A data infrastructure for digital cultural heritage: characteristics, requirements and priority services

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Abstract: The European amount of digitized material is growing very rapidly, as National, regional and European programmes support the digitization processes by Museums, Libraries, Archives, Archaeological sites and Audiovisual repositories. The generation of digital cultural heritage is accelerated also by the impulse of Europeana that is fostering the European cultural institutions to produce even more digital content. Moreover digital cultural heritage content is complex and interlinked through many relations. European countries are working for the future, in order to create a data infrastructure devoted to cultural heritage research. Currently, Europe has 2 twin-projects (DC-NET and INDICATE) ongoing and a new international coordination action is under preparation to design a validated Roadmap for the preservation of digital cultural content. These initiatives are contributing to smooth the way to the Open Science Infrastructure for Digital Cultural Heritage which is foreseen in 2020.

1. The Digital Cultural Heritage sector: characteristics and needs

Since early 2000s, a wide range of activities was carried out by the European Member States in order to accept the challenge of driving the European Cultural Heritage through the digital age.

Digital evolution of the Cultural Heritage field has accelerated rapidly in the past few years. Massive digitization and annotation activities are in progress all over Europe and the world, following the early developments at the European level [1] and the "Lund principles" [2]. Furthermore, the strong involvement of companies like Google, together with the positive reaction and increasing support of the European Union, have led to a variety of, rather converging, actions towards multimodal and multimedia cultural content generation from all possible sources (i.e. galleries, libraries, archives, museums, audiovisual archives etc.). The creation and evolution of Europeana [3] as a unique point of access to European Cultural Heritage, has been one of the major achievements of these efforts. At the moment, more than 20 million objects, expressing the European cultural richness, are accessible through the Europeana portal, and it is expected that this number will be doubled within the next five years.

The matter has 2 faces: on one side, the Memory Institutions (museums, archives and libraries at first, but also Archaeological sites and Audiovisual repositories) feel the unavoidable need of digitizing their content, both for preserving it in a digital format and for granting and enlarging the access to them by researchers, students and citizens. It is esteemed that only a very small part of the European cultural heritage had been digitized until now, therefore there is a lot of work to do and memory

institutions are bearing big efforts to carry on this huge deal. A growing number of projects for digitization is supporting the process and indeed the cultural heritage sector is going through wide transformations and changes.

On the other side, furthermore, our society is like never before accumulating a huge amount of digital-born material (result data from the research, materials' analysis, digital art, bibliographies and so on). The digital-born heritage is therefore adding data and content to the digitization process output.

The volume of digital cultural heritage data is incredibly growing year after year, so that it became immediately necessary to reflect upon the tools which permit to manage such a huge amount of data in an efficient and selective way, in order to make the data available to the researchers and the citizens in a European dimension, and towards a global dimension too.

The first issue which was felt of immediate importance, also considering that each of the Member States had its own methodology and procedures, had been building a shared platform of recommendations and guidelines and developing common data models and services. To this aim, 2 major projects (Minerva [4] and Michael [5]) permitted to have the proper basis from which two branches had started.

First branch, towards citizens: the flagship project of digitization process that produced data, made available for all the citizen is Europeana, which holds a series of related projects: projects to add content to Europeana itself, projects to develop tools and guidelines and to manage all the upcoming content properly and accordingly, and projects for parallel uses of Europeana contents.

Second branch, towards researchers of Cultural Heritage: the research in the cultural heritage sector is rapidly transforming into a data-based science and therefore it is

becoming more and more crucial to develop dedicated e-infrastructures which will enhance the research and will facilitate the researchers' workflow. See Fig. 1: European projects overview.

In the end, Digital Cultural Heritage (DCH) content is extremely complex and interlinked through many relations, and there is a growing feeling that Europe actually needs to create a space for research in the sector.

Therefore, the needs of DCH sector are :

- high quality information technology management, to ensure trust, availability, reliability, long-term safety of content, security, preservation and sustainability;
- enhanced access facilities
    i. to the researchers who will look for contents into the DCH e-Infrastructure for their research;
    ii. to the cultural institutions that will deliver their data to the DCH e-Infrastructure;
- interoperation among existing cultural heritage repositories, among cultural portals and among data from the digital cultural heritage and from the research.

2. The vision towards a DCH data infrastructure

The e-infrastructure for DCH is not going to be a "new infrastructure", but it should be instead conceived as a "new approach" based on the interoperation and federation of national and regional systems, with the scope of valorizing existing resources.

The keyword is interoperability among National, Regional and Thematic systems.

The embracing of the e-Infrastructures by the digital cultural heritage community will open new scenarios of use and exploitation with an impacts expected on different sectors:

- impact on the cultural heritage sector

  The managers who work in the Cultural sector will become more aware about the potential that the e-infrastructures can offer to their work: storage, preservation, access services for the cultural institutions, etc.

- impact on the research

  A better integration of the cultural sector with the e-Infrastructures will enable the research of new advanced services and applications

- impact on the economic sectors

  Digital cultural content will become more usable and re-usable for education, cultural tourism, long-life learning, non-professional cultural interests, creative industry, etc.

It is possible and recommendable also for the digital cultural sector to focus on the use of the existing research e-Infrastructures as a channel for managing their data, using the storage, computing, and connectivity services they already provide to the research sector.

For the matters of connectivity, the DCH sector is already more and more using the facilities offered by the National Research and Educational Networks (NREN). To this regard, it is still necessary to develop further the national policies in order to open completely the access to the services of the NREN also to the cultural heritage institutions, since this is not yet the case in all the European Member States.

For the matters of storage and computing, in the past years the research about high energy physics was supported by the creation of specific e-infrastructures with powerful computing systems, the GRID computing, able to manage a huge volume of data. These e-infrastructures, together with authentication, authorization and accounting mechanisms that they offer, can well serve the needs of the DCH sector.
The emerging cloud services, both from the commercial providers and as services based on the GRID are also another important domain of investigation for the DCH sector.

As there is no need of building a new e-Infrastructure to be dedicated to DCH sector, the issue is indeed to establish factual cooperation among cultural heritage institutions and e-Infrastructure providers that are not used to work together. See Fig. 2: Cooperation and collaboration. Key players from the DCH (Ministries of Culture and cultural institutions at cross-domain level, represented by museums, libraries and archives together) need to develop further competences and to establish cooperation and collaboration with the correspondent key players from the research (Ministries of Research, Researchers in the Humanities, Researchers in ICT applied to Cultural Heritage) and with e-Infrastructure providers: this is the only way for reaching the ideal concept of a DCH devoted e-Infrastructure.

The work has just begun, and there are several preparatory actions currently on-going:

- To define priorities among the services to be deployed

  This action has been the matter of DC-NET project, which has develop a

  Handbook about Service Priorities further presented and discussed in Section 4.
- To consult and to advocate with stakeholders

Stakeholders are a complex set of actors, including: Programme owners and Programme managers (Ministries, Councils, national Agencies) who define where the spend public money; e-Infrastructure providers (providers of connectivity, computing, storage, cloud services) who set the policies of access to their services; research centres in the humanities and in ICT (universities and academies) who are changing their competencies integrating them into a new science often called “ICT for the humanities”; memory institutions (museums, libraries, archives) who own the content and who need to set new policies for the right over the digital content; the private sector (small and medium enterprises as well as the big corporations) who should be motivated to invest into the cultural products.

- To engage with programme owners

  The owners of the public programmes of investment, such as the European Commission and the Member States, should become aware of the need to allocate funds to the creation, maintenance and operations of the DCH e-Infrastructure, as it is already the case for the e-Infrastructures dedicated to other sciences.

- To improve awareness: standards, who-is-who, …

  This is mostly a networking activity: sharing knowledge and information is the basic action to prepare for the creation of a sound community.

- To promote trust building, covering different aspects and including organizational, operational and legal issues

  Trust building is a matter of knowing who are the other parties (and in this sense, this actions is very much dependent from the networking activities), but it is also an issue of technologies, that should enable sophisticated identification and associated authorization mechanisms. These technologies exists and the

organization to use the technologies have been put in place in other sciences and the cultural sector can and should benefit of what already exists.

- To run experiments: pilots and use case studies

  The hands-on approach is one mean to become familiar with the "unknown" and in this sense it can generate many positive feedbacks. Further, it is a way to measure the actual understanding of the involved people and to raise issues that are difficult to be discovered if the technology is used only in the closed laboratories.

- To open international cooperation

  The whole scientific development reached an international dimension in the past years. This is happening also in the cultural sector and is providing an answer to the implicit nature of culture that has never had borders, since the antiquity until the present. E-Infrastructures are operating internationally, also thanks to the EU investment on international links of the GEANT European network. Cultural and memory institutions are sharing methods and standards for digitization. Capitalizing these available results, and progressing on the international cooperation is very important for an harmonious growth of the digital cultural sector.

- To establish an e-culture community

  All the actions discussed in the previous points should together contribute to create a motivated community of people and organizations, aiming towards a common goal that is to make available the digital cultural heritage as a continuum of information and data, open to research, learning, industrial and leisure activities.

This DCH e-infrastructure should be able to serve the research in the humanities, but it should also include complementary services dedicated to the education, learning and public access.

The schools will find on such e-infrastructure a major source of information and teaching material, both in the forms of articles and even data. And the availability of data will be a way to stimulate a research dimension in the educational process too. The students will be able to use the e-infrastructure for their home-work and for leisure too. The information accessible on the e-infrastructure will stimulate their curiosity in addition to provide all the necessary resources to complete their study. Also tourists, families and citizens in general will have access to an enormous quantity of high quality information: tourists will be able to plan their vacations on a more informed way, parent will spend their time at home with the children to discover new stories about their territory and their local or foreign cultures; people interested on specific cultural matters will have very powerful instruments in their hands to make their researches.

Different types of authorizations will be easily implementable by exploiting the work already done on the management of federation of identities and identity providers, which are techniques fully deployed within the e-infrastructures for the other sciences. The development of educational, learning and public access services will be a matter for private providers, triggering a virtuous circle of demand and offer of technology. In this sense such e-infrastructure for the digital cultural heritage will not be just an instrument for a limited number of cultural experts, but it will be open to cross-domain and multidisciplinary communities of researchers as well as to the public society.

3. Two inter-related projects: DC-NET and INDICATE

In the framework of initiatives to support the development of the DCH space-Infrastructure, three initiatives are worth to be mentioned which are preparing the way for the new European program Horizon 2020 for research, development and innovation [6].

Both projects are funded by EC FP7 e-Infrastructures:

1. DC-NET: joint activities plan for DCH e-infrastructure implementation (priority and programming)
2. INDICATE: international cooperation, use case studies, pilots, policy harmonization (support and demonstration)

DC-NET ERA-NET: Network for the European Research Area

The core objective of the DC-NET project is to establish a common awareness of perspectives, priorities, constraints and capabilities across the digital cultural heritage and e-Infrastructures communities in Europe. While the use of e-Infrastructures for arts, humanities and social sciences has increased in recent years, the dominant users of e-Infrastructures remain the “hard” sciences, notably physics, with increasing levels of bio-informatics and life sciences use. The cultural heritage sector has the potential to be a significant user of e-Infrastructures capabilities, just as the e-Infrastructures sector can facilitate important research and services progress for DCH.

The vision of DC-NET is a seamless data and services infrastructure for cultural heritage, which unobtrusively but reliably provides key services such as preservation

and backup, authentication and data integrity, collaborative research environments, advanced (cross-collection, multilingual and semantic) search and retrieval, while enabling intellectual property management and authorised use of DCH content.

The DC-NET project has worked to bring this potential closer to realisation, by establishing networks of contacts, by exploring priorities and capabilities, and by agreeing a common action plan for R&D into the future.

Full information about DC-NET are available on the project website at http://www.dc-net.org

The final conference of this project took place in Rome on 8th March and it was the successful conclusion of a very important path across EU Member States to establish an operative dialogue between cultural heritage and e-Infrastructures communities in Europe.

Programme Owners and Programme Managers in the cultural sector worked to agree common perspectives and priorities, and to identify constraints and capabilities in order to establish a plan of joint activities for the implementation and deployment of a new data and service e-Infrastructure for the DCH research.

Coordination and integration among the European Countries are the core of the DC-NET approach: to contribute to the Joint Programming Initiative on cultural heritage [7], to integrate the research capabilities of the participant Member States, to identify standards, needs and solutions and to valorize the existing projects and results.

INDICATE: A concrete approach within an international dimension

The goal of the INDICATE project is to coordinate policy and best practices for the use of e-Infrastructures by the DCH community in the Mediterranean region. A network of common interest composed of experts and researchers from e-

Infrastructures, DCH and ICT domains was established to share experience, promote standards and guidelines, seek best practices and policy harmonisation, and to transfer knowledge from DCH organisations experienced with the use of e-Infrastructures to those with less experience. INDICATE also carried out practical experimentation through pilots and use case studies using the policies and best practices identified by DC-NET, which explored the available e-Infrastructures in Europe, described the policies, programmes and regulations related to e-Infrastructures, as well as the current standards in the area. The Paris Declaration, adopted by the INDICATE partners on 07 June 2012 at the Strategy and Future Plans Workshop (the Paris Declaration can be downloaded from the home page of the project's website at www.indicate-project.eu) details the future priorities and commitments of the network beyond the lifetime of INDICATE. The shared vision of the INDICATE network is that in ten years' time, access and use of digital cultural heritage will be available to all and that collaboration with the e-Infrastructures community will facilitate realisation of this vision.

Full information about INDICATE are available on the project website at http://www.indicate-project.eu

Indicate is intended for stimulating the international cooperation of e-Infrastructures providers and cultural heritage users, and it supports and applies the DC-NET results with concrete and real experimentations in countries of the Mediterranean region and internationally.

The network set up with this project is indeed a community of partners who share common interests and aim to long-term collaboration also beyond the lifetime of the project.

Within this network of common interest, the following activities take place:

- establishing working groups dedicated to specific aspects of e-Infrastructures-enabled cultural heritage which are relevant across national and organizational boundaries;
- holding conferences, workshops and seminars on the convergence of e-Infrastructures and Arts, Humanities and Social Sciences (AHSS) with special focus on digital cultural heritage;
- developing on-line tools and resources for the working groups such as use case studies, pilots and other services.

Within INDICATE, the partners explore the potential of e-Infrastructures to overcome key problems which are rising in the e-Culture such as long-term preservation, virtual exhibitions, management of geo-coded cultural content.

The project is not only Europe-centered, but it has instead a genuine international vocation: Egypt, Turkey and Jordan are partner of the project; cooperation are ongoing in China in liaison with the EPIKH Grid School, in Taiwan in the frame of the TELDAP Conference and in South America in the frame of experiments for live distributed performances in liaison with the CHAIN and GISELA projects.

The INDICATE project started in September 2010, it will last until September 2012. See Fig. 3: Timeline.

The two DC-NET and INDICATE projects have many partners in common, and are targeted to the same DCH community. The e-Infrastructure programmes identified in DC-NET will be at the basis of the sustainability of the results of INDICATE.

4. Service Priorities

Priorities for the Digital Cultural Heritage sector have been put together, having in mind the typical workflow of the DCH research.

- Find: accessing information
- Process: tools for manipulating information
- Publish: make the results visible online
- Conference: discuss and annotate published information
- Preserve: maintaining access to content over the longer term
- Secure: implementing authentication and authorization mechanism to control access to data
- Plus low-level "basic digital services" such as email, data storage, web hosting, etc.

The services priorities identified by DC-NET can be usefully divided into three categories. These are:

- Services for content providers and related to the creation of online data resources for DCH
- Services for managing and adding value to the content itself
- Services which enable, support and enhance virtual research communities and the activities of content consumers

These three categories encapsulate three key aspects of digital cultural heritage. Content providers are those memory institutions which digitise and place content online. Their work includes not only selecting and digitising the content, but also preparing metadata, building data resources such as websites, portals, digital libraries and repositories. The creation of data resources is a core task for any DCH initiative.

Every DCH project needs some type of "database" or online data resource, as a structure within which digital content can be placed. Important issues here include interoperability across resources, tools for searching and navigating the resources, long-term value of the resources, etc.

Of great importance to content providers is effective networking and sharing of information across DCH initiatives, the building of consensus and best practice, so that content providers can learn from one another, and the development of skills within the DCH community, to enable new research to be carried out.
Managing and adding value to the content itself goes beyond simply publishing digitised material online. There are many attractive ways to enhance the data, make it more user friendly and attractive and to facilitate its re-use in education, in commercial ventures, in collaborative projects, etc. Key issues here include visualisation, geo-referencing, 3D representation and manipulation, IPR management, annotation, statistical analysis and other activities which add value to the actual content and/or make it easier to manage. (This is an area of critical value to Europeana – and to similar initiatives -, as it seeks to add value to the metadata corpus which it holds.)

Services for virtual research communities focus more on the users of the content and less on the content itself. A major priority for the holder of any DCH corpus is to add value to it by nurturing a research community around the material, by enabling annotation, discussion and user-contributed content. Underpinning such new facilities are requirements for user management (authentication, auditing, accountability), for

tools and environments which stimulate collaboration across virtual communities of researchers, for communications, conferencing and publishing.

The three categories are further discussed below.

1. **Services for content providers**

   These services includes: services for content creation, networking services and technical services.

   The creation of an online "location" for the presentation of DCH materials online is a central part of any digital heritage initiative. The model applied will most commonly be a content management system, a portal system, a digital library or digital repository which has been specifically designed and built for the purpose.

   Online resources have several **common issues**:

   - In general, each online resource uses its own technical solution or blend of solutions to meet its own needs. As has been discovered, for example, during the aggregation work of Europeana and its "feeder" projects, this does not lead to simple interoperability of the online resources.
   - Insularity in terms of searching - each online resource typically has its own search interface and algorithm. Searching across multiple resources and combining the results is technically challenging.
   - Changes in location – items within online resources are typically accessed via their URL. When the resource is reconfigured, reformatted, moved or

restructured, this leads to broken links and issues with access (particularly from portals and third party services).

- High cost of establishment – setting up a new online resource is a complex technical task and usually requires customisation and adaptation of the technology to meet the specific needs of the DCH users.
- Vulnerability to technical problems. The resources typically represent a very large investment by the DCH community and a strategic asset of the owners. A technical problem such as server failure could be catastrophic.
- Limitations on server capacity and processing – online resources are frequently hosted in-house or by a commercial hosting company; when the resource consumes the space or processing power allocated to it, there is a high potential for disruption when the system needs to move to a new platform.

These issues lead to the identification of the first set of **priorities for the DCH research community**:

- **Interoperation**: services are required which simplify the interoperation of online DCH resources. Such services may involve the transformation of metadata and database data sets to a particular common standard, or the creation of mappings between the metadata and data formats of different online resources.
- **Aggregation**: services which can harvest and combine material from several DCH resources are needed in order to enable multi-resource facilities such as Europeana to be delivered.

- **Cross-Search**: services are needed which enable searching across multiple online DCH resources. This may involve the transformation of a centralised search into the local search calls for multiple DCH resources; alternatively it may build on the interoperation services mentioned above, or utilise linked data as described below.
- **Semantic Search**: services which take advantage of advances in semantic web technologies, such as linked data and ontologies are needed. Such services can offer a new level of intelligence and relevance in meeting the needs of users and can support new models of searching navigating and experiencing complex and interlinked resources. Again, such searches must work across multiple DCH resources.
- **Persistent identification**: services are needed which simplify or automate the maintenance of persistent identifiers and their mapping to specific locations within DCH resources. PID services which shield external users from internal reconfiguration are needed if portals and services which build on interoperability are to be stable in the medium to longer term.
- **Setup services**: facilities and tools which simplify the construction of online digital culture resources themselves are badly needed. Templates and tools (ideally open-source, or available under unrestrictive licences) which can be customised to simply create digital libraries and repositories are a high priority. Such a service would reduce the cost of DCH initiatives; several data resources using the same tools would also have a high likelihood of interoperability and standards compliance.
- **Stable platforms**: infrastructure services for hosting, backup and availability of the DCH resources are needed, in order to raise confidence

in the ongoing stability of the resources and to ensure that strategic assets and major investments are not jeopardised.

- **Scalability**: services which enable arbitrary levels of scaling and growth are required, as the amount of digitised material grows and the usage levels increase.

Enabling and developing a Europe-wide virtual **research community** dedicated to digital cultural heritage is a high priority. While DCH research has been an active field for some decades, there is still an urgent need for greater integration, consensus and collaboration. The research field has tended to fragment along national and sectoral (museums, libraries, archives, monuments, etc.) lines; additional fragmentation has been caused by the involvement of multiple ministries in some countries, by different funding models, etc.

The following specific services have been identified by DC-NET:

- **Knowledge and documentation of user needs**. The end users of DCH work tend to be DCH researchers and/or members of the general public. As in other areas of IT, there is a temptation to deliver solutions which take advantage of new technologies, without first ensuring that such a solution is actually required. Developments in the broader Web, such as social networking, semantic web technologies, adaptive systems etc. all offer potential for new DCH services – however, it is essential that end user appetite for such services is actually present. Research into the interests and requirements of the end user communities is needed. This research must be ongoing over time, as the end user priorities and expectations will themselves evolve. End user priorities must be

documented and validated by the end users, so that DCH providers, technology partners and the users share a common vision.

- **Who is who**. DCH research is typically fragmented along national and sectoral lines. This can lead to repetition of research, to the re-invention of common solutions and to organisations failing to learn from the experiences of others. A key solution to this issue is to be able to identify the organisations and the individuals who are active in DCH and to summarise their particular areas of expertise and experience. A "directory" or "who is who" guide to Europe's DCH community would be a valuable addition to the current situation, where contacts tend grow organically, serendipitously and by word-of-mouth. As with user needs documentation, such a directory would need to be updated on a regular basis, in order that levels of activity and types of experience are truly reflected.
- **Policies and programmes**. A further perspective on the DCH landscape is that of policies and programmes. Each country, each sector and often each organisation will have policies and guidelines for accessing, sharing and processing the content under its control. Such policies range from digitisation guidelines to access control, commercial re-use to integration with Europeana. Not only should DCH policies be considered here – DC-NET itself clearly demonstrates the importance of the policies governing access to e-Infrastructures, for example. Where DCH research is being envisaged, it is important for all concerned to have a clear picture of the policies that will impact on the research. An awareness of the programmes already in place, and how new research initiatives can impact on those programmes, is also important. The impact or take-up of a new service will

be affected if a similar programme already exists in a target "market". Research into this domain must be kept up to date and must cover as many countries, sectors and organisations as possible. It is to be hoped that ongoing efforts at consensus (including DC-NET) may help to simplify the policy landscape over time; however it remains a critical element of any successful collaborate DCH research initiative.

- **Handbooks and technical reference**. The experience of completed and ongoing DCH initiatives needs to be shared with new and planned projects. While all projects produce reports and deliverables, a greater emphasis should be placed on the generation of widely-applicable guidelines and handbooks which formalise and integrate the lessons learnt. The loss of knowledge when projects end is an important source of inefficiency in DCH research; measures to address this are a priority. While this may not represent a research domain in its own right, it is an important aspect of the activities of any new research project.
- **Consensus Building** - Seminars, workshops, dissemination. While sharing knowledge and experience is very beneficial, international and cross-sectoral impact can best be achieved by face to face discussion and consensus building. Best Practice Networks, ERA-NETs and bodies such as the MSEG all contribute to this process, but such efforts need to be ongoing, need to involve as many member states and organisations as possible and need to address as many issues relevant to DCH as possible[1]. The mechanisms used for consensus building are typically meetings, seminars, conferences, etc. The results can be usefully validated through

[1] This, for example, is the driving force behind the DC-NET "follow-on" project, INDICATE (www.indicate-project.eu), which involves many Mediterranean-bordering countries including several outside the EU.

dissemination events where they are exposed to, and receive feedback from, the broader DCH community. The results of the consensus should, as noted above, be documented as handbooks and technical reference, so that they are as useful as possible for other initiatives.

2. **Services for managing and adding value to the content itself**:

   While the core of DCH is the digital content itself, this content is indeed much more useful and appealing when it is made available for the consumers/end users, and re-usable for educational purposes.

   Services that improve the content are for example geo-referencing, 3D visualization and manipulation, virtual reality and immersive interfaces, annotation linked data generation

3. **Services** which enable, support and enhance virtual research communities and the activities of **content consumers**:

   As the research communities are becoming virtual and there is not anymore the need of being geographically local to the studied material, it is necessary to enable a wide range of new services to support the researchers' participation to the research: user authentication, group-based access control, collaborative environments, annotation services, advanced search support, visualization services.

   Content consumers are of course free to pick and choose the services which they will use, and those which they identify as being of greatest importance. This "cafeteria model" enables a broad range of services to be made available, without

the need to actually deliver them for all members of a (primarily undemanding) researcher community.

This category of services includes, for example: user authentication and access control, collaborative environment – conferencing, discussion, annotation, etc. - and visualization services.

The previous paragraphs present the most important new or improved services for the DCH sector, which can benefit from e-Infrastructures support. The **priority ordering** (from the most important service, to the least important) must reflect both the input of the DCH community and also the impact which e-Infrastructures support can make. In addition, the amount of R&D needed to make the new service a reality must also be taken into account – "low-hanging fruit" should be prioritised, so that tangible benefits are achieved in the short term. None of the services listed is "low priority" – all of the services promise substantial benefit to the DCH community. The following ordered list takes these into account.

1. **Long-term preservation**

   This is given top priority because

   - e-Infrastructures are in a position to offer substantial storage immediately
   - Preservation is an urgent issue, with hardware obsolescence and the need for media migration a looming problem for many digital culture collections
   - Relatively minor R&D is needed for "raw" or "simple" storage (clearly, digital repository frameworks and other middleware are another issue)
   - Moving critical DCH holdings to a cloud environment places it on a new and stable platform for other new services.

2. Persistent identifiers

This is given second priority because

- Broken links and moving digital content due to website redevelopment, etc. are an urgent problem impacting on all portals and aggregators (thus, for example, PIDs are a key element of the Europeana Content Development Strategy)
- There is excellent research and development already done in this area, and one or more of the existing schemes (e.g. DOI, ARK, URI, URN, etc.) could be adopted with minimal adjustment
- A PID registry is a service which can benefit significantly from a centralised, cloud-based implementation; e-Infrastructures have much to offer here
- The PID requirements do not vary significantly from one DCH initiative to another – this represents a service useful to most DCH work, 'out of the box'.

3. Interoperability and Aggregation

This service receives third priority because

- Although very important for European DCH, it is technically challenging and will require substantial effort and investment. The effort increases linearly with the number of data resources made interoperable – a solution for one resource will not often be immediately applicable to another.
- Once achieved, interoperability can underpin aggregation, some advanced search services and some elements of digital rights management. As such, it is strategically important, even if difficult to achieve.

4. Advanced search

This service receives fourth priority because

- It is technically challenging and requires a great deal of effort. Several initiatives are underway, others have been completed and more will be needed before this realises its full potential.
- It can benefit significantly from interoperability and from PIDs; thus, these should be addressed first. Because it includes topics such as multilingual support, it can be argued that this should be completed before interoperability; it may emerge that both of these services will be addressed hand-in-hand.
- Of course, this is perhaps the single most important user-facing new service.

5. Data resource set-up

This service receives fifth priority because

- It is effectively an "add-on" for persistent storage and preservation, rather than a key issue in its own right
- It will require customisation and adjustment for each DCH organisation which sets up a data resource – thus as a research proposition it is not a neat package like PIDs or multilingual terminologies, for example.
- However
    - It is identified as valuable by many DCH organisations
    - It can aid in interoperability and in advanced search
    - It can facilitate the migration of data to the e-Infrastructures environment, with associated benefits in stability, scalability and network access.

6. User authentication and access control

This service receives sixth priority because

- persistent storage/preservation and advanced search are higher priority
- the R&D required will be significant, and customisation (especially for access control) for each data resource means that the research itself will not be "neat package".
- None the less
    - This research is essential for community-focused, collaborative and interactive/annotation services
    - This research is an important element of the enforcing of IPR and DRM policies
    - User authentication is an ideal centralised and scalable services for e-Infrastructure implementation

7. IPR and digital rights management

This service receives seventh priority because

- Other services are also of very high priority, and benefit more from e-Infrastructures
- However
    - IPR is an urgent issue for all collaborative and portal initiatives
    - DRM must be addressed effectively if a content industry is to be nurtured in the EU

All the services identified here are important and valuable. Ordering them in terms of priority is both difficult and somewhat subjective. This list and its order combines short-term feasibility of implementation with e-Infrastructures added-value and DCH strategic importance. All these services are important, and the priority order doesn't mean that the lasts are the least: it is necessary to point towards a common research action plan and therefore cooperation and coordination among the three sectors (culture, research, e-Infrastructures) is at the core of the DCH e-infrastructure.

5. Network of common interest

The network of common interest that was built among the DC-NET and INDICATE projects combines regional, national and international levels with both bottom-up (working groups) and top-down (Joint Programming) approaches.

The working groups are composed by experts seconded by their cultural, research and infrastructure organizations, and cooperation was established with other networks and projects as EPIKH, CHAIN, EUMEDGRID-Support, EUMEDCONNECT2, LINKED HERITAGE and many others.

A dialogue is also established with strategic bodies that work in Europe and abroad on DCH and e-Infrastructures policies:

–e-IRG e-Infrastructure Reflection Group

–ESFRI European Strategy Forum on Research Infrastructures (with particular regard to the Social Science and Humanities thematic working group - SSHTWG)

–EGI.eu European Grid Initiative

–TERENA Trans-European Research and Networking Association

–MSEG Member States Expert Group on digitization

–ASREN – Arab States Research and Education Network

6. A position paper of the digital cultural heritage sector

The key aspects for the progress of the research and innovation in the domain of the DCH were listed also in a Position Paper which was presented by DC-NET and Linked Heritage [8] projects in response to the Open consultation on the Green Paper on Common Strategic Framework (which was the starting point for the preparation of Horizon 2020):

1. European Coordination: the role of Member States and European Commission

   The integration of investments from the private and the public sector within a globalized dimension demands for attention and reflection of the member States and the European Commission in a coordinated and synergic manner
2. Europeana: towards its full deployment

   The flagship project of European heritage is now entering into its full deployment phase that needs to be properly supported by the European Commission
3. Preservation: a task for the Member States

   The preservation of digital master copies takes place under the responsibility of national governments of Member States within their specific frameworks
4. Digital Cultural Heritage: the need for a research e-Infrastructure

To achieve all the wished results, and to guarantee the continuity of the services, the sustainability of related initiatives, and a long lasting life of the e-Infrastructure, it is necessary to facilitate involvement of all-levels institutions in the decision making process

5. Research and innovation in the digital cultural heritage: an international matter

   it is felt as unavoidable matter to enlarge the cooperation with other regions of the world far beyond Europe, to share best practices, joint research, development and innovation projects

6. Users involvement: the success factor

   Users should be actively involved into pilots, awareness and training activities in order to achieve success of the new ventures

7. Coordination and demonstration: a requirement for the DCH sector

   As the digital cultural heritage sector is quite new to the ICT, it needs to be accompanied by proper actions to support the stakeholders.

The next implementation plan will be part of the new Horizon2020 programme that the European Commission will launch in 2014 and will run until 2020.

7. What has been delivered by the projects and the lessons learnt

The DC-NET, INDICATE and Linked Heritage projects are different in their nature and timing even if they cope with a common goal which is to support the cultural heritage sector to go digital and to be alive in the digital space.

The DC-NET project ended in March 2012 and its legacy consists mainly in three parts:

1. The list of **services** that are considered of major priority for the sector; this list is endorsed by a wide number of Ministries of Culture in Europe and it represents a valuable starting point for any public and private organization that intends to enter into the sector with its own offer of services;
2. A plan of **joint activities** aiming to establish a digital infrastructure for the cultural heritage, endorsed also this by a wide number of European Member States' agencies and research centres, that are now committed to contribute to its execution, contributing with funding, technologies, human resources and cultural digital content;
3. A **living network of people and organization** that meets in the frame of a range of projects and initiatives, in Europe and globally, that share a need: to develop a community, with common tools and a common understanding of the respective skills, standards, technologies, vocations and interests. This is probably the most relevant result that DC-NET has left to the next projects and initiatives.

The main lesson learn in DC_-NET is that the process to make stakeholders converging on common goals is feasible, what is much more difficult is to make them allocating the resources necessary to realize those goals. In this sense, the approach taken by DC-NET is to enlarge the basis of the actors involved in the process and through the involvement of more people and ore organization to increase the possibility to get the new projects funded.

INDICATE is ending in October 2012. Its legacy consists mainly of practical results, namely:

1. The first result is made of studies of **use cases** about matters that are of major interest for the sector at the moment (namely digital preservation, virtual exhibitions and geo-coded cultural content) and for each of them an analysis of how the e-infrastructures can enable the delivery of improved and enhanced services to the cultural institutions.
2. Further, INDICATE played within concrete **pilots** in order to demonstrate from a practical point of view what does it mean to let the cultural institutions to use the e-infrastructures. The pilots demonstrated that from a technological point of view the solutions are available, but the cultural institutions are still missing a real awareness and knowledge of what the e-infrastructure are, which is the level of security that they can offer, how to take benefit of the computing and networking power, and in general we can say that the cultural sector is not yet ready as the other sciences to take full advantage of the new technologies.
3. The third legacy of INDICATE is to have opened an international dialogue among the actors of the cultural sector on the possibility to approach the e-infrastructures for the delivery of advanced services. INDICATE worked directly with three **Mediterranean countries**: Egypt, Jordan and Turkey. Each of them is represented in the consortium and participated actively to all the project activities. Further, a workshop was organized in Beijing in cooperation with the Peking University and INDICATE participated to the 2011 and 2012 editions of TELDAP Conference in Taiwan. The experience has shown that, more or less in each country and region of the world, there is

still much bureaucracy that influences the operations of the cultural sector and this limits in a certain way the capability of the sector to react to innovation. However, the people in the cultural sector are eager to use the new technologies and are looking very much for experimenting innovative solutions and this can be the real engine to move the sector toward the new digital dimension.

The main lesson leant from INDICATE is **that learning by doing** applies also to this case and the practical experiences carried out in INDICATE have produced a major impact on the participating partners in terms of awareness of the meaning of a new e-infrastructure for the digital cultural heritage.

Linked Heritage is a project totally different from DC-NET and INDICATE. It belongs to a "family" of projects that primarily deal with the support to Europeana. In this sense, the first type of results of Linked Heritage are mostly related to the ambit of Europeana. This is not the right place to start a thorough analysis of Europeana and its actual capability to deliver the expected results, because it would be too complex and too long. Europeana is certainly a work in progress and there are different opinions about its aim to become "the" unique access point for European culture. This is something that will be possible to assess only in the next decades. However, at this stage, we can realistically say that Europeana is a very interesting opportunity for the cultural institutions to work with the digital technologies, at international level and it has mobilized thousands and thousands of European and international experts in discussing about the future of the cultural heritage in the new digital sphere: where the libraries are going with the advent of the digital libraries, what the archives should become if the documents are accessible online for public consultations and are no

more kept secret in closed buildings, how the museums should transform in order to be attractive for the new generations, which is the role of the audiovisual content in the context of the preservation of the cultural heritage and many other questions have been discussed all over Europe in the last years. And this discussion has fostered new understandings, among which, for example: the need of innovating the cultural sector and the skills of the people working in this sector, the need of sharing standards, guidelines and best practices, the need to work globally because the network is global, the need to redesign the policies of rights protection. Persistent identifiers, linked data, metadata standards, multilingualism, bridging public and private sectors are among the themes that are faced in Linked Heritage, among more than 40 cultural organizations from all over Europe. The momentum that this discussion is creating is extremely interesting. The project is approaching its mid-term review, concrete results will be available by end of 2013. Beyond its ingestion of metadata into Europeana, the project has already achieved its first important result that is to created a community of people, researchers, professionals, students, managers of cultural institutions who recognize to have a set of common interest and who are willing to share their knowledge, their experiences, their solutions, with the others. This is the first step towards a new way to conceive the management of the cultural heritage in Europe.

8. The next step: a Roadmap for the preservation of digital cultural heritage

INDICATE and DC-NET are part of a wider process, which started 10 years ago among cultural institutions and this process entered in a new phase, by joining the research e-infrastructures.

Time is now ready to start working towards an Open Science Infrastructure for Digital Cultural Heritage in 2020, and concretely to establish a roadmap for DCH that express clear workpaths, alliances and strategies. See Fig. 4: Towards Horizon 2020.

The use of e-Infrastructures well linked and integrated, will allow to distribute advanced services for digital cultural heritage research and contents.

The use of existing research e-infrastructure is an efficient channel for the delivery of advanced services to the digital cultural heritage.

To achieve this goal, NREN and NGI facilities needs to be complemented with targeted specific services. DC-NET and INDICATE started the work.

The new initiative DCH-RP Digital Cultural Heritage Roadmap for Preservation, expected to start in October 2012 and lasting 2 years, will continue adding more concrete results in the specific area of the digital preservation. See Fig. 5: DCH-RP.

The main objectives of DCH-RP are:

i. to harmonize data storage and preservation policies in the DCH sector at European and international level
ii. to progress with the dialogue among DCH institutions, e-Infrastructures, research and private organizations
iii. to establish the conditions for these sectors to integrated their efforts into a common work
iv. To identify the most suitable models for the governance, maintenance and sustainability of such integrated infrastructure for digital preservation of cultural content

The main outcome will be a Roadmap for the implementation of a preservation infrastructure for DCH, supplemented by practical tools for decision makers and

validated through a range of proof of concepts, where cultural institutions and e-infrastructure providers will work together on concrete experiments.

DCH-RP Roadmap is intended as the first instance of the Open Science Infrastructure for DCH in 2020.

DCH-RP will establish a practical liaison among the participants to the project that can represent a model of cooperation also for the rest of the sector. It will start with its thirteen partners, will then move to the 20 ‘external partners’ from Europe, Taiwan, India, Malawi, USA and South America who have already expressed their intent to participate to the study with the aim, eventually, to become pan-European and global. See Fig. 6: beyond Europe borders.

9. Digitalmeetsculture.net

The DCH sector, while approaching towards digital solutions and technologies, also needs spaces and tools to share best practices, develop cooperation, and be visible to the world. Visibility is also necessary to DCH projects in order to be shared with the community, and also to support the dissemination: to this purpose, an useful, customizable and flexible tool is the www.digitalmeetsculture.net portal.

digitalmeetsculture.net is a communication platform open to world-wide contribution, run by company Promoter, and it was designed as an on-line magazine about the digital culture for collecting and sharing related information and events.

The portal is a remarkable meeting point with a global dimension, that takes into account the different approaches that scientific, humanistic and artistic culture have to the digital age.

Through the portal it is possible to give visibility and comply with the dissemination packages of any project or activity, thanks to dedicated services: each project is provided with a customizable showcase; it is easily accessible with an evident button with logo, which is present in the Home Page and in any other page in the website.
Clicking on the project's logo opens a dedicated page which contains a presentation of the project, beside related articles and interviews, and focused issues; the page contains also other useful information like contact details, auto-refreshing news (via RSS), multimedia galleries, and much more.
Another service which is going to be fully developed in the next time is the Repository Area, where any kind of documents, prototypes, websites which had been produced during the projects' life will be stored and preserved.

The editorial staff is assisted by Correspondents from all over the world, who cooperate to harvesting news and information. Furthermore, a particular role is played by the Referents: key people who act as main contact point inside relevant organizations or institutes, to keep the portal always up-to-dated on the most prominent initiatives, projects, events and progresses in the digital culture field.
Interactivity is a key-point of the portal: like any modern communication website, users can register to the portal, thus being allowed not only to simply comment the articles, but mostly to play an active part and send events and articles, until the point of joining the staff as correspondents or even Referents if they wish.
The global dimension of the project is therefore sustained and implemented by enlarging the group of involved people who act as content providers, in order to open the magazine to any input.

To sum up, the portal is built in order to create a useful tool for the dissemination of digital cultural heritage projects: by giving wide visibility to the projects' activities and achievements, by deepening their topics through interviews and related articles, and by offering a repository service for the projects' results.

See Fig. 7: www.digitalmeetsculture.net.

10. Conclusions

The digital cultural heritage can benefit from the access to the e-Infrastructures that exist for the research, with the final aim to construct a real infrastructure dedicated to the sector.

To achieve this goal it is necessary to develop a dialogue among people and organizations who are not familiar to work together: museums, libraries, archives, ICT research centers and e-Infrastructure providers.

Further, it is necessary to create a policy environment that support this dialogue, by getting together national, regional, European and international authorities, to achieve common commitment on shared goals.

It is also necessary to run experiments, use case studies, pilots able to demonstrate at operative level the feasibility of a long-term vision.

DC-NET, INDICATE and the future DCH-RP have started to work in this direction. The coming years will be important to bring also the arts and the humanities to participate at full to the global open science.

The programmes offered by the European Commission to support this process are important. In this light the new Horizon2020 will play a very important role. The

complexity of the participation to the EC programmes remains a serious matter that could influence the delivery of impact of the projects that run with the support of such programmes. However, on the other side, the width as well as the international dimension of the creation of an infrastructure demands necessarily for the public support. And in Europe, the European Commission is the primary source of funding for initiatives that go beyond the national borders.

The sense of the European-belonging is not complete and the idea of a European e-Infrastructure for the digital cultural heritage is fully dependent from this sense of EU-belonging - which is still under construction -. Building such an infrastructure will be more difficult than for the other sciences, and this is not due to pure technological issues, but to the real nature of culture heritage, that is where Europe is so unique, extraordinary, but also so difficult to be developed.

End notes

[1] European Council (2001) “European Content in Global Networks: Coordination Mechanisms for Digitisation Programmes (Lund Principles)”, Consulted January 31, 2012. Available:ftp://ftp.cordis.lu/pub/ist/docs/digicult/lund_principles-en.pdf

[2] European Commission (2002a) “Technological Landscapes for Tomorrow’s Cultural Economy: Unlocking the Value of Cultural Heritage”, DigiCULT Report, Luxembourg: Official Publications of European Communities, Consulted January 31, 2012. Available: http://www.digicult.info/pages/report.php

[3] Europeana is the public digital library promoter by the European Union and referred as one of the flagship initiatives in the Digital Agenda for Europe. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions COM(2010)245, Brussels, 19.5.2010. Avaliable: http://ec.europa.eu/digital-agenda and http://europeana.eu

[4] MINERVA is the Ministerial Network for valorising activities in digitisationof cultural heritage. It has run as a series of projects (Minerva, Minerva Plus and Minerva EC) supported by the European Commission in the frame of the Fifth and Sixth Framework Programme for the Research and Technological Development and in the frame of the eContent Plus Programme to support the development of a content industry in Europe. Available: http://www.minervaeurope.org

[5] MICHAEL is the European portal that provides a unique access point to the European digital cultural collections. The portal has been implemented in the frame of two project, Michael and Michael Plus, supported by the European Commission in the frame of the eTEN Programme for the ICT Trans-European Networks. Available: http://www.michael-culture.org

[6] Horizon 2020 is the new Programme for research, technological development and innovation that the European Commission is preparing. The Programme will run from 2014 until 2020. Available: http://ec.europa.eu/research/horizon2020/index_en.cfm

[7] The Conclusions of the Council of the European Union on the 2nd of December 2008 indicated the Joint Priogramming Initiatives (JPI) as the instrument to correlate the national investment on the research on the bid societal challenges in Europe with the resources make available on the same themes by the programmes of the European Commission. A JPI has been established among the European Member States, based on a variable geometry, specifically addressed to the Cultural Heritage. Available: http://ec.europa.eu/research/era/areas/programming/joint_programming_en.htm

[8] Linked Heritage is a Best Practice Network for the aggregation of content to the European digital library Europeana. Available: http://www.linkedheritage.eu

FIGURES:

Figure 1: European projects overview:

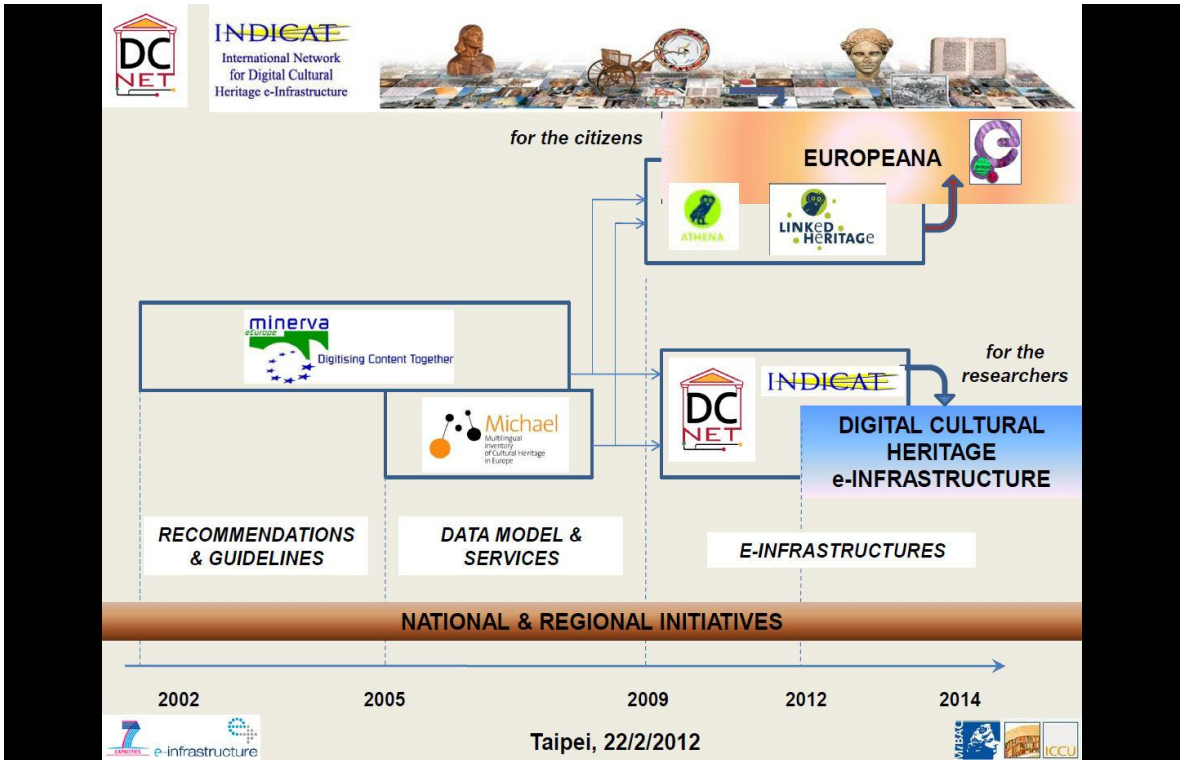

Figure 2: Cooperation and collaboration:

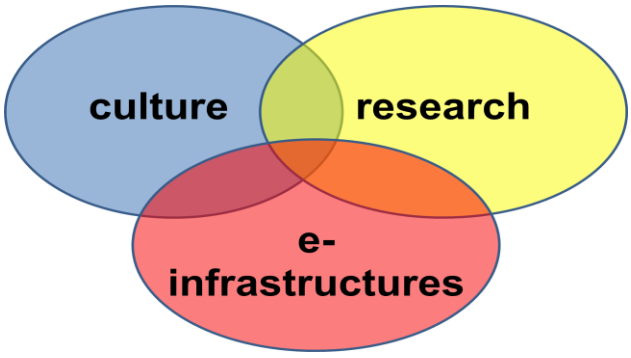

Figure 3: Timeline:

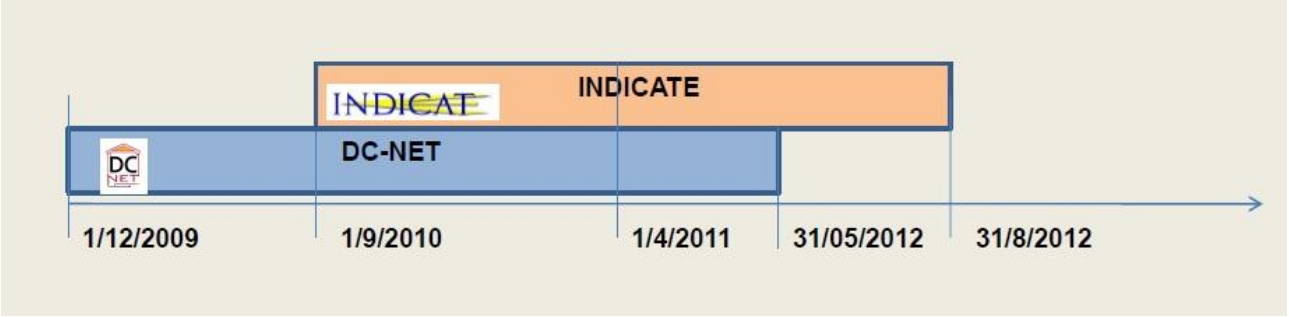

Figure 4: Towards Horizon 2020:

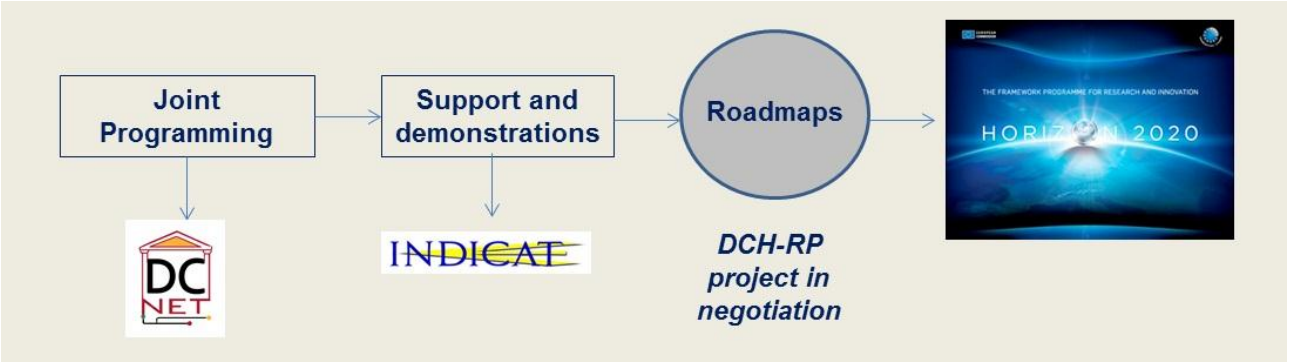

Figure 5: DCH-RP:

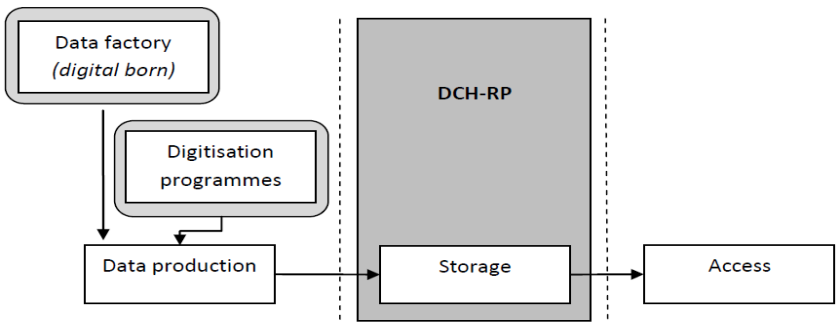

Figure 6: beyond Europe borders:

Figure 7: www.digitalmeetsculture.net