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Abstract:	**This report reviews developments since the release of D2.1 and D2.2, examines the implications for the requirements and Unique Selling Points identified in these reports and identifies themes for future research.**
Keyword List:	**Use cases, requirements, ICN, Unique Selling Points**

Executive Summary

Requirements for the CONVERGENCE framework and the CONVERGENCE middleware were extracted from early use cases described in D2.1 (Preliminary Use Cases and Requirements). These requirements remained stable for the rest of the project – guiding the development of the CONVERGENCE Systems Architecture described in D3.2.

In the first annual review, reviewers criticized D2.1, arguing that the use cases were poorly defined and that several were unrealistic. Accepting this criticism, the Consortium produced a new version of the report (D2.1 v.2) with just four scenarios, which were used to define requirements for the applications and tools used in the CONVERGENCE trials. They also were used to draft a preliminary list of CONVERGENCE's Unique Selling Points for end-users and for developers.

Since that time the partners have gained significant practical experience with the CONVERGENCE framework, tested it in three rounds of user trials, developed new use cases, formulated plans for the commercial and non-commercial exploitation of their work and studied its broader social and economic implications. This work has a number of implications. In particular

- The specification and implementation of the CONVERGENCE Security element (CoSec) - the component of the CONVERGENCE Computing Platform level responsible for implementing basic security functionality has led to the definition of new security and privacy requirements.
- Applications and tools development work has generated new functional and non-functional requirements, while suggesting that some of the original requirements may have been unnecessary.
- Exploitation planning has demonstrated the importance of backwards compatibility with the current Internet architecture.
- The analysis in D8.5 identified elements in the CONVERGENCE framework of critical importance for its future social and economic impact: in particular support for licensing, new modes of search, and privacy-enhancing technology.

The partners have also identified a number of new user scenarios, demonstrating possibilities for

- Use of the same VDIs by different users and applications
- "Distributed social networking"
- B2B e-commerce
- New models of e-commerce
- Book publishing
- Efficient network management for mobile video delivery
- Disaster management

The analysis shows that the original list of requirements was relatively complete. However it also identifies a number of new requirements, particularly concerning

- Licensing and the REL
- Support for security and privacy
- Search and filtering
- Backwards compatibility to IP
- General purpose tools at an intermediate level between the middleware and applications.

The analysis identifies a small number of requirements that were not used in the applications tested in the trials. Nearly all of these requirements are relevant to other important use cases.

The study goes on to examine the implications for the Unique Selling Points USPs identified in D2.1 v2, formulating two revised lists. The first list identifies USPs fully supported by the current CONVERGENCE framework:

- The VDI as a single unit of distribution and transaction
- The CONVERGENCE middleware
- The ability to publish to all users on the CONVERGENCE network
- The CONVERGENCE subscription mechanism
- Content-centric security
- The ability to monitor use of VDIs
- The ability to dynamically update VDIs after publication
- Digital forgetting
- Support for in-network caching of content
- Backwards compatibility to IP

It goes on to identify three additional USPs, fully compatible with the framework, but whose practical realization require additional research and development:

- Search functionality
- CONVERGENCE licensing and the CONVERGENCE REL
- Anonymous and pseudonymous access, publishing and search

The study concludes that the initial CONVERGENCE requirements analysis was extremely successful. The requirements resulting from the work were *sufficient* to allow the implementation of a powerful framework covering a broad range of user scenarios; nearly all of the requirements were *necessary* for the implementation. Nearly all the Unique Selling Points identified in the original work are essential features of multiple use cases.

From an end-user perspective, the key issues for future research are probably the following:

- Novel search mechanisms for CONVERGENCE networks

- CONVERGENCE licensing, the CONVERGENCE REL and related enforcement mechanisms
- Privacy protection mechanisms.

These topics are additional to and do not replace topics identified by groups working on technical aspects of the CONVERGENCE framework.

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TERMS AND DEFINITIONS

TERM	DEFINITION
CoMid	The CONVERGENCE Middleware Level.
Community Dictionary Service (CDS)	A Functional Block belonging to the CONVERGENCE Middleware Level that provides all the matching concepts in a user subscription, search request and publication. The CDS parses and interprets the ontologies created by the CONVERGENCE users. It thus enables to understand users subscriptions or search requests as well as publications.
CoNet	The CONVERGENCE Network Level.
Content-Centric networking	A network concept, introduced by Van Jacobson [1] in which the fundamental unit of transaction is a “named data unit”.
CoSec	The CONVERGENCE security framework.
Digital forgetting	Techniques designed to ensure that VDIs do not remain accessible for indefinite periods of time, when this is not the intention of the user.
Expiry date	The last date on which a VDI may be legitimately used by a user of the CONVERGENCE System. The last date on which the CONVERGENCE system will allow a user to find the VDI in a search or subscription or to retrieve the VDI.
Information-Centric Networking	Synonymous with Content Centric Networking (see above)
IPR	Intellectual Property Rights
License	In CONVERGENCE, a machine-readable expression of Operations integrated in a VDI, that asserts the terms and conditions under which a user can use the VDI. A subset of these terms and conditions is directly enforced by the CoMid and the CoNet
Metadata	Data describing a resource referenced by a VDI, including but not limited to provenance, classification, access rights, expiry date etc.

MPEG eXtensible Middleware (MXM)	A standard Middleware specifying a set of Application Programming Interfaces (APIs) so that MXM Applications executing on an MXM Device can access the standard multimedia technologies contained in the Middleware as MXM Engines.
MPEG-M	An emerging standard being developed by MPEG; MPEG-M includes the previous MXM standard.
Rights Expression Language (REL)	A language allowing the owner of a VDI to express a license.
Service Level Agreement (SLA)	An agreement between a service provider and another user of CONVERGENCE to provide the latter with a service whose quality matches parameters defined in the agreement.
Subscribe	The act whereby a user requests notification every time another user publishes or updates a VDI that satisfies user-defined subscription criteria (key value pairs in the metadata, free text, key words etc.). Note: subscription criteria should be formulated in the same way as search criteria. Subscribe is a CoMid function.
Tool	Software providing a specific functionality to an application. Different applications may use the tool in different ways and provide different interfaces between the tool and the user. Applications will often incorporate more than one tool.
Versatile Digital Item (VDI)	A structured, hierarchically organized, digital object containing one or more resources and metadata, including a declaration of the parts that make up the VDI and the links between them.

Table 1: Terms and definitions.

1 Introduction

1.1 Background

Requirements for the CONVERGENCE framework and the CONVERGENCE middleware were extracted from early use cases described in D2.1 (Preliminary Use Cases and Requirements). These requirements remained stable for the rest of the project – guiding the development of the CONVERGENCE Systems Architecture described in D3.2.

In the first annual review, reviewers criticized D2.1, arguing that the use cases were poorly defined and that several were unrealistic. Accepting this criticism, the Consortium produced a new version of the report with just four scenarios (D2.1 v2). D2.2 further developed the scenarios, giving them the names used in subsequent reports

- Photos in the cloud and down to earth (Alinari)
- Videos in the cloud and analyses on the earth (FMSH)
- Augmented Lecture Podcast (LMU)
- Smart Retailing (WIPRO/UTI)

The scenarios were used to define requirements for the applications and tools used in the CONVERGENCE trials. They also were used to draft a preliminary list of CONVERGENCE's Unique Selling Points for end-users and for developers. CONVERGENCE, the report claimed, would allow end-users to

- Bundle data resources and structured metadata describing these resources into a single, standard, self-consistent package (the VDI) with a unique identifier and the capability to represent media, services, people and Real World Objects;
- Define a license using a standard language to define who can access the VDI and the precise conditions for access;
- Digitally sign and/or encrypt the content of a VDI;
- Define ontologies making it easier for users to search for the VDIs they publish and make these ontologies available to all users of the CONVERGENCE network;
- Publish the VDI making it available to all authorized users on the CONVERGENCE network, (if desired, to all users);
- Monitor the use of VDIs they have published;
- Update the information in the VDIs they have published, ensuring the update reaches all users of the VDI;
- Rapidly and reliably retrieve VDIs, regardless of the location of the VDI owner (thanks to network caching);
- Search for and retrieve any VDI on the CONVERGENCE network, exploiting the VDI metadata and the semantic capabilities of the CONVERGENCE Community Dictionary Service;
- Subscribe to VDIs meeting specified search criteria, and receive a notification on publication or update of VDIs satisfying the criteria;
- Verify the authenticity of a VDI and decrypt any encrypted content (key owners only);

- Communicate with owners of VDIs without the need to access personally sensitive information;
- Ensure that copies of VDIs do not persist on the network beyond a pre-defined expiry date (digital forgetting).

Developers would be able to build applications that exploit and add value to these functionalities, ensuring that different businesses and individuals can exploit CONVERGENCE functionality in the ways that best meet their needs.

Network operators would benefit from the move from the current *packet switching* paradigm to a *content switching paradigm* in which content is efficiently distributed across the network, taking account of network capabilities, traffic conditions and the transmission requirements of specific types of content.

1.2 Goals and scope of this report

D2.2 was completed in June 2011. Since that time the partners have gained significant practical experience with the CONVERGENCE framework, tested it in three rounds of user trials, developed new use cases, formulated plans for the commercial and non-commercial exploitation of their work and studied its broader social and economic implications. The goal of this report is to re-examine the findings of our earlier reports in the light of this experience, which is briefly summarized in section 2. Section 3 examines the implications in terms of the requirements for a working CONVERGENCE system. Section 4 proposes a reformulation of the original list of Unique Selling Points. Section 5 concludes, identifying themes for future research.

As supplementary information, Appendix I provides a detailed description of two new user scenarios, one of which will be shown in the final CONVERGENCE review, in May 2013. The new proposals provide a first example of the way the CONVERGENCE framework can facilitate collaboration among organizations with different needs, without forcing them to adopt a monolithic software solution. This, we now believe, is one of the CONVERGENCE's critical advantages.

2 Developments since the last report

2.1 Sources of new requirements

The majority of CONVERGENCE work since the release of D2.2 has been dedicated to the specification, implementation and testing of the CONVERGENCE systems architecture and the CONVERGENCE applications, based on the requirements defined in D2.1 and D2.2. However, some of our research has led to the definition of new requirements, or thrown new light on those that had already been defined. In particular

1. The specification and implementation of the CONVERGENCE Security element (CoSec) - the component of the CONVERGENCE Computing Platform level responsible for implementing basic security functionality (see D3.3) led to the definition of new security and privacy requirements.
2. Applications and tools development work (see D7.2 and D7.3) generated new functional and non-functional requirements, while suggesting that some of the original requirements may have been unnecessary.
3. Exploitation planning (see D9.3, and D9.5) showed the importance of backwards compatibility with the current Internet architecture.
4. The analysis in D8.5 identified elements in the CONVERGENCE framework of critical importance for its future social and economic impact: in particular support for licensing, new modes of search, and privacy-enhancing technology.

2.2 New user scenarios

Since the release of CONVERGENCE D2.2, the partners have produced a number of ideas for new user scenarios. One of these has already been tested in the third round of the CONVERGENCE trials; two more were developed for demo purposes. For a complete description of these scenarios readers are referred to Appendix I. Other ideas have come from work on the social and economic impact of CONVERGENCE and from partner publications.

2.2.1 Videos in the cloud for education

The purpose of this scenario is to demonstrate one of the most important features of CONVERGENCE – namely the use of a common unit of transaction (the VDI) and a common middleware (the CoMid) by different applications managed by different actors.

In the scenario, resources (especially videos) are shared between educational actors from different organizations. The scenario exploits the features offered by the existing LMU and FMSH applications as well as 6000 hours of scientific, pedagogical and cultural online videos, made available by FMSH's ARA program (http://www.archivesaudiovisuelles.fr). As shown in Fig. 1, LMU and FMSH share video material, provided by the two organizations. In

this scenario, the LMU application allows students not only to watch and annotate video podcasts as usual but also allows them to watch and annotate ARA materials. Similarly FMSH analysts and video channel owners can access video materials produced at LMU.

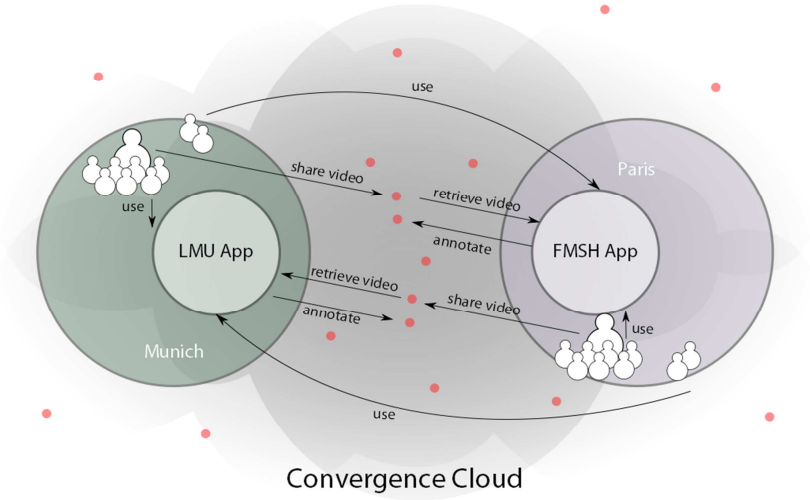

Figure 1: Sharing videos in the cloud

In future work, it may be possible to enlarge the network to include other universities in Germany, France (or elsewhere). In particular, University lecturers could use the technology to create and manage "Course Channels" which students could subscribe to. For example, students enrolled in a Master degree in computer science could subscribe to a dedicated channel for the course, allowing them to receive automatic notifications of all new videos, podcasts, and analyses posted on the channel. The same services could be extended to any actor in long-life learning, wishing to produce or consult learning materials. Figure 2 shows how applications and tools used by LMU and FMSH share videos, analyses and podcast in a common cloud.

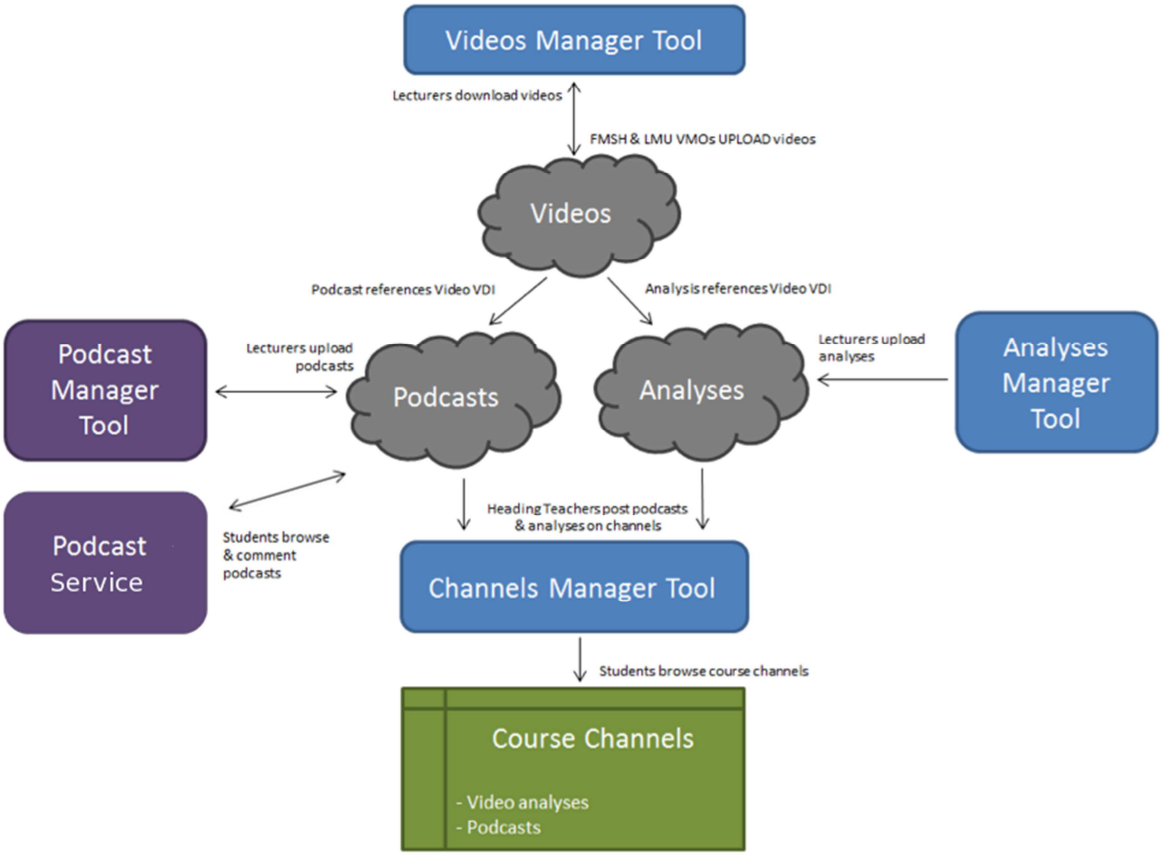

Figure 2: Main principle of the "Videos in the Cloud for Educational Purposes" scenario

2.2.2 Integrated Photographic Retail Application

Like the previous scenario, the Integrated Photographic Retail Application (to be shown at the Dublin review in May 2013) demonstrates the possibility of sharing VDIs between different applications and actors.

The scenario involves a content creator (a photographer), a content consumer, a manufacturers and a retailer. The business stakeholders are Alinari (which sells image rights, fine art books and printed material), WIPRO and UTI (both technology providers for the retail industry).

The scenario begins when a photographer creates a new image. The image file is bundled with automatically generated camera information, such as the name of the camera model and the lens. After the image has been published, CONVERGENCE associates it with the Product VDIs for the relevant camera and lens (created with the WIPRO application), and with special offers for these products (created with the UTI application). When the user retrieves images through the PAM-Photographic Archive Management application, she receives this information at the same time. In this way, the images in the photo collection help to promote cameras and lenses.

2.2.3 Other new scenarios

Other work in the project has produced additional less detailed scenarios, relevant to requirements for future CONVERGENCE systems and to CONVERGENCE's Unique Selling Points.

2.2.3.1 Distributed social networking

As suggested in D8.5, CONVERGENCE would provide a natural medium for *distributed social networking along* the model proposed by the Diaspora Project [2]. The fundamental operation in the currently dominant model of social networking is *posting.* With CONVERGENCE, posting would consist of the publication of a VDI on the CONVERGENCE network. A key requirement is that users should be able to define who should have access to their posts. This can be efficiently achieved by CONVERGENCE licensing. CONVERGENCE ERRs would allow users to monitor the readers of their posts. Users should also be able to define which posts they wish to receive. This is a natural role for the CONVERGENCE subscription mechanism. CONVERGENCE tagging would allow users to signal posts of potential interest to other users. CONVERGENCE content-centric security could prevent unwanted monitoring by commercial or state agents. CONVERGENCE mechanisms for digital forgetting would ensure that all posts are removed from the network after a user-specified period of time and would allow users to remove posts immediately if they so desired.

Critical advantages compared to current services include:

- The absence of a central operator, monetizing user generated content
- The absence of a single point of failure and a single target for government censorship, private liability suites etc.
- Vastly improved privacy and security
- Digital forgetting
- The possibility of using the same data (VDIs for posts) with different client applications
- Novel forms of search and filtering using VDI metadata.

2.2.3.2 B2B e-commerce

Alinari exploitation planning (see D9.3 and D9.5) suggested that CONVERGENCE could provide an ideal medium for e-commerce among professional providers and consumers of information (in the Alinari case: photographers, stock photography agencies, newspapers and magazines etc.). D8.5 expands on this proposal, suggesting that CONVERGENCE could provide effective support for other communities of individuals and companies who regularly purchase or sell copyrighted materials, and who need to be sure of the provenance and ownership of these materials. For instance, musicians and music companies could package

songs or albums as VDIs, protected by a license and use the CONVERGENCE event-reporting mechanism to monitor use of their works.

2.2.3.3 New models of music consumption (B2C)

In recent years, rapid growth in online sales of music has led to a shift away from the sale of albums (packages of songs) towards the sale of individual songs. Today, services such as Spotify have begun to offer services allowing users to access a limited quantity of DRM-protected music free of charge or, to access an unlimited number of songs in return for a monthly fee [3]. This business model, like those of other large Internet companies allows the service provider to extract a rent from its position as a broker between music providers (musicians, music companies) and consumers.

By contrast, CONVERGENCE has the potential to eliminate or drastically reduce the role of the intermediary. In a CONVERGENCE-powered music market, consumers could choose between purchasing individual songs and albums and purchasing a subscription, allowing them to consume unlimited amounts of music for a certain period.

In both cases, musicians and music companies would publish songs and albums as license-protected VDIs. A consumer wishing to purchase an individual song could search for it on the CONVERGENCE network, download the VDI and then use the link to the owner of the VDI to purchase the song directly. This model has the potential to improve revenues for music providers while simultaneously cutting prices for consumers.

A consumer wishing to purchase an unlimited subscription could purchase a pseudonymous access key from a centralized identity provider, which would give her access to all music VDIs published over the network. A neutral non-commercial entity (e.g. a Performing Rights Society) could then use CONVERGENCE ERRs to monitor the number of users accessing specific VDIs and to equitably share subscription revenues among music owners. Other commercial and non-commercial organizations could offer competing search services and retrieval software. The resulting business ecosystem could be significantly more diversified and competitive than the current market for digital music.

2.2.3.4 Book publishing

Some of the difficulties of the music industry are replicated in book publishing – an area in which publishers have lost revenues to very large-scale retailers such as Amazon, which are squeezing their margins, and to illegal copying. In this market too, VDIs could allow publishers to cut out large intermediaries and to sell books directly to consumers. This could be especially important for e-publishing – allowing publishers to earn revenues from older books that bookshops are unwilling to stock and which it is no longer economic to print. The use of VDIs would also make it easier to trace the provenance of old and out of print books, reducing the risk that third party services will treat them as “orphan works”.

2.2.3.5 Efficient network management for mobile video delivery

In [4], it is pointed out that about 60% of current Internet capacity is dedicated to video delivery and that an increasing proportion of this traffic is carried over expensive mobile channels. The authors, two of the CONVERGENCE partners, go on to suggest that

> "The multicast nature of ICN and the inherent support of in-network caching provided by ICN can significantly reduce the amount of resources needed to transport video traffic. In addition, ICN handles mobility much more naturally and without having to store states: when a user changes point of attachment to the network, she will simply ask for the next chunk of the content she is interested in." [4]

2.2.3.6 Rapid access to patient records during medical emergencies

In medical emergencies, it is important for emergency room physicians to gain immediate access to information contained in the patient's medical records (medical history, previous diagnoses, test results, medication, allergies etc.) [5-7]. To date, the main issues that have prevented large-scale implementation of online schemes are the difficulty in winning acceptance for standard solutions from physicians and health providers, and concern for patient privacy.

CONVERGENCE could help to resolve both issues. In the scenario we are envisaging, doctors, hospitals etc. would package health records as VDIs, encrypt the VDIs and publish them to the CONVERGENCE network. The internal format of the data would respect the format normally used by the organization maintaining the records, removing the requirement for strong standards. The use of the CONVERGENCE publish-subscribe mechanism, and the CONVERGENCE update mechanism would ensure that the record was accessible across the CONVERGENCE network and that it would always be up to date.

Patient record VDIs would be protected by a CONVERGENCE license. Access in an emergency would require the use of the patient's private key (which could be stored on her electronic ID card, a health card etc.), and the physician's private key (issued by an appropriate authority). The CONVERGENCE ERR mechanism would make it possible to maintain an audit trail of all requests. For safety, patients might also be able to share their key with a relative or a trusted third party.

2.2.3.7 Disaster management

In [8] Trossen et al. user a disaster scenario to support the case of Information-Centric networking. According to this paper, the generic advantages of ICN include the ability of emergency workers to access information through multiple applications and devices, better governance of information and reductions in information overload through efficient information filtering; A more recent paper by two of the CONVERGENCE partners [4] uses a

similar scenario, to show additional advantages, in particular support for asynchronous access to information over a fragmented network.

3 Implications for CONVERGENCE requirements

3.1 Introduction

The final versions of the CONVERGENCE framework, the CONVERGENCE middleware and the CONVERGENCE applications tested in the trials, satisfied nearly all of the requirements defined in D2.1v2 and D2.2. As we will discuss below, a very small number of requirements proved irrelevant to the final implementations. In the majority of cases, however, these requirements are relevant to other uses cases not tested in the trials and should not be discarded. In what follows, therefore, we will focus on requirements that go beyond the needs of the original CONVERGENCE applications.

3.2 New requirements

3.2.1 Licensing and the REL

According to the analysis in D8.5, one of the most significant aspects of ICN and CONVERGENCE is their support for a strong concept of content ownership. In particular, the CONVERGENCE licensing concept (made possible by the REL), combined with content-centric security and license enforcement in the CoMID and CoNET, would make it easier for Information Providers to control the way their content is used, and to prevent it from being used without adequate compensation. Licensing could allow professional and individual Information Providers to charge large sites for distributing their content; meanwhile CONVERGENCE support for pseudonymous and anonymous access could limit commercial sites' ability to collect personal information about users, perhaps inducing them to compensate users for providing the information (see the proposal by Lanier in [9]). As described in D3.2 and D3.3, licensing and the REL are intrinsic features of the CONVERGENCE architecture. D4.2 goes further, defining the syntax for the REL and proposing a number of new verbs additional to those already defined in MPEG-21 syntax. However, D2.1 v2 defines no specific requirements in this area.

The definition of detailed requirements goes beyond the scope of this deliverable. It seems likely, however, that new verbs will be needed to support the scenarios described in the previous chapters and others that may emerge. Examples include the following:

- Publishers of VDIs shall be able to grant or deny permission for search engines and other third party services to index or otherwise re-use a VDI (necessary to support user privacy and – possibly – payments by search engines to owners of valuable content)

- Publishers of VDIs shall be able to grant or deny permission to use a VDI in a derived work (necessary to support creative re-use of non-commercial materials, as in the FMSH scenario).
- Publishers of VDIs shall be able to grant or deny rights to a specific user or group of users (necessary to support the use of CONVERGENCE for distributed social networking).
- Publishers of VDIs shall be able to explicitly grant or deny rights to use a VDI in specific ways (e.g. commercial vs. non-commercial use, monitoring of employee activity by company HR departments).

Particularly important is the ability of the publisher of a VDI to specify *who* can access a VDI for what purposes and the network and middleware capabilities that enforce these conditions. This is an essential requirement for the social networking and the medical records scenarios described in paragraphs 2.2.3.1 and 2.2.3.6.

The requirements in D2.1 specify that "A VDI shall allow users to define access rights for VDIs" (VD162). With adequate implementation access control could become one of CONVERGENCE's major selling points. However, this requirement needs to be spelled out in greater detail. Possible requirements include the following:

- The publisher of a VDI shall be able to grant rights to specific individual users, and/or groups of users, authenticated through the system
- The publisher of a VDI shall be able to grant rights to anonymous and/or pseudonymous users
- The publisher of a VDI shall be able to deny rights to specific individual users, and/or groups of users, authenticated through the system
- The publisher of a VDI shall be able to deny rights to anonymous and/or pseudonymous users.

3.2.2 Support for security and privacy

D2.1 v2 defined requirements for CONVERGENCE security (VD162-169) and for privacy protection (VD171). However further research showed that the original formulation did not take account of the full range of possibilities offered by modern encryption and security technology (e.g. so-called Identity-Based Encryption). To fill this gap, D3.3 (Technologies and Connectors Infrastructure) defined a new set of security and privacy requirements, offering a more complete solution. In particular, the document included a requirement that users should be able to access CONVERGENCE pseudonymously[1]. Later in this report, we

[1] Pseudonymous access implies that a user can create or search for a VDI using a pseudonym issued by a certified identity provider. In normal circumstances the pseudonym certifies her membership of a particular group but does not reveal her individual identity. However, the identity provider retains the ability to re-identify the user (e.g. for purposes of law enforcement).

suggest that such a feature could make a significant contribution to CONVERGENCE's social and economic impact.

One of the major concerns expressed in D8.5 is that explicit identification of the authors of VDIs and screening of metadata could facilitate surveillance of CONVERGENCE users by governments, commercial agents and individuals. The focus groups organized during the second round of CONVERGENCE trials (see D8.3) showed that this concern was shared by many end-users, especially in Germany, a country in which public opinion is very sensitive to privacy issues. These concerns could represent a significant obstacle to uptake of the new technology.

The original CONVERGENCE requirements contained only a cursory reference to anonymity (an essential if not a sufficient requirement for protection against government surveillance) and no reference at all to pseudonymity (which offers protection against unauthorized monitoring for commercial or private purposes). The new CoSec specifications defined in D3.3 partially remedy this situation, mandating explicit support for pseudonymity. It is evident, however, that much additional work is required in this area. Many privacy advocates would express the need for additional requirements to protect user privacy, for example

- Users of CONVERGENCE shall be able to send and receive private communications in ways that do not allow a third party to identify the origin, or the destination of the message and which do not allow third parties to read the content of the message
- Users of CONVERGENCE shall be able to publish VDIs anonymously, in ways that do not allow a third party to identify the owner of the VDI
- Users of CONVERGENCE shall be able to search for VDIs anonymously, in ways that do not allow a third party to identify the originator of the search
- If the license for a VDI permits, users of CONVERGENCE shall be able to subscribe to and download the VDI anonymously, in ways that do not allow a third party to identify the originator of the subscription or the download request
- Where the license for a VDI has granted rights to a principal, CONVERGENCE shall always allow the principal to exercise these rights, preventing filtering by third parties.

This kind of "privacy by design" would encounter strong opposition from many state actors, as well as from commercial companies, a "tussle" that may need to be settled via regulation and/or legislation [10, 11]. The choice of solution will influence take-up, encouraging and discouraging use of ICN and CONVERGENCE by particular groups of users.

3.2.3 Search and filtering

According to the analysis in D8.5, ICN and CONVERGENCE technology have the potential to create a radical shift in the balance of power between the large web companies that currently dominate the Internet economy and smaller Information Providers. However, many of these companies fulfil important user needs (e.g. search, social networking). In the case of

search, it is highly desirable that the CONVERGENCE framework should facilitate solutions that go beyond the functionality provided by current systems.

The CONVERGENCE architecture allows classical search engines to index VDIs (if authorized by the owner of the VDI). ICN and CONVERGENCE also provide a range of additional functionality, including fast location of named data items and (in the case of CONVERGENCE), the use of metadata, the CONVERGENCE Dictionary Service (CDS) and user tagging of VDIs, allowing the creation of folksonomies [12] [13][2]. However, many improvements are possible. Possible new requirements include the following

- Users shall be able to perform complex queries retrieving VDIs whose metadata satisfy user-specified search criteria (e.g. all VDIs representing songs, with price <x and genre=y and audio sampling rate >z).[3]
- Users shall be able to find all VDIs containing a certain tag
- Users shall be able to filter out all VDIs containing a certain tag

In a business perspective it is probably best to leave the development of more advanced search capabilities to specialized third-party services. However, it could be some time before such services emerge. It may therefore be useful to develop an initial search application meeting the requirements below.

- CONVERGENCE shall provide an application (a CONVERGENCE search engine) allowing users to efficiently search for VDIs
- The search engine shall index all VDIs whose licenses permit indexing
- The search engine shall support full text search, search by VDI metadata, search by tag and combination searches involving mixes between these mechanisms
- The search engine shall automatically rank search results.

3.2.4 Backwards compatibility for IP networking

Jacobson's original proposal for Content-Centric Networking (also referred to as Information-Centric Networking or ICN) required a wholesale revision of the current architecture of the Internet with the replacement of the current network layer by a new structure for the routing of "named data items" [1, 14]. In practical terms, this would require the installation of new software on routers across the network. The difficulties experienced when attempting to implement IP v6 suggest that this kind of change would be very hard to implement.

CONVERGENCE exploitation planning is based on the creation of "islands of innovation" (see D8.5) demonstrating the value of the new technology. In practical terms, this plan, like any realistic plan for introducing new Internet technologies, requires that CONVERGENCE

[2] Unfortunately, none of the applications tested in the CONVERGENCE trials made extensive use of end-user tagging.

[3] The definition of a VDI supports this possibility. However, it was not tested in the CONVERGENCE trials.

should be backwards compatible to the current Internet. Specifically, it requires that CONVERGENCE middleware should be able to use IP networking. This is a new, very general requirement that was not included in the original requirements specification.

In addition, as regards the new ICN network layer, our CONET approach does not follow the so-called "clean slate" approach, which aims at fully replacing the IP layer. Rather, we see two strong drivers for an "integration" approach, in which ICN interworks with IP: i) conversational services still remain very important and ICN does not provide apparent benefits for such services; in our "integration" approach conversational services are supported by IP, while ICN is used for content-oriented communications; ii) the only way for a real deployment of ICN is an evolutionary path from existing IP networks. The conceptual difference between other ICN "overlay" (i.e. putting the ICN layer on top of the IP layer) solutions and our "integration" approach is that we introduce ICN functionality in a backward compatible way in IP routers, rather than "tunneling" ICN information over UDP or TCP. We have defined and experimented two ways of transporting name based information. The first one introduces CoNet IP options in IPv4 and IPv6 headers [18],[19]. The second proposal includes it in the headers of our proposed CoNet transport protocol [20]. In both cases, each IP packet supporting content-based communication carries the content-name and further content-related information so that it can be efficiently processed by CoNet nodes (while CoNet unaware nodes can still process it as a regular IP packet). This is very helpful for a smooth migration path from current Internet to ICN.

3.2.5 Tools

During development of the applications for the CONVERGENCE trials, WP7 developed a set of tools, which provided commonly used functionality (User Registration, Content Registration, Publish VDI, Unpublish VDI, Revoke VDI, Subscription to VDI, Browse Event Report and Create Annotation VDI) to applications (for details see D7.1). The tools, which are positioned at an intermediate level between the CONVERGENCE middleware and the applications, proved to be extremely useful. This suggests a new non-functional requirement for CONVERGENCE

- CONVERGENCE shall offer developers a set of tools, lying above the middleware, that facilitates the implementation of functionality found in a broad range of applications. Examples of new functionality suitable for implementation as a tool might include
    - Definition of templates for publishing a VDI in a specific category[4]
    - Addition of a user-defined tag to a VDI
    - Definition of licenses and access rights to VDIs

[4] This was one of the original CONVERGENCE requirements, but it was not implemented in any of the applications used in the trials.

- Definition of metadata for specific classes of content
- Updating a VDI with a new version
- Browsing a set of VDIs meeting specific criteria
- Browsing different versions of a VDI

3.3 Requirements not used in the CONVERGENCE applications

Below, we will briefly review the very small set of requirements from D2.1v2 which were not implemented in the CONVERGENCE trials (numbers in brackets refer to the code for the original requirement)

- *Location-based services (VDI2, VDI54).* D2.1v2 defined requirements that it should be possible to specify the physical location of a VDI and that users should be able to search for VDIs within a specified distance of a given location. This requirement was not implemented in any of the applications used for the CONVERGENCE trials. It is, however, very relevant for several of the use cases described in chapter 2, in particular the WIPRO/Alinari e-commerce scenario (location information would allow a user to find a shop selling a particular camera or lens close to her home) and in the Disaster Management Scenario (location-based filtering would allow a user to filter out information not relevant to the zone of the disaster – reducing information overload). Nothing in the CONVERGENCE architecture prevents the framework from supporting location-based tags. This requirement should therefore be maintained.
- *Support for SLAs (VDI7).* D2.1v2 specified that "the CONVERGENCE System shall allow service providers to conclude, and monitor SLAs with information consumers". This possibility was not tested in the applications. However, CONVERGENCE ERRs provide all the functionality necessary to implement an SLA. Therefore the requirement can easily be met.
- *Publishing templates (VDI39).* According to D2.1 v2, "the CONVERGENCE System shall provide a standard tool allowing a user to create a publishing template for another user in which all fields are predefined. The template shall include instructions for the user, default values for fields etc.". The applications tested in the trials did not provide such a system. However, it is clear in retrospect that it would have been extremely useful. It would be very useful in the B2B, B2C, and book publishing scenarios described in Chapter 2. Again the requirement should be maintained.
- *Generic VDI browser (APP2) / Generic VDI creator (APP3).* The original CONVERGENCE requirements specified that CONVERGENCE should create generic applications to browse and publish VDIs of any category. In reality, WP7 developed tools for browsing and publication (software for developers) but did not develop an end-user browser or an end-user publishing tool. This choice reflects a general market trend away from generic browsers towards domain-specific "apps". The results of the trials do not provide any indication whether it was a good or a bad

one. At the time of writing there seems to be no urgent need for a generic browser or a generic VDI creator. However, nothing in the CONVERGENCE architecture would prevent their development at a future date.

4 Unique selling points of CONVERGENCE

4.1 Introduction

D2.1 v2 defined a list of CONVERGENCE's Unique Selling Points (USPs). In the following paragraphs, we formulate two revised lists, the first describing USPs already present in the current implementation of the CONVERGENCE framework, the second listing USPs compatible with the framework but whose implementation requires additional research and development.

The two lists are derived in part from the original list, in part from the experience accumulated over the last one and a half years. They include reformulated versions of many of the original USPs and some new ones. Some of the original USPs are not included. In paragraph 4.3, we explain why. The discussion will point to some of the themes for future research identified in chapter 5.

4.2 Unique Selling Points of CONVERGENCE

4.2.1 A single unit of distribution and transaction

CONVERGENCE makes it possible to bundle data resources and structured metadata describing these resources into a single, standard, self-consistent package (the VDI) with a unique identifier and the capability to represent media, services, people and Real World Objects.

This is the most important novelty introduced by CONVERGENCE. It also represents a significant innovation with respect to classical ICN as described by Jacobson[1, 14] and Trossen [8, 11], which does not consider the internal structure of "named data items"[5]. VDIs lie at the heart of all the CONVERGENCE use cases. Perhaps their most important feature is that they allow different applications and services to operate on the same basic unit of transaction, a possibility demonstrated in the LMU-FMSH and in the WIPRO-Alinari scenarios described in paragraph 2.2.1 and 2.2.2 respectively.

4.2.2 CONVERGENCE middleware (CoMid)

CONVERGENCE provides a middleware framework (a specification and a reference implementation) that allows applications to perform standard operations on VDIs.

[5] The concept of the Digital Item, as a standardized unit of distribution and transaction was introduced in the MPEG-21 standard. Concepts developed by the MPEG community have played a role of fundamental importance in the development of the VDI concept.

The idea of providing a middleware framework to support operations on Digital Items (in CONVERGENCE VDIs) was not included in our original list of CONVERGENCE's Unique Selling Points, and represents a major innovation with respect to the original ICN concept[6]. The CONVERGENCE middleware is fundamental to all the use cases tested in the CONVERGENCE trials and has the potential to make a key contribution to the new user scenarios introduced in this deliverable (paragraph 2.2.1 and 2.2.2).

4.2.3 Publishing to all users of the CONVERGENCE network

CONVERGENCE allows any user to publish a VDI (to make it available) to all users of the CONVERGENCE network

ICN and of CONVERGENCE allow any user to publish a VDI to the CONVERGENCE network and ensure that the VDI is available to all users authorized to access it, even when the user does not know the web address of the publisher, or the publisher is offline or the network is disrupted. This is a fundamental feature of CONVERGENCE that appears in all the use cases. However, the practical effectiveness of CONVERGENCE publishing depends on the effectiveness of CONVERGENCE search, a theme that still requires research (see paragraph 4.3.1).

4.2.4 The CONVERGENCE subscription mechanism

The CONVERGENCE subscription mechanism allows users to publish Interest-VDIs describing their interest in VDIs meeting user-specified criteria. They will then receive a notification every time another user publishes a VDI matching the criteria.

This feature provides the basic search mechanism for CONVERGENCE and has already been implemented in the CONVERGENCE framework. Several of the user scenarios (the LMU distance education scenario, the Disaster Management scenario) directly exploit the ability to subscribe to VDIs that have not yet been published. This is a possibility completely unsupported by current web technology.

4.2.5 Content-centric security

CONVERGENCE provides content-centric security, providing users with standardized mechanisms to digitally sign VDIs, to encrypt their content, to authenticate VDIs published by other users and (if they have appropriate rights) to decrypt their content.

These features of CONVERGENCE represent a fundamental improvement over the current Internet, in which the huge majority of content, messages and searches are unsecured. The availability of these mechanisms plays an important role in most of the CONVERGENCE

[6] The CONVERGENCE framework and middleware is built on top of the MPEG-M (MXM) standard (see D3.2)

user scenarios (all scenarios involving B2B and B2C transfers of media content, distributed social networking, access to patient records during medical emergencies, disaster management) and provide an important incentive for take-up.

4.2.6 Monitoring of use

The CONVERGENCE ERR mechanism allows the publisher of a VDI to monitor use of the VDI.

This feature, poorly supported by current Web technology, is important for all e-commerce scenarios and plays an important role in many scenarios involving non-commercial use of CONVERGENCE (e.g. the FMSH "videos in the cloud" scenario, distributed social networking, access to patient records in a medical emergency). The availability of a standardized monitoring mechanism would provide an important incentive for take-up of the system. An enhanced version of the current mechanism, providing strong guarantees against the profiling of individual users, would be well accepted by those end-users who object to the lack of transparency of current monitoring technology.

4.2.7 Dynamic updating of VDIs after publication

CONVERGENCE allows the publisher of a VDI to create a new version of the VDI after publication ensuring that users will always access an up-to-date version.

This feature plays an essential role in several of the user scenarios. In the LMU podcast scenario for instance, dynamic updating ensures that teachers can update their podcasts, and that learners will be notified of the change. In the "patient data for emergency care" and the "disaster management" scenarios, dynamic updating ensures that users always have access to the latest data, even when the original publisher of the data is temporarily offline. The same feature would allow users to receive updates to a VDI (e.g. a parts manual, prescribing information for a drug) automatically, without checking manually. This functionality would be equally valuable for end-users (who often lose track of the provenance of electronic documents) and publishers (who want to ensure that end-users always have access to the latest version of the information they provide).

4.2.8 Digital forgetting

CONVERGENCE allows the owner to define an "expiry date" for a VDI. Additional mechanisms allow the owner to revoke a VDI after it has been published.

The right to digital forgetting[15-17] is a frequent (and frequently criticized) demand of privacy advocates, which may soon be enshrined in European data protection legislation. However, it is completely unsupported by current web technology. Digital forgetting is a very important requirement for the LMU podcast and the distributed social networking scenarios and for many other use cases in which the publisher of a VDI may wish to revoke it, or to

guarantee that it is automatically revoked on a certain date. The availability of digital forgetting will not void all privacy-related concerns related to CONVERGENCE (see D8.5). Undoubtedly, however, it will improve the acceptability of the system to users with privacy concerns.

4.2.9 In-network caching

CONVERGENCE allows in-network caching of VDIs

This is a fundamental feature of ICN and of CONVERGENCE, with many advantages. It allows small Information Providers to offer media materials to their users without deploying a large network infrastructure, frees Network Operators and ISPs from the need to deploy proprietary CDNs, reduces the vulnerability of the network to failures in individual hosts and network links, makes it harder for governments and commercial operators to censor content they do not like, and improves the overall efficiency of network communications.

4.2.10 Backwards compatibility to IP

The CONVERGENCE CoMid is designed to allow deployment over the IP networking layer

This feature was not included in the analysis of CONVERGENCE USPs in D2.1v2. However the exploitation plans described in D9.3 and D9.5 and the analysis of social and economic impact in D8.5 make it clear that it is essential for CONVERGENCE's future deployment prospects. Without this feature the "islands of innovation" strategy discussed in D8.5 would lose its meaning.

The CONVERGENCE CoNet is designed to allow a smooth migration path from current IP networks

This feature was not included in the analysis of CONVERGENCE USPs in D2.1v2, for further details see [4], [18], [19] and [20].

4.3 USPs requiring further research and development

Future research and development could enhance the CONVERGENCE framework in ways that go beyond the features provided by the current specification and implementation. In what follows, some of the USPs we describe were already identified in D2.1v2. Some are new.

4.3.1 Search functionality

CONVERGENCE semantic technology, the CONVERGENCE CDS and support for user tagging of VDIs allow users to find any VDI that has been published on the network, without knowing the name of the host where it originated.

Today, the visibility of information published on web sites depends on the notoriety of the site and above all on the way the information is indexed by major search engines. Pages that consistently receive low ratings are for practical purposes invisible. Theoretically, CONVERGENCE has the potential to level the playing field, making it easier for individuals and small businesses to reach their target public. This is an essential requirement for most of the CONVERGENCE user scenarios. This feature of CONVERGENCE complements support for publishing, and is an essential feature of most of the CONVERGENCE use cases.

The CONVERGENCE framework already contains features (metadata, tags, the Community Dictionary Service) allowing new forms of search and presents no obstacles to more traditional techniques (e.g. full-text). However, none of the applications tested in the CONVERGENCE trials include anything resembling a "CONVERGENCE search engine". Simulation and modelling work in track 2 of the CONVERGENCE trials (see D8.3 and D8.4) has shown a satisfactory relationship between search time, and the number of VDIs in the network. However, effective search also requires a way of ranking search results. This is an issue that goes beyond the scope of CONVERGENCE and requires future research.

4.3.2 CONVERGENCE licensing and the CONVERGENCE REL

CONVERGENCE allows the publisher of a VDI to specify who can index, see and use the VDI, together with terms and conditions for its use. The CoMid provides mechanisms for the enforcement of (some of) these conditions.

The ability to restrict access to VDIs and to define and enforce conditions for their use is one of the most powerful features of CONVERGENCE, and is of vital importance for many user scenarios, ranging from B2B and B2C media publishing to distributed social networks. The current CONVERGENCE framework already provides the basic features needed to define and enforce access control and licensing. However, many use cases require additional functionality not present in the current version of the REL (see paragraph 3.2.1). This is another important theme for future research.

4.3.3 Anonymous and pseudonymous access, publishing and search

Users of CONVERGENCE can access CONVERGENCE, publish VDIs and search for VDIs anonymously or with pseudonymous access credentials[7].

Anonymous access is important for users wishing to use the network for purposes of political dissent or whistle blowing; pseudonymous IDs can allow users to demonstrate their membership of a particular "circle" (e.g. owners of a store fidelity card) while preventing the

[7] Pseudonymous access credentials guarantee that a user is a member of a particular group (e.g. members of a club), prevent normal users from ascertain the identity of the user but guarantee that it is possible to trace the identity of the user for legitimate purposes (e.g. law enforcement, identifying an anonymous patient in a clinical trial when clinical analyses turn up incidental findings).

issuing organization from tracking their individual behaviour. The CONVERGENCE CoSec provides the basic features necessary to implement these features. However they were not tested in any of the CONVERGENCE trials and do not appear in the use cases discussed in paragraph 2.2. In practice, implementing these possibilities will require further research and development, covering organizational as well as purely technical issues.

4.4 Other USPs mentioned in D2.1v2

4.4.1 Communication with owners of VDIs

CONVERGENCE allows the publisher of a VDI to communicate with current owners of the VDI without the need to access personally sensitive information.

D2.1 v2 identified this functionality as one of CONVERGENCE's Unique Selling Points. However, none of the applications tested in the trials used the feature and none of the new scenarios described in paragraph 2.2 require it as an essential feature. There are circumstances in which it could be useful (the feature was originally introduced as mechanism supporting safety recalls in the WIPRO consumer electronics scenario).

4.4.2 Multiple versions of VDIs

CONVERGENCE allows an application to access multiple versions of a VDI.

This feature is intrinsic to the basic architecture of the CONVERGENCE system and requires no further development work. However, it was not tested in the CONVERGENCE trials and does not appear in any of the other use cases.

4.4.3 Ontology creation

The CONVERGENCE CDS and related services allows users to define ontologies and to make them available to all users of the CONVERGENCE network.

This is another of the Unique Selling Points, identified by D2.1 v2 that was not tested in the CONVERGENCE trials[8], and which does not appear to be essential to any of the other use cases. In principle, ontologies could provide a useful adjunct to CONVERGENCE publishing (helping publishers to find good descriptions for their VDIs) and for CONVERGENCE search (helping users to define good search terms). Furthermore, ontologies are already making a vital contribution to specific niche applications (e.g. Information Retrieval for scientific and medical research). However, the creation of a useful ontology requires a major investment of resources, which would only be justified in very specific circumstances. The ability to create ontologies should thus be seen as a useful add-on rather than a Unique Selling Point.

[8] The FMSH "Video in the Cloud" scenario used a pre-existing ontology.

5 Conclusions: topics for future research

From the analysis in the previous chapters, we conclude that the initial CONVERGENCE requirements analysis was extremely successful. The requirements resulting from the work were *sufficient* to allow the implementation of a powerful framework covering a broad range of user scenarios; nearly all of the requirements were *necessary* for the implementation. The Unique Selling Points identified in the original work are essential features of multiple use cases.

This having been said, from an end-user perspective, the key issues for future research are probably the following:

- Novel search mechanisms for CONVERGENCE networks (end-user features and supporting technical mechanisms) including methods to rank search results and effective exploitation of semantic technology
- CONVERGENCE licensing, the CONVERGENCE REL and related enforcement mechanisms facilitating the definition and enforcement of the diverse requirements of a broad range of use cases
- Privacy protection mechanisms including support for anonymous and pseudonymous access, publishing and search

Obviously these topics are additional to and do not replace topics identified by groups working on technical aspects of the CONVERGENCE framework.

Appendix I: New use cases

FMSH-LMU Joint Scenario

Note: in bold are the new steps of the walkthroughs (compared to initial single FMSH & LMU scenarios)

Videos in the Cloud for Educational Purposes

Description of general user population
a) Content Producers / Publishers: Audiovisual professionals Researchers and professionals working to produce audiovisual documentation for life-long learning University lecturers **b) Content Consumers** University students Any individual consumer of resources for life-long learning.

Specific classes of user considered in scenario and description of role
Users of FMSH and LMU: **Video Material Owner:** member of audiovisual staff in charge of the recording and collecting of video recordings (of lectures) at LMU University or ARA Program of FMSH. **Users of FMSH:** **Analyst:** University lecturer in Communication, Information or Computer Sciences who wish to provide rich metadata within a video of his course in order to provide students with resources and analyses that complete their knowledge about a specific aspect of the course. The analyst role can be assumed by any individual or collective actor (researcher, laboratory, association) wishing to provide material for life-long learning. **Video Channel Owner.** The person who manages the video channels dedicated to a specific course ("Bachelor in Communication & Information Sciences", "Master in

Computer, Sciences" etc.). This role can also be assumed by lecturers wishing to broadcast their own course channels, as well as by any individual or collective actor (researcher, laboratory, association) broadcasting life-long learning channels.

Video channel users. Students, subscribers to video channels offering relevant pedagogical content. This role can be assumed by any actor in the field of life-long learning.

Users at LMU

Lecturer. The person responsible for publishing a podcast. The lecturer can also play the roles of *Analyst* and *Video Channel Owner*.

Student: Student at LMU watching and commenting a podcasts (with synchronized slides if available). The student can also play the role of *Video Channel User*

General description of scenario

In this scenario, resources (mainly videos) are shared between educational actors from different organizations, taking advantages of the features offered by the existing LMU and FMSH applications, and of the 6000 hours of scientific, pedagogical and cultural online videos provided by FMSH's ARA program (http://www.archivesaudiovisuelles.fr).

Video material, produced by LMU and FMSH, is shared between users in the two organizations. Thus, LMU students can watch and comment their video podcasts as usual, but also have the opportunity to watch and comment audiovisual material from ARA (seminars or conferences in Communication and Information Sciences). Similarly, FMSH analysts and video channel owners can access video material provided by LMU. In the future, lecturers at other universities in Germany, France (or elsewhere) will also be able to create educational channels. This means that lecturers will be able create and manage "Course Channels" to which students can subscribe. For example, master students in computer science will be able to subscribe to the channel associated with the "LMU Master of Computer Sciences"

Thanks to the CONVERGENCE infrastructure, the scenarios can be easily implemented with only some minor changes to the existing FMSH & LMU scenarios.

Description of individual use cases

Name of use case:	**Registration and Authentication**

Classes of users considered in use case and description of role
All user and roles
Detailed walkthrough
Registration 1) (Optionally) **VMOs, Analysts and VCOs** receive a smart card holding the following data: a) User identifier b) Secret key c) An automatically generated PIN d) A Signature key e) A Group Signature key 2) User launches the Registration Tool, then: a) (Optionally) Inserts smart card on his device b) Fills in a form containing fields for personal information (First name, Last Name, Email, Company, **City, Country**), **Username and Password**, **c)** Indicates her role(s) : i) Video Material Owner (VMO) ii) Analyst iii) Video Channel Owner (VCO) iv) Lecturer (this role covers the roles of Analyst and VCO as well) v) Student/Video Channel User (the both grant the same rights) d) Sends a registration request 3) System a) Identifies the user b) Stores the identity of the user in the system **Common authentication procedure** 1) User launches the Authentication Tool **a)** Enters an username and password

2) System performs user authentication 3) User authenticates herself to the network **<u>Smart card enabled authentication of VMOs, Analysts and VCOs</u>** 1) User launches the Authentication Tool **a)** Inserts her smart card in his device b) Enters her PIN 2) System performs user authentication 3) User authenticates herself to the network
New requirements for application
• Registration Tool shall enable a User to describe his/her City and Country • Registration Tool shall enable a User to choose an username and a password • Registration Tool shall enable smart card-based registration as well as username/password registration • Authentication Tool shall enable mutual authentication with smart card between User and Device, as well as username/password authentication
New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)
None

Name of use case:	Creation and Publication of a Video

Classes of users considered in use case and description of role

Video Material Owners (VMOs)

Detailed walkthrough

1) Video Material Owner launches the Video Manager Tool, then:

a) Authenticates herself

b) (Optionally) Encrypts a video resource:

i) Selects the video file **in MPEG-4 format** to encrypt

ii) Selects the location of the new file to be created and clicks on the "Encrypt" button causing an encrypted video file (a new file) to be generated at the specified location; the decryption key can only be released to authorized users

c) Fills in main form, which (depending on the application) asks for:

i) Title of the video, **keywords**, **author(s)**, sub-title, short description, original language(s), date of realization, localization, producer(s), **content copyright(s), production copyrights**.

ii) Location in local device of the previously encrypted video file

d) Creates licenses for

i) Author(s) of the video (ie. Lecturers) to use the video for any kind of use (this license should be set automatically)

ii) Analysts to subscribe to, decrypt, download and analyse the video

iii) Video Channels Owners to subscribe and post the video

iv) Video Channel Users **and Students** to subscribe and watch the video

e) Creates requests for notification (event reports) to the owner(s) of the video when:

i) An analysis referencing the video is published

ii) An analysis referencing the video is unpublished or revoked

iii) The video is posted on a channel

iv) The video is unposted from a channel

v) The video is decrypted and downloaded

g) Clicks on the "create & publish" button.

2) System :

a) Creates a Video VDI, referencing the video resource

b) Embeds licenses & notification requests

c) Signs the VDI

e) Uploads the VDI and stores it on the network

f) Injects and stores on the network a Publication VDI referencing the Video VDI

g) Notifies the author(s) and subscribers that the new video has been published

New requirements for application

- Video Manager Tool shall enable the Video Material Owner to encrypt a video file in MPEG-4 format
- Video Manager Tool shall enable the Video Material Owner to enter the authors of the video by selecting Lecturers from a User Identification Service

New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)

None

Name of use case:	Unpublication/Revocation of a Video
Classes of users considered in use case and description of role	
Video Material Owners (VMOs)	
Detailed walkthrough	
Common steps 1) Video Material Owner (VMO) launches the Video Manager Tool, then: a) Authenticates herself b) Browses the Video VDIs he published Unpublication 2) User selects a Video and clicks on the “Unpublish” button 3) System checks the license to check if the VMO is a valid author of the Video VDI 4) An Unpublish request is sent to the network 5) The corresponding Publication VDI is revoked Revocation 2) Selects a Video and clicks on the “Revoke” button 3) System checks the license to check if the VMO is a valid author of the Video Resource 4) A Revoke request is sent to the network 5) The corresponding Video VDI is revoked **6)** The corresponding Video Resource is removed from the network Notification The following Users are notified of the unpublishing or revocation of the Video: **a)** Author(s) of the Video b) Analysts and Students who have subscribed to the Video c) Analysts who have published an Analysis referencing the Video e) Video Channel Owners who have posted an Analysis referencing the Video	
New requirements for application	

• Video Manager Tool shall check with the license of a specific Video VDI for the identified User to unpublish it • Application shall send notification to authors and subscribers of both applications when a video is unpublished or revoked
New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)
None

Name of use case:	Downloading a Video
Classes of users considered in use case and description of role	
Analysts, Students	
Detailed walkthrough	
1) User launches the Video Manager Tool. a) Authenticates himself b) Browses Video VDIs he subscribed to or for which he is mentioned as author c) Selects a Video to download d) User indicates the location in his device where to store the video 2) System checks the license of the Video VDI the user wishes to download and if the user has the right to download the video. 3) If video resource was encrypted, system decrypts the video using user license 4) The video resource is downloaded **5)** The user plays the video file in MPEG-4 format, then can use it for creating a Podcast or an Analysis	
New requirements for application	
• Video Manager Tool shall allow users to browse Video VDIs they have subscribed to or for which they are mentioned as authors • Applications shall check licenses generated by both FMSH and LMU users • System shall check user licenses for decrypting a video	
New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)	
None	

Name of use case:	Search for a lecture podcast or video

Classes of users considered in use case and description of role

Students, **Video Channel Owners (VCOs)**

Detailed walkthrough

CONVERGENCE allows students and Video Channels Owners to search for a lecture podcast or podcast components:

- Using the Podcast Service Tool
- Using the Channel Manager Tool

Search with the Podcast Service Tool

1) Student enters her search query in a text field and has the possibility to set filters for the search (e.g. only podcast from computer science)

2) Student receives a series of candidate VDIs matching the search query:

a) Podcast VDIs

b) Video VDIs - including Video VDIs published by any Video Material Owner (ie. from LMU or FMSH)

3) Student views VDI of interest

a) In case of Video VDI, system checks his right to VIEW the VDI

4) Student subscribes to VDI of interest if he wish to get notified when the VDI is updated or commented (optional)

Search with the Channel Manager Tool

1) VCO enters his search query in a text field and has the possibility to set filters for the search (e.g. only podcast from computer science)

2) VCO receive a series of candidate Podcast VDIs

3) VCO views Podcast VDI of interest

4) VCO subscribes to Podcast VDI of interest if he wish to get notified when the VDI is updated or commented (optional)

5) VCO posts a Podcast of interest in his channel (optional)

a) System checks his right to POST the Video VDI referenced by the Podcast VDI

New requirements for application

- The Podcast Service Tool shall be able to search for any Video VDI whatever who (LMU or FMSH) published it

• The Podcast Service Tool shall be able to preview content of Video VDIs • The Podcast Service Tool shall be able to check VIEW rights of user before displaying a Video VDI • The Channel Manager Tool shall be able to search for Podcast VDIs • The Channel Manager Tool shall be able to preview content of Podcast VDIs • The Channel Manager Tool shall be able to subscribe to Podcast VDIs • The Channel Manager Tool shall be able to post a Podcast VDI in a channel • The Channel Manager Tool shall be able to check the POST rights of user for the Video VDI referenced by a Podcast VDI before posting a podcast in a channel
New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)
None

Name of use case:	Subscription to a lecture podcast or video with notification of updates and new releases

Classes of users considered in use case and description of role

Students, **Video Channel Owners**

Detailed walkthrough

Students **and Video Channel Owners** interested in a lecture podcast can subscribe to podcast episodes or components of a podcast. They can decide whether to be notified about updates and new releases or not. In the latter case updates and downloads are completed transparent to the user. Subscription options can be changed any time in the podcast application.

Subscription

1) User search for VDI (as detailed in use case 6: “Search for a lecture podcast or video”)

1) User selects a Podcast or Video VDI of interest

2) User subscribes to selected VDI

Notification of updates and new releases

The system sends notifications either through the Podcast Service Tool or Channel **Manager Tool**.

Notification using Podcast Service Tool

User:

1) Logs into the Podcast Service Tool

2) See a list of lecture podcasts **or videos** he has subscribed to

3) See notifications for:

a) New annotations to a video (video of podcast or single video from FMSH)

b) New episodes in a podcast

c) Updates to a podcast

4) Previews the content concerned by the notification:

a) Selects an annotation and jump to the annotation within **video**

b) Selects a podcast and jump to the podcast

Notification using Channel Manager Tool

User:

1) Logs into the Channel Manager Tool

2) See a list of lecture podcasts he has subscribed to

3) See notifications for updates or new episodes in a podcast

4) Previews the updated Podcast

5) (Optionally) Video Channel Owner can decide to post or unpost the podcast from his channel

a) if VCO has the right to POST the Video VDI referenced in the Podcast VDI

New requirements for application

- The Podcast Service Tool shall provide a subscription to videos mechanism, including to videos published by FMSH
- The Podcast Service Tool shall notify students when are published new annotations on single videos they subscribed to
- The Channel Manager Tool shall provide a subscription to podcasts mechanism
- The Channel Manager Tool shall notify Video Channel Owners about updates on podcasts and videos
- The Channel Manager Tool shall show Video Channel Owners the updated content
- The Channel Manager Tool shall enable Video Channel Owners to post or unpost podcasts from their channel
- The Channel Manager Tool shall be able to check the POST rights of user for the Video VDI referenced by a Podcast VDI before posting a podcast in a channel

New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)

None

Name of use case:	Posting/Unposting a Podcast on a Channel

Classes of users considered in use case and description of role

Video Channel Owners (VCOs)

Detailed walkthrough

Common Steps

Video Channel Owner launches the Channel Manager Tool, then

1) Authenticates herself

2) Browses Podcast VDIs she subscribed to (as described in "Subscription to Podcasts" use case)

3) Selects a Podcast she wants to post or unpost in her Channel

Post

1) Clicks on the "Post Podcast" button

   a) The rights of the identified User to post the Podcast VDI, as well as the referenced Video VDI, are checked

   b) A Publication VDI referencing the corresponding Channel VDI and the Podcast VDI is injected into the network

   c) Subscribers, as well as Publishers of the Video VDI and Podcast VDI, are notified of the new post in the Channel

Unpost

1) Clicks on the "Unpost Podcast" button

   a) The corresponding Publication VDI is removed from the network

   b) Subscribers, as well as Publishers of the Video VDI and Podcast VDI referenced in the Publication VDI, are notified of the unpost in the Channel

New requirements for application

- Channel Manager Tool shall make it possible to browse Podcast VDIs the Video Channel Owner has subscribed to
- Channel Manager Tool shall check with the license of a Video VDI for the identified User to post a Podcast referencing a Video
- Channel Manager Tool shall have the capability to create a Publication VDI referencing a Channel VDI and a Podcast VDI, and inject it in a peer
- Peers shall notify users when a Publication VDI referencing a VDI they published

is published or unpublished
New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)
None

Name of use case:	Individual and collaborative learning with Augmented Lecture Podcast and Channels

Classes of users considered in use case and description of role

Students, Video Channel Users

Detailed walkthrough

The scenario enables students, as well as any Video Channel User interested in long-life learning, to:

- Browse channels dedicated to particular courses
- Get notified of any new content posted in a channel
- Access to analyses of the video lectures provided by lecturers
- Revise and make annotations (comment) about the lectures through the Augmented Lecture Podcasts

Learning with Channels

User launches the Channel Manager Tool, then:

1) Authenticates himself with username and password

2) Receives notifications of new content in a Channel he has subscribed to

3) Select and browse a Channel

a) Each Analyses and Podcasts posted in the Channel are listed

b) Selects an Analysis he wants to browse on a Channel

c) View information of the Publication VDI:

i) Title or URL of the Channel VDI referenced in the P-VDI

ii) Title, sub-title, spoken language(s), date, location, short description, long description of the Analysis VDI referenced in the P-VDI

iii) System redirects user to web channel, where he can read analysis metadata and watch video**.** If the video was encrypted, system checks the user license and decrypts the video before it is streamed by the application.

d) Selects a Podcast he wants to browse on a Channel

e) View information of the Publication VDI

i) Title or URL of the Channel VDI referenced in the P-VDI

ii) Title, description of the Podcast VDI referenced in the P-VDI

iii) Titles and descriptions of the episodes of the Podcast VDI referenced in the P-VDI

iv) System redirects user to the Podcast Service Tool, where he can watch and comment the Podcast

Learning with Augmented Lecture Podcast

User launches or is redirected to Podcast Manager Tool, then:

1) Read Annotations to Lecture Podcast or single Video published by FMSH

Students watching the lecture podcast or video can see other students' annotations, which can be restricted or public. Restricted annotations can be personal (only visible to the author) or shared within a certain group. Public annotations are visible to all users registered to the system. Public annotations may be anonymous. To read the annotations, students go through the following steps:

a) The right of student to VIEW the Video VDIs from FMSH is checked
b) If the video was encrypted, system checks the student license and decrypt the video resource before it is streamed by the application

c) Choose whether to view all annotations or only annotations to the current slide

d) Choose whether or not to display: personal annotations, shared annotations or public annotations

e) Select an annotation and view the content: author (when annotations are non-anonymous), text of annotation, replies to annotation

2) Create/Publish an annotation related to another annotation

While watching the lecture podcast, students can make own annotations or reply to other public annotations. To do this they go through the following steps:

a) Click on slide to make annotation

b) Write content of annotation

c) Select publishing options: personal, shared, public/non-anonymous, public/anonymous

d) Enter expiry date for annotation

e) Sign

f) Publish their annotation

i) Student must have POST right to publish an annotation referencing a FMSH Video VDI

3) Edit Annotation

The author of an annotation has the right to change her/his annotation. To do this she:

a) Selects the annotation to be changed (only possible for authors)

b) Make changes to the content (text) and the license

c) Save the changes

d) publish the annotation

i) Student must have POST right to publish an annotation referencing a FMSH Video VDI

4) Delete Annotation

If the annotation is public or shared with other students and Video Channel Owners, are notified of the change or deletion

New requirements for application

- Channel Manager Tool shall enable users to browse Channel VDIs matching Video Channel User subscriptions
- Channel Manager Tool shall present content included in the Publication VDI
- Channel Manager Tool shall have the capability to redirect User to web URLs embedded in VDI metadata
- Podcast Service Tool shall display Video VDIs and stream corresponding video resources in MPEG-4 format
- Podcast Service Tool shall display all annotations made to a single video published by FMSH
- Podcast Service Tool shall enable the creation and modifications of annotations to a single video published by FMSH
- Podcast Service Tool shall be able to check user's VIEW right of Video VDIs before watching videos
- Podcast Service Tool shall be able to check user's POST right of Video VDIs before publishing video annotations
- System shall check user licenses for decrypting a video

New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)

None

Description of general user population

a) **Content Creators:**
Professional Photographers
Freelancers

b) **Content Consumers**
Customers that are interested either in specific photos or in products related to photos (e.g. cameras, lenses, etc.)

c) **Manufacturers,** who make use of the WIPRO application (i.e. creation and publication of product VDIs)

d) **Retailers** that make use of the UTI application (i.e. creation and publication of Offer VDIs).

General description of scenario

The use case involves four user profiles, one for the content creator (a photographer), one for the content consumer and one for manufacturers/retailers. The business stakeholders are Alinari (which sells image rights, fine art books and printed material), WIPRO and UTI (both technology providers for the retail industry).

Once the photographer creates new photographic images, she has the option to include automatically generated camera information, such as camera model and lenses. After image publication, CONVERGENCE associates the photo with the Product VDIs for her camera and lenses (created with the WIPRO application), and with special offers to buy these products (created with the UTI application).

When the content consumer retrieves images through the photographic application (PAM-Photographic Archive Management), she receives similar information, such as offers on the camera and lenses. This puts the consumer in a position to purchase these products.

Users registered to the Alinari application are able to:

- Create, Annotate, License and Publish photos (photographers)
- Submit queries, personalizing the period to which the query refers (photographers and content consumers)
- Purchase products related to digital photos, such as cameras and lenses (photographers and content consumers).

The application automatically matches EXIF information incorporated in the photo with product VDIs, for cameras, lenses etc. Other trusted subjects (e.g. UTI), can then use this information to generate offer VDIs, which can then be visualized through the PAM application.

In brief, the application provides the consumer with information that could lead her to make new purchases – in this case, cameras and lenses, in the future books from the photographer, Alinari books and posters, etc.

Description of individual use cases

Name of use case:	**Authentication to CONVERGENCE applications with a Single-Sign-On mechanism**

Classes of users considered in use case and description of role

All users and roles

Detailed walkthrough

The system offers two kinds of registration/authentication, a username/password based Single-Sign-On (SSO) and a sophisticated smart card based SSO.

SSO Registration with smart card

1) User receives a smart card from holding the following data:
   a) User identifier
   b) An automatically generated PIN
   c) A Signature key
      i) Smart cards implement digital signature schemes that comply with current regulations and standards
      ii) The user's signature key is *generated* on the card, and *certified* during registration (this is achieved without revealing the corresponding secret key)
      iii) The user's private key *never* leaves the smart card, and is not known to *any* entity outside the smart card (not even to the user herself)
      iv) The certificate containing the user's public key is kept for subsequent distribution.
2) User launches the **Registration Tool**, then:
   a) Inserts smart card on his device
   b) Fills in a user form containing fields for First name, Last Name, Email, Company
   c) Sends a registration request
3) System
   a) Identifies the user
   b) Stores the identity of the user in the system

SSO Registration with username/password

1) User registers to the COVNERGENCE SSO server providing the following information:
   a) User identifier, Alias, E-mail
   b) Personal information: First name, Last name, Company
2) System stores the identity of the user

SSO login using smart card

1) User
   a) Opens a CONVERGENCE application, locates and follows the 'Login with CONVERGENCE' link
   b) Launches the **Authentication Tool**
      i) Inserts her smart card in her device

ii) Enters her PIN

2) System
   a) Challenges the card in order to authenticate the originality of the card
   b) Authenticates the user
   c) Shares First name, Last name, E-mail and User Identifier with the application
   d) Redirects the user to the application's home page as a registered user
3) User can access all CONVERGENCE applications without
   a) Registering to each application
   b) Authenticating himself on each application

SSO login using username/password

1) User
   a) Opens a CONVERGENCE application, locates and follows the 'Login with CONVERGENCE' link
   b) Provides his username and password
2) System
   a) Authenticates the user
   b) Shares First name, Last name, E-mail and User Identifier with the application
   c) Redirects the user to the application's home page as a registered user
3) User can access all CONVERGENCE applications without
   a) Registering to each application
   b) Authenticating himself on each application

SSO logout

1) User locates and follows the 'Logout' link provided by the application he is using
2) Application contacts the CONVERGENCE SSO server and logs the user out of all CONVERGENCE applications.

New requirements for application
Registration Tool shall enable a User to choose a username and a password Registration Tool shall enable smart card-based registration as well as username/password registration Authentication Tool shall enable mutual authentication with smart card between User and Device, as well as username/password authentication Users shall be able to access all CONVERGENCE applications without registering to each application and without authenticating on each application
New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)
None

Name of use case:	**Creation and Publication of a Product**
Classes of users considered in use case and description of role	
Manufacturers	

Detailed walkthrough

Creation of a product

Manufacturers who release new products to the market create VDIs for the products and publish them to the CONVERGENCE network. The VDI id is used as a global identifier for the product and in the case of a camera; it is embedded in the EXIF metadata of each new photograph. The creation and publication of a Product VDI involves the following steps:

1) User authentication: before creating and publishing products VDIs, the manufacturer has to login to the application, with a username and a password
2) Creation of Manufacturer product type VDI (MPT-VDI)
   a) Identification of resources (documents, images, videos) used to describe the product
      i) The VDI id and the product name is used in any content generated by the product
   b) Description of resources
   c) Definition of the product metadata information, using the CDS
   d) Creation of license
      i. Grant rights to issue a child VDI (update)
      ii. Grant rights to access VDI information
   e) Identification and Signature of VDI
   f) Packaging and Storage of VDI
3) Publishing of VDI to the Network

New requirements for application

None

New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)

None

Name of use case:	Subscription to Products, Creation, Publication and Match Event Reports of an Offer

Classes of users considered in use case and description of role

Manufacturers, Retailers, Customers

Detailed walkthrough

Subscription to Products

Retailers are interested in Products published by Manufacturers and perform therefore subscriptions to receive new products or updates to existing products.

1) Retailer creates a subscription to Products and specifies
    a. Product type
    b. Product name
    c. Wanted product features
2) Retailer receives notifications that match his subscription and may create offers for them.

Create Offer

When a Retailer receives a notification for a new product, he may create an Offer in order for consumers to purchase the product.

1) Retailer creates an Offer by specifying
    a. Relevant Product
    b. Price of the product
    c. Special features for the product e.g. refurbished product by the manufacturer.
2) Publishes the Offer in the CONVERGENCE cloud
    a. Specifies the relevant Product Id
    b. Adds a Match Event Report Request.

Match Notification

Each time the Offer created by the retailer is matched an Event Report is generated to inform the retailer of this.

1) Retailer browses his Offers
2) System provides the notification count of the specified Offer.

New requirements for application

There shall be an application allowing to end users to parse and extract metadata from VDIs created with other applications

New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)

None

Name of use case:	4) Creation and Publication of a Photo

Classes of users considered in use case and description of role
Content creators

Detailed walkthrough
1. A professional photographer or another registered user accesses the photographic application with his security card or his username and password 2. She creates a photo VDI. To do this she: • Uploads one image on PAM application, • Annotates the image • Assigns a License to the image (e.g. everybody can view the image and subscribers classified as "Gold" can also download it) 3. System parses the EXIF metadata of the photo a. Searches for the Camera Product VDI Id and the Lens VDI id b. Searches for the product name 4. System creates subscriptions for Offers regarding the products found in the photograph 5. User publishes the photo in the CONVERGENCE cloud.

New requirements for application
The application shall be able to parse EXIF metadata of photos and identify the camera with which the photo has been taken The application shall create subscriptions for offers related to cameras

New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)
None

Name of use case:	Browsing for photos
Classes of users considered in use case and description of role	
Content consumers	
Detailed walkthrough	
1. A registered user of the PAM application launches the application 2. She creates subscriptions using certain search criteria 3. She receives notifications related to the previous submissions. She also receives offers on products related to the photos. 4. She can purchase the photo. She can also reply to special offers associated with the photo (e.g. offers for cameras or lenses). In this case she is redirected to the UTI application where she can purchase the product specified in the offer	
New requirements for application	
There shall be an application allowing end users of the PAM application to see offer VDIs that have been created with the UTI application A user shall be able to click on an offer and be redirected to the UTI application	
New requirements for CONVERGENCE (architecture, definition of VDI, framework, network, other)	
None	

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