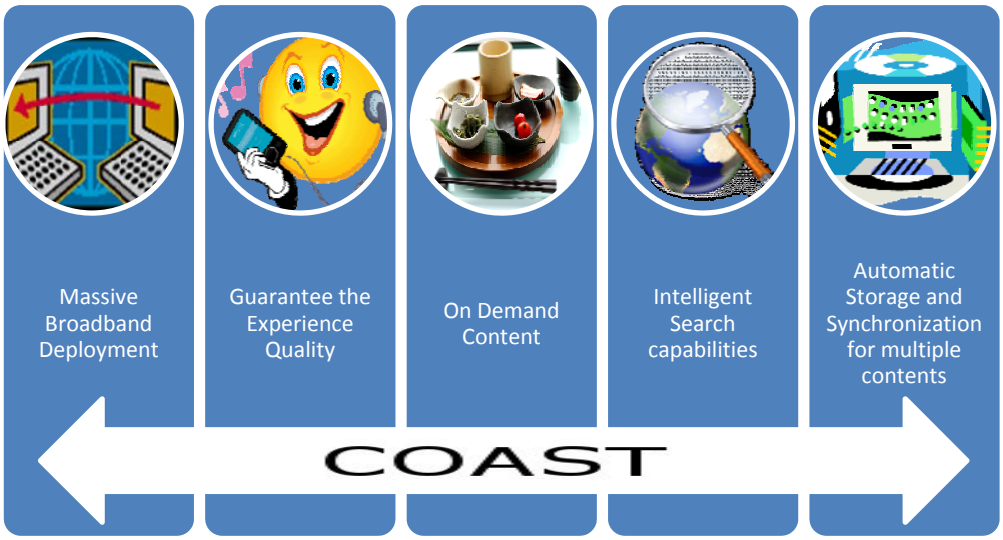

Figure 19: Residential BB services challenges related to the COAST objectives

6.1.2. Internet Search Engines

Among all services that Yahoo! owns and offers to users worldwide, search is one of the most important and contributes significantly to the company yearly revenue. In the USA alone, there have been 14.7 billion core search queries in December 2009 across the main commercial search engines (source: ComScore). An older study shows more than 24 billion in Europe in May 2008 (source: ComScore). Given the volume of queries worldwide, advancing search technology becomes of critical importance to keep the competitiveness on the search market.

One aspect of search which is underdeveloped is the one of tailoring search results to local preferences, partly due to the constraints current search engine architectures impose. Yahoo! Europe, for instance, comprises local sites for UK and Ireland, France, Germany, Italy, Sweden, Norway, Denmark and Spain. Each site offers local language information and e-commerce services dedicated to meeting the needs of local consumers. Given the presence of its portal in several countries and the importance of the search market, being able to tailor search results to local markets even further represents an important business opportunity. Moreover, the development of an architecture that enables breaking up markets into smaller portions even further enables an unprecedented degree of customization.

Relating to COAST enabling technologies, the following is a list of potential opportunities for search engines given the technologies that are proposed in the context of the project:

Deep-packet inspection: Deep-packet inspection represents a key opportunity for search. Many mechanisms inside a search engine require input on user preferences, but they are often limited to the accesses processed directly by the engine;

Network feedback: A tighter integration between the search engine and the network enables the engine to adjust results according to location of the user and the conditions of the sources. For example, the engine can point a user to the nearest cached copy of objects among search results;

Object and result caches: Caching intelligently content on the network and informing the search engine of such locations can improve the user experience if the engine uses such pointers to redirect users;

Distributed architecture: There is evidence that multi-site search engines enable lower operational costs by reducing the size of indexes to process queries and by reducing communication costs. However, it is still necessary to explore further how to crawl and index efficiently, and how to improve relevance of results based on the locality of queries. Future search engines must be energy-efficient as well as increase relevance of search results.

6.1.3. Set-top-box market

The STB market is experiencing a constant growth in the past few years, thanks to the novel encoding technologies and standards new delivery services are available with an increased video quality and resolution. The transition from Standard Definition (SD) to High Definition (HD) set top boxes, as well as the integration of Personal Video Recording (PVR) capability are providing STB vendors a solid growth opportunity; also in the future HD/SD boxes and systems containing hard drives for video recording will both add unit growth, and not only in the new market of emerging countries.

Market analysis also show an increase in the number of hybrid STB, supporting both IPTV and DVB-S/T services. Thanks to the availability of in home broadband connections, the potential of growth for "Connected TV" (for both IPTV and InternetTV services) is expected to reach 223 million TVs worldwide by 2012, with game consoles and set-top boxes continuing to increase sales. (source: IPTV forum)

Such a growing market will greatly benefit from the technologies that will be implemented during the COAST project. The aim of COAST is in fact the realization of a FCDN capable of offering to each user a fast and efficient research and retrieval of high quality contents, adapted to network and terminal conditions and to user location and preferences; furthermore novel interactive services will be possible for users (i.e. on the fly interactive 3D viewpoint selection). With COAST the connected STB will become the real multimedia centre of the home. Therefore the overall COAST infrastructure will clearly introduce great opportunities to boost the STB and STB chipset market.

In particular, we foresee the following potential business opportunities for the STB market:

- Set-top-box are becoming nowadays more and more powerful in term of memory and CPU capacity; the increased processing power can give for example the possibility to decode multiple HD streams in parallel or to support novel PC-like functionalities (i.e. web browsing, picture browsing, Internet streaming). Based on these powerful CPUs it will be possible to build SoC supporting the advanced video codec standard (such as MDC, SVC) that have proven to greatly improved the perceived quality of the video stream.
- In COAST novel technologies for 3D/MultiView coding and streaming will be studied and developed. 3D and MultiView will be the key video technologies in the near future; completely new visual experience will be available for the users, as well as novel business opportunities for service and content providers. Thanks to the COAST video and network technologies, 3D/MultiView contents will be delivered in real time over the Internet; distributed overlay topologies will be also considered in order to efficiently use network resources. Apart from the 3D vision the users will have the opportunity to interact with the stream changing on the fly the three dimensional view-point, incredibly enhancing the reality

of the watched video content. The introduction of 3D/FVV services will lead the development of chipset for the support of the new MVC video coding formats as well as powerful graphics processing units (GPU) for 3D rendering.

- Nowadays STB boxes have great storage capacity, as they are usually connected to HDD. This storage is mainly used for PVR services. The COAST network will provide to its customers the possibility to access from remote sites the contents stored locally in their STB cache.
- The COAST network overlay will enable the real time distribution of user-generated multimedia contents. These features will be possible also thanks to the implementation of efficient P2P protocols supporting RT streaming. Users connecting their STB to the COAST infrastructure will be able to produce and distribute non-professional and high quality video/audio contents; also novel services based for high quality Video-Conference will be available with COAST. This means that novel powerful chipset supporting RT encoding of high quality H.264/AVC and SVC contents as well as specific processors to HW accelerate the P2P engine will be required by the market.
- The future COAST STB won't be only the terminal point of the delivery chain, but will be also able to redistribute the content inside the home network. Redistribution will require new server capability for STB, and the possibility to adapt the content according to the each terminal connected to the home network. Even in this case, ad-hoc chipset may be introduced to accelerate in HW the process of on-the-fly inspection and adaptation of the contents.
- COAST will add novel social features on the top of the existing IPTV services available for STB (for example on-line comments/video-chatting during the vision of a content, possibility to manage incoming audio/video phone calls, on screen notification of sms and messages etc.).

6.1.4. On the Move Services

Mobile phones are becoming important as a source of information while we are moving. They are small devices that fit in everyone pocket and we bring them with us every time and everywhere. Hence they can be extremely useful sources of information. Mobile phone platforms are becoming open to applications generated by users or third parties, independently from the company that generated the hardware. This paradigm allows more creativity and innovative services, sharing the revenues also with the application providers.

One promising application is to provide tourism information about the surrounding to the user. Some similar services were also foreseen in the past [7] [8]. Tourist Promotion office may pay a Mobile Telephony Operator for the service to promote the tourist locations. Tourist Promotion Office itself may raise revenues from local hotel managers for whom it could provide advertising. Alternatively a company may provide the user with some tourist information about the places where he is located, for example, a small movie about the area and the history of the place. The movie can finish with a link to the company Internet site, where further information about availability of hotels, cinemas and commercial centres in the surrounding. Such services are already foreseen in the current MBMS specifications ("…Precondition: The user is a registered with an MBMS Broadcast service providing streaming audio and/or visual content related to a local area, such as audio and visual guides to local attractions, traffic reports etc…" in [9][8]). The MBMS technology is now getting some momentum. In a recent article[3], Nokia declared it "might start supporting the MBMS technology with its future device launches". Also operators are considering the technology for future services [10]. In Italy, Telecom Italia together with Qualcomm and Huawei conducted field tests some time ago.

A business which may be connected with the previous one is geotagging. Users may upload photos and video of their holidays and containing shots of monuments and places of a particular interest. The user generated content is tagged with a GPS coordinates so that the content can be placed on a map. Panoramio is offering a similar service. In one interview, Eduardo Manchon, co-founder of Panoramio, is showing the business model behind his services. As uploaded contents are geo-located and contains textual information, Google Adsense allows adding some banners presenting

accommodations and further information on the place [11],[12]. One correlated opportunity was presented in[12]. The user may upload a photo of a particular place that attracted his attention and the server provides some useful information about the content of the photo and the surroundings. Also in this case, advertising about restaurants and accommodations on the surrounding, together with additional information other interesting places would allow revenues from the service.

Advertising to mobile phones seems is gaining momentum in the last years [15]. According to recent news from Reuter [14], this segment should take off in the next two to three years, driven by new applications for smartphones and popular social networks as Facebook. According to Ineum Consulting, mobile advertising is seen growing at annual average of 45% to 28.8B$ in 5 years. A similar figure was given in [12] for viral marketing, boosting from 1.8B$ in 2007 to 24B$ in 2013. Viral marketing is a set of marketing techniques that uses pre-existing social networks to produces increases in brand awareness or to achieve other marketing objectives, such as product sales. MeYou is an application from MoConDi, a company specialized in products and services for mobile content distribution. MeYou rewards users for purchases and recommendations with redeemable credits [12]. Knowing the GPS position of the mobile phone, a subscribing user may receive information about surrounding shops sales, restaurant menus, cinema movies. Users are encouraged to write a review about their experience in a particular place. Consumers are rewarded by the saving purchase time, additional quality about the product and credits for future purchases. Knowing the user tastes allows selecting the advertising that are more likely to produce a purchase, reducing costs of unsuccessful advertising and gives the company an immediate feedback about the perception of consumers about the offered products, saving extra money for consumer surveys.

Final users of the COAST solutions will enjoy higher performances for audio and video streaming, bringing more users to the operators that make use of the technology. Akamai – the largest delivery network in the world – is exploring a similar technology for iPhone, based on a server component, the Akamai network and the client software [16]. Akamai is using HTTP and HTTPS streaming of H.264 over MPEG-2 transport, splitting the stream in short media files and the streaming protocol switches between bitrates according to network conditions and smooth quality playback experience.

6.2. Business Models

In this section we do not pretend to establish yet another methodology in order to construct business models. After analysing the available bibliography ([17], [18], [19], [20]) on business modelling, we will introduce below in a summarized fashion the business models coming out of the different scenarios introduced above, categorizing them by well distinguished market areas. The latter in order to simplify the value chain and outlaying relationships.

The main characteristics that will be analyzed are:

- Value proposition, describing a product or a service that could be offered and sold based on COAST and how it has a value to our customers;
- Customers and market segments, who our target customers could be and how they are distributed in various markets and market segments, and how we will reach these customers with our offering through various customer interfaces.
- The technical realisation of the COAST services leading to a cost structure and profit potential, how all the costs of bringing our product to market could be allocated on various elements, and how we propose to generate revenue and hence profit from the offering;
- Internal value chains, how we are proposing to produce and distribute the product or service/s, including all the necessary operational aspects and capabilities necessary for conducting a sound business; and the
- Strategy for positioning and competition, the strategy we propose to pursue in order to position ourselves in the marketplace and to compete successfully for customers and revenues.

It is important to mention that the business models presented here are a first approach of what we think COAST can deliver in terms of services at a very premature stage in the project when the first scenarios are drawn. The service concepts and implementations will be later analyzed and evaluated in WP7 by real users leading perhaps to some transformations on the models presented below.

COAST services introduce multi-stakeholder benefits. This fact justifies the need of dividing the business models into different sub-models depending on the final user that is addressed by the scenarios end-users. Benefits are the key drivers for a company when designing a product strategy

In more details a number of benefits for the end users, the service provider and the telecom operator may be summarized in the following:

Benefits for the End-User	Services
Simpler operation. The user does not care about the content location. He/she gives the name or the description of the film and the system finds the server in the network.	CS-1, CS-2, CS-3, CS-4
Faster content delivery/smaller start-up time. The content may be already cached in a server close to the user (even at his RG or home server).	CS-1, CS-2, CS-3, CS-4
Personalised video. In addition to the video location and the network path selection, the video is adapted to the user terminal, context and preferences.	CS-2, CS-3, CS-4
Better perceived quality of service. The video is streamed via the *best* alternative end-to-end path, where only the end-user terminal is fixed, while the content location and the network links are flexible.	CS-1, CS-2, CS-3, CS-4
Security and privacy. The user is sure that the content that will be streamed is the original and that his privacy is not at stake.	CS-1, CS-2, CS-3, CS-4, CS-5
New user experience. The video may be interactively adapted, selected modified	CS-2, CS-3, CS-4

without losing the video continuity.	
Scalability & availability. The prosumer does not need a broadband uplink connection. The necessary scalability and availability will be increased as they are outsourced to the network/telecom provider.	CS-1, CS-2, CS-4, CS-5, CS-6, CS-7, CS-8
Lower start-up and operational costs. The prosumer not need to invest in super video servers and expensive infrastructure. Only a few end-users will go directly to the service provider servers. After the start-up overhead, the content will be stored in the network and local caches closer to the user will be preferred.	CS-1, CS-2, CS-4, CS-5, CS-6, CS-7, CS-8
Enhanced/Personalised content retrieval. The user (either individual or enterprise) may take advantage of the COAST intelligence by receiving query replies which lead to faster content delivery, enhanced search results and better QoS.	CS-1, CS-2, CS-3, CS-4
Faster IP connectivity. The user (either individual or enterprise) may take advantage of the COAST network-awareness and services provided by the network/telecom operator to provide faster access to his/her web site.	CS-6, CS-7, CS-8

Benefits for the Service Provider	Services
Lower start-up and operational costs. The service provider does not need to invest in super video servers and expensive infrastructure. Only a few users will go directly to the service provider servers. After the start-up overhead, the content will be stored in the network and local caches closer to the user will be preferred.	All
Scalability & availability. Though the service provider will invest less for the infrastructure, the provided availability & scalability will be increased as they are outsourced to the network/telecom provider.	All
Faster IP connectivity. The service provider may take advantage of the COAST network-awareness to provide faster access to his/her web site, IP applications , SOA services, etc.	All
New business and added-valued services. The service provider may take advantage of the COAST network-awareness to provide new business and service differentiation, better PQoS, while in parallel may offer new services and features including user profiling and preferences, HD or 3D streaming etc.	All
Advertisements/Replies promotions. The service provider may provide faster and more accurate searching results. In parallel, may get profit from side advertisements that may appear in parallel to the searching results or under contract promote specific web sites or service providers	All

Benefits for the Telecom Operator/ISP/Network provider	Services
Lower infrastructure costs. The network/telecom provider drastically lowers the operational costs by replacing the long, fat and expensive wan and metro network pipes with low-cost distributed storage.	All
New business and added-valued services. The telecom operator may take advantage of the COAST network-awareness to provide new business and service differentiation, better PQoS, while in parallel may support new services and features (e.g. HD or 3D streaming) without any additional investments.	All

The above benefits are further materialized into specific business models.

6.2.1. Value Proposition

The value proposition of a product or a service is the set of functionalities and characteristics that will provide the final user with improvements or new advantages on the area the new service is offered. This means that the value is not directly linked to the actual use, but the availability for use. E.g. a security service has high value even if it is very seldom or ever used.

The value proposition of COAST must take into account the total picture of potential different services that may be offered by the introduction of the new functionality and network equipment that COAST implies. Hence the same functionality may enable several products/services that will for sure and can be offered in the near future. For the end user/customer (in this case we are talking about a residential user) many new potential products may therefore be purchased that may in combination with the network elements implement a given set of functionality enabled for example by the searching engine enhancements of COAST. Each product will individually or as combination (bundle, or service package) have a value for the user. The individual products or the service package will also be looked upon in terms of revenue for the operators/service provider. How the different services are bundled or packed as service packages could affect the attractiveness for the end users and his/her willingness to pay and customize and use the COAST related service functionality. To be able to grasp the impacts of COAST each main service category identified for the home based services will be analysed separately in terms of value for the user. When discussing the cost one must bear in mind that many services may be realised on the same basic network technology platform so the increase in cost could turn out to be minimal.

The value proposition for the identified service areas is described below:

1) **Optimal Access to Web content**

   From this service will benefit everyone that is accessing Internet via a service provider that has integrated the COAST technology on its network elements and servers. The technology enabling optimal web access to web content will also be able to support for example business workers to access business related information at their office building or at home. The residential user is examined in this business case trying to get content of practically any kind at home or when he is on the move. People today, especially young people share and access pictures, videos, games, books, emails or other data that are stored on the Internet. This information is uploaded to the Internet coming from “anonymous” cameras video-recorders etc. Today, videos, games, music tracks are easy to download from the Internet and many music stores, newspapers and bookshops for example, have contracts with people to download daily or weekly newspapers, selective video clips, booklets etc. People would like to be able to access this personal information wherever they are in a timely manner and almost automatically.

   In different situations and moments the user will try to access this type of information, and most of the cases very much related to his past internet activity, to the actual location where the home is. By enabling the COAST networking functionalities, installed in most the cases on network nodes, the service that is in essence not new will experience an important boost in real quality (perceived and measured) and will certainly change the way Internet in conceived. By this service one can e.g. log onto any Internet enabled device at home and access content on the web in the most optimal way since the stream of data will be adapted also to the user context (e.g. network conditions and terminal used, etc.).

   Information that would be accessible would be of any kind, including but not limited to:

   - Videos, games, pictures, music tracks.
   - Newspapers, books and other papers.
   - Receiving streams from live events

2) Publishing of user generated content

Users are more and more interested in publishing their own content. People is now communicating and integrating themselves into Internet communities that allow them to share experiences, tastes, knowledge and opinions. They appreciate a lot the technologies that will allow them to publish in a simple and fast way their content (pictures, videos, etc.). They are worried about the fact of not having the control of the information they have introduced in the Internet. In the same way, they would like their content to be accessed and thus referenced by search engines in a more effective way. With COAST they will be able to publish content directly from their home environment using for example networked discs that will be indexed by search engines.

At the same time if the latter content is being accessed, by other user it will soon be automatically cached in the core network to be accessed in a more effective way, eliminating the restrictions imposed for example on the uplinks of common ADSL connections.

3) Personalized and optimal Internet TV

Users are now shifting their spare time from TV watching to Internet video services such as YouTube. Internet is thus impacting TV and now also it is being mashed-up with the Internet by including, in an easy way, several widgets that allow the users to watch, in a very friendly manner, their local weather, the news, photos on Flickr, etc. as they are watching a given program.

Still the quality and the speed of the connections do not allow viewing Internet videos and content in a timely manner on TV sets with the expected quality. It is not easy to search content from the TV due to the fact that normally search engines do not take into account personal profiles, the content location, the history of the user experience and use of the Internet. Users would like to access almost immediately the types of content they normally like, they would like to get information about the content itself (its proximity and relation to his own tastes). The experience of watching Internet TV/video streams should be similar to a normal TV broadcast channel. COAST will certainly pave the way for this.

4) Live events streaming

Users are not only interested in existing content stored on servers, but they highly appreciate live content and the feeling of being present at an on-going event. In addition to live programmes provided by broadcasters and the professional segment of electronic news, the availability of cameras in mobile devices opens the opportunity for any user to share a live event with a community that is not present at the event. Here, the COAST technology will boost the video distribution to multiple receivers. In addition, live streams can be distributed using new techniques for media delivery. This will overcome restrictions of a wireless uplink which would prevent transmission of the live video stream to multiple recipients through concurrent point-to-point connections. Future devices will also provide sufficient resources for SVC and HD encoding or even 3D capabilities.

5) Enhanced search and indexing of contents on the Internet

Search functionality is indispensable when the amount of information available is large. Users have depended upon web directories and search engines to find relevant content on the Web for over a decade. With the growth of the Web and the increasing number of users accessing content on the net, the task of building commercial search engines has become increasingly difficult. One particular drawback of current search systems is the reliance upon single large data centres to crawl, index, and process queries. Being able to efficiently split the functionality of search engines across data centres is critical to enable search engines to keep up with the growth of the web.

Although dealing with infrastructure issues is important, it is also important to accommodate new user requirements. It is natural that users become more demanding over time with respect to search services. Consequently, users not only expect access to a broader set of web content, but also to have new mechanisms that simplify the task of searching over web content.

COAST enables a search engine to determine the popularity of content by inspecting packet flow in the network. Popularity information is important when ranking objects upon a search query and has the potential to improve the search result quality. COAST further enables a search engine to discover new content quickly by inspecting network traffic, i.e., through passive crawling. The passive crawling strategy leads to effective real-time indexing and also increases the content coverage of the search engine.

The search engine makes the content on the COAST network searchable/accessible by providing pointers to the content in its search results. Moreover, it provides the functionality to detect the closest copy of the content with respect to a user location. Locating a copy near to a user improves the overall service performance: users are able to watch videos more conveniently or to download pictures faster, for example.

6) On the move content access

Users more and more require to be offered meaningful content while they are on the move. Although the service providers have been addressing the current user needs in that they have improved their service (improved connectivity, mobile devices, data rate business models, etc), the end-user still has to spend much time to manually search for and select the needed content. Time and PQoS however are critical attributes especially when users are on the move. As the content selection does not necessarily regard the current connectivity, end-user terminal, and requirements (user profile and activity), the selection of meaningful content and perceived quality of service (PQoS) in content delivery are not satisfying.

COAST allows for new and smarter services in content delivery in that it combines the knowledge of available network capabilities and end-user devices capabilities with the user context and needs. Thereby not only is meaningful content selected for the user, but it is also ensured that this content can be delivered in time in case of a download or with stable and reasonable quality in case of a streaming application. While COAST improves the PQoS, it allows for a new user experience as it finds meaningful and needed content that the user will probably consume.

6.2.2. Customer and market segments

COAST targets a very broad market. In this chapter we analyze the private segment and the enterprise segment. From the value proposition, we see that almost all kind of users could be attracted by the COAST benefits.

1. ***The Private Sector.*** The potential customer types may be segmented in different ways such as, age, education, income, etc. For COAST the segmentation could be based on age since the services should be easy to understand and use. Examples of such segments could be:
   - Young kids,
   - Youth,
   - Middle aged (single),
   - Middle aged (family with kids) and
   - Elderly people.

   The market segments that are most relevant to make use of the COAST functionality may include all age groups. Internet and TV services are popular for all segments. Although it is true that young users are the most likely to share and publish their own content. They are now

mostly interested on the content that lies on the Internet and less and less on what the conventional TV has to offer. Older people are more likely to demand more an optimal Video on Demand service which will feature a simple to use search facility allowing them to get what it fits better to their tastes.

2. ***The Enterprise sector.*** In this sector again COAST may offer attractive solutions for a wide variety of enterprises. In most economic activities, Internet presence and business web operations is almost a "must". Therefore COAST can offer really attractive improvements on all these areas were increased efficiency and quality for internet access and content delivery.

   Below a typical and general segmentation is listed. For COAST it is not really important to further elaborate on the industry sectors since the COAST value proposition relies mostly on how content is accessed. Nevertheless we could mention specifically that enterprises dealing with video streaming would be specially targeted by some of the COAST features.

   - SOHO (Small Office, Home Office). Less than 10 employees and normally handling niche markets or support activities. They normally have little or none own infrastructure.
   - Small business market. We are talking here about enterprises of less than 100 employees. They have typically an important IT infrastructure and Internet is most probably on the core of their business in many possible ways.
   - Medium enterprises
   - Large enterprises

   The two latter enterprise types normally have strong links with the Internet in terms of use for internal operations or of the provisions of services directly to their own clients. COAST addresses for sure these two sectors.

6.2.3. The technical realisation of the services

COAST will support a rich variety of services by creating a technological framework allowing users to access content in a very effective way. Automation and flexibility together with always accessibility to the content will create a new way people perceive the Internet which will be characterized by the proximity to their own tastes, to their context, allowing them to be a part of it from their own homes. This however demands upgraded functionalities and a new architecture not only at the network side but also upgraded functionalities on the devices (on the middleware side). To analyse the business profitability of COAST these technical issues need to be taken into account as a fundamental prerequisite both for conducting techno-economic analysis of cost/revenue and for the business modelling.

The main technological entities for the realisation of the COAST services are:

- Firstly, upgraded routers at the core network, able to identify the type of content that is flowing through them.
- Secondly, network elements such as servers, routers with storage capacity, data centres that will store and cache content to allow users to get faster to content copies closer to them.
- Thirdly, Search engines that will be using the information provided by the latter elements to index better the content that the users are looking for, addressing copies that are closer to the users.
- Fourthly, content processing engines at the network that will automatically codify and stream the content to the users in an optimal way taking into consideration context information such as networking capacity, device capabilities, etc.
- And finally user end devices that will feature middleware (small footprint code in the form of web services most probably) that will allow them to be referenced by the above network elements and to provide for example context information.

The functionality of all components is vital to realise the COAST concept and must be taken into account when conducting a techno economic analysis of the business profitability.

6.2.4. COAST value chain

In this section, we present reference roles (for the stakeholders) and relationships model for the COAST business model. Its main objective is to offer a menu of roles (stakeholders) expected to take part to the COAST business environment. The reference Roles and Relationship Model (R&RM) can thus be used as a basis whenever building a concrete R&RM for any COAST-based service/product.

The business roles identified are a result of our modelling approach where we combined a top-down view that takes into account the results of investigating the genuine values of the COAST concepts, and bottom-up view that considered business roles identified in the scenarios described in this deliverable. The relationships between stakeholders will be discussed as well. In this sense, a relationship reflects the "what" is delivered between the parties (contractual relationships) and what does the actor get in exchange? (payment relationship).

The following stakeholders are identified in COAST:

- **End-User:** the people that will enjoy from the services being offered via COAST.
- **The Subscriber:** An individual who signs a contract with a service provider such as an ISP to get Internet connectivity.
- **The Network Operator:** Company providing the IP related traffic.
- **The Internet Service Provider**: In the case of COAST we talk about any of the content related services such as YouTube, Flickr, Facebook, etc.
- **The COAST Service Provider**, who may be different from the network provider.
- **The Content producer:** In COAST the final user may have this role and thus must be included.
- **Network and IT Equipment Vendors:** They are included in a singular stakeholder since their relation with the others will be very similar in the model. They must include the facilities needed to establish the CDN aimed by COAST.
- **CPE vendor:** Will provide the customer related equipment that will have to be able to support the COAST scenarios. In principle not very demanding requirements are expected.
- **Internet Search Engine Provider:** this is a critical actor in COAST that will allow the content to be indexed effectively by the users.

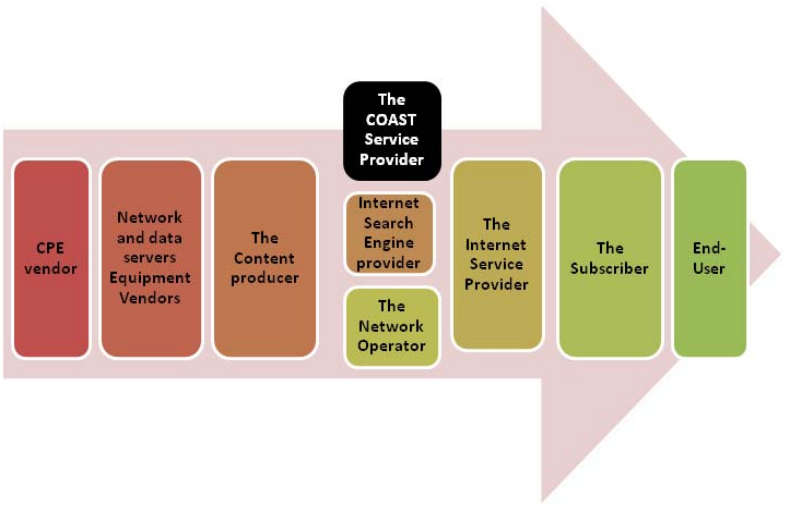

Figure 20: Stakeholder Value Chain in COAST

On a generic level the relationship between the different stakeholders are illustrated in Figure 20.

On Figure 21 the relationships that are displayed are the ones that are relevant when considering COAST at the heart of the business model. In other models (even closely linked), other relationships between the different stakeholders may exist.

Also it is important to highlight that we have introduced a COAST service provider which is strongly related to the search engine and the network operator and that is why there is an implicit hierarchical relationship and in fact we have introduced them as being on a group. In certain cases for example the COAST SP role can be adopted by the network operator for example.

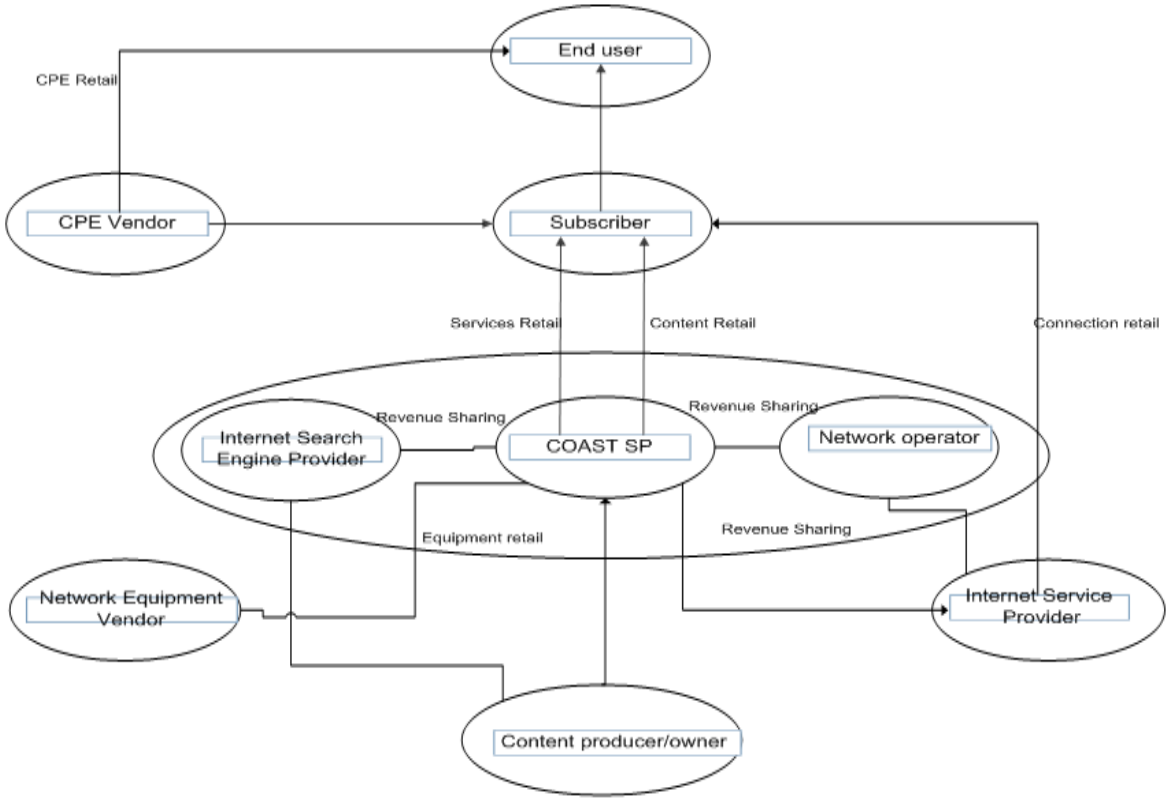

Figure 21: Stakeholder relations in COAST

6.2.5. COAST revenue opportunities

In this section we explore what revenue opportunities are created by COAST for the different stakeholders.

Most COAST functionality is transparent for the end users. However COAST will provide a better user experience when accessing content on the Internet regardless of the terminal type or network access. This competitive advantage can be exploited by network providers in different ways:

- Offer a premium internet access service for a higher price than the regular non-COAST enabled service.
- Offer an optional COAST acceleration service on top of the regular internet access service for a supplementary fee.
- Include COAST in the regular service for no additional price as a way to increase the market share.

The COAST Service Provider (SP) has the opportunity to apply different revenue schemas to the stakeholders that make use of its services:

- Subscribers: the COAST SP may provide services directly to end users. In this case, there are several revenue possibilities:
    - Service fees.

    - Retail of content and web services. This revenue would be shared with the content and service providers.
    - Revenue from advertising.

- Network Providers: those Network Providers offering COAST services to their users may share part of the revenue with the COAST SP or be charged by the latter based on the traffic generated in the COAST infrastructure.
- Service Providers: the COAST SP may offer other Service Providers services like web acceleration, streaming acceleration, content delivery or specialized search services. Again the COAST SP may obtain revenue from the Service Providers in the form of service fees, revenue sharing or metered use of the COAST infrastructure.

The services provided by the COAST SP may be used by different kinds of Service Providers:

- On-demand content providers such as YouTube, Flickr or Amazon may benefit from the caching, adaptation, delivery and searching capabilities brought by COAST.
- Streaming content providers such as Hulu or Netflix, IPTV or live events providers may benefit from the streaming and adaptation COAST functionalities.
- All kinds of web sites and web services may use the web acceleration and caching functionalities of COAST.

All these Service Providers may benefit from lower infrastructure and operational costs, as well as higher service quality and better scalability.

Finally, the manufacturers of network equipment and customer premises equipment may obtain additional revenue by selling COAST enabled equipment to the COAST SP and NP.

7. Conclusions

The most important result from this document is the definition of the service requirements for the COAST framework. They have been obtained after the analysis of a number of different aspects such as:

- The actual market and social trends in relation to the use of technology.
- The technological context in which users access content from the internet.
- Insights on user needs and expectations from technology and the evolution of search, enterprise and mobile services.
- COAST service scenarios, which have been defined to cover all functional areas to be address by the COAST framework.

As a result of this analysis, the core functionalities and core services have been identified. They can be classified into the following groups:

- Discovery: COAST must be able to get all the information needed to optimize the access to content: content and services in the network, network topology, network traffic, content popularity, terminal type, user context and user location.
- Caching: The replication of content across the network will improve the quality of service and lower network load.
- Searching: The search engine will take into account the network information to return the results which are more closely cached to the user. Also, the search engine will benefit from the content discovery and popularity information.
- Adaptation & Personalization: the delivery of content will be adapted to the user context and the terminal characteristics and will also be personalized to the user's likings.
- Routing & Streaming: Network information will also be exploited by COAST to improve routing and streaming.
- Additional functionalities: include the management of user profile and preferences, video encoding adaptation and access and privacy control.

Requirements have been defined for each of these functionalities. An important requirement is that COAST must remain backwards compatible with the actual content encodings and protocols.

Finally, the document provides a preliminary analysis on business perspectives and business models. This analysis includes the value proposition, the relation between the stakeholders and revenue opportunities.

The information provided by this document will guide the work of the forthcoming tasks and work packages:

- The service requirements are an input for task 2.2 Architecture & Interfaces specification and for the WPs 3, 4, 5 and 6 in which the functionalities will be implemented.
- The service scenarios are an input for integration and validation tasks in WP7.
- The business analysis is an input for task 8.1 Market Analysis & Exploitation.

Being the first technical deliverable of the project, this document may need to be revised in the future when work on other tasks has progressed,

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