The Global Virtual Museum of Information Science & Technology, a Project Idea

Giovanni A. Cignoni, Giovanni A. Cossu

Hyperborea srl
Via Giuntini, 25 – 56023 Navacchio, Pisa, Italy
g.cignoni@eidolon.it, g.cossu@eidolon.it

Abstract. Information Science & Technology (IST) has pervasively affected our everyday life, thus becoming a proper cultural heritage of humanity. The growing curiosity about IST history has determined the creation of important collections devoted to the conservation of IST relics. Physical relics are naturally located close to their origins, but they are only one aspect of preservation and dissemination of IST history. The whole knowledge about IST history has to go beyond the local boundaries and become a globally shared and worldwide accessible heritage.
Our proposal is to establish a *Global Virtual Museum of IST* based on a *knowledge base* able to manage all the information of the domain, created and updated by museum keepers and other experts, and capable of offering new enjoyment opportunities to wider public audience. It is a radical change in the idea itself of cultural heritage information management, up to now bound to the traditional cataloguing approaches.

Keywords: Virtual Museums, Cultural Heritage Management, Knowledge Base

1. Introduction

IST (for Information Science & Technology, we like to add science in the more usual IT acronym), intended as a scientific discipline with a wide neighbourhood of technologies and applications, can be rightfully considered as an international cultural heritage. The development of IST has always been capable of overcoming geographical boundaries, both as scientific discussion and dissemination of technologies.

Nevertheless, if we look at how the IST history is maintained and presented to the audience, a strong localization can be observed. The museums are the places where the relics are preserved: many of early days IST relics are preserved where they were created. It is in the order of things and it is even correct to give the right importance to the local relics in their presentation to the public: it is natural that the *Pascaline* are in France, that the *Zuse Machines* are in Germany, that the *Manchester Baby* replica is… in Manchester, etc.

Getting excited in front of the pieces of history is the reason that drives us to visit museums appreciating the uniqueness and the differences among various collections.

Nevertheless, there is a dissonance between the international nature of the discipline and the localization of its preservation.

There is a further aspect. IST underlies many radical changes in the world and in the current way of life of each of us. In addition, almost always the IST revolution goes in the direction of the so-called "globalization": cancelled distances, availability of information for everyone, everywhere.

However, there are still cases where the application of IST has produced only an evolutionary innovation. One of these is the management and enjoyment of cultural heritage. IST are used and applied, but the catalogues of the collections are still built up with criteria inspired by inventories and not by knowledge management. The idea of "virtual museum", in most cases, is intended as the virtualization of a real museum. The technologies reproduce a surrogate of a physical visit deprived of the emotion of being in front of the original pieces. Of course, it has the great advantage of eliminating distances and enhancing accessibility, but at the state of the art not much more.

The article proposes a radical change in the way we treat the cultural heritage of humanity through the comprehensive and mature use of IST. The history of IST is also the proposed first application domain: it is an acknowledgement of the revolutionary nature of IST and its contribution to the management of knowledge.

The historical information preserved, mainly but not exclusively, by museums are collected in a single *Knowledge Base* (KB). In addition to the data of the pieces in the collections, the KB maintains and makes explicit the relations between pieces, hardware and software products, companies, scientists and inventors, documentation, events, and more. The KB is shared: it facilitates the work of museum keepers and provides the historians with a powerful research tool. The KB is public and, for researchers and enthusiasts, is an authoritative source of references.

The KB is the "virtual warehouse" of the *Global Virtual Museum of Information Science & Technology*. Using the KB as a source, new virtual exhibitions can be built: they do not surrogate the visits to museums, instead they offer new discovery pathways across the whole heritage of IST history. The intrigued visitor can navigate the KB, exploring all details and going beyond the physical location of collections. In traditional exhibitions the KB enhances the visitor experience by making accessible all the information that surrounds the physical relics.

The paper is organized as follows. In Section 2 we discuss how the physical approach to conservation of relics naturally leads to localized collections. In Section 3 we introduce the new proposed approach, which fully exploits IST to radically change the way the knowledge of cultural heritage should be globally managed. Section 4, using IST history as a case study, outlines how our proposal relies on a KB. In Section 5 a practical example is given to show how navigating a KB can lead to discover all the complexity of IST history. Section 6 shows how basic technologies are already in place, thus giving evidecne of the technical feasibility of the project. Conclusions also address the viability of the idea as a sustainable project.

2. Localization vs Internationalization: IST as a Case Study

The preservation of cultural heritage is traditionally local: the monuments rarely move and museums tend to keep relics related to their territory. Consequently, the way we enjoy cultural heritage is likewise localized: we must go to Siena to see, let's say, the "Majesty" by Simone Martini. Yet, even in the Middle Ages, Simone Martini's work was part of an international movement – the Gothic painting – originated in England and France, passed through Germany and finally arrived in Italy in the time frame of less than a century.

Despite culture is international, the traces it leaves, being physical, are subject to the law of Newton and tend to stay where they are; indeed, we perceive as unnatural their displacement – with subsequent instances for restitution.

The same applies to the IST history. The places where the relics are preserved often coincide with the places of origin, but their stories have a broader extent.

Consider for example the very first mechanical calculators. Blaise Pascal (French) left us several *Pascalines*, most of which are now in Paris [1]. Gottfried Leibniz (German) was well acquainted of Pascal's work when he built his *Rechenmaschine.* The very first prototype was presented in Great Britain at the Royal Society of London; two others machines were made, but only the second has survived and it is preserved in Hannover [2]. From Pascal's Pascaline also derive the machines made by Tito Burattini (Italian) and those by Samuel Morland (English). The first had probably studied Pascal's calculator while attending the court of King Władysław IV of Poland, the latter when he was on a diplomatic mission to the court of Queen Christina of Sweden – Pascal promoted his work by giving samples of his machine to royal families interested in things of science. Wanting to see a specimen of Burattini's or a Morland's, suggested sites are Florence [3] and London [4].

Coming to more recent times, the first electronic computers were bulky and unique or produced in small numbers. When the original machines still survive, they remain in their home areas. Reconstructions are also made locally: it is natural and correct that replicas like the *Manchester Baby* [5] or the *Colossus* [6] are in their respective places of origin.

With personal computers IST has definitely become an international consumer market. Collections of PCs show usually a high grade of internationalization. Yet, when focusing on less known machines, it is still much likely meeting strong localization: there is a wealth of *Acorn* PCs at Bletchley Park [6] and at Cambridge [7] as well as there are many Olivetti PCs in Ivrea [8]. There is even an innate interest in preserving the relics where the producing firms are located.

There are, of course, exceptions where the geographical position of the collection does not coincide with the origin of the pieces: an example is the relevant collection of Apple machines and memorabilia in Savona [9].

However, the collection is still confined: it is in a given place. A virtual version of the museum can cancel distances, like in the case of the Savona collection where a nice *app* allows visiting the exhibition from everywhere. However, it is still a confined experience: it tells the story of a great set of Apple's pieces, but with few links to the rest of the IST history.

Such a localization is not representative of the universal nature of IST. Collecting the whole IST history in a KB which makes explicit all the relations among facts will help in highlighting the circulation of ideas, the spreading of technologies, the evolution of industrial partnerships, the changes in the global market.

3. IST, Revolutions and Evolutions

Today it is quite difficult to think of a world without IST. Within a few years our habits have dramatically changed. Could you imagine how you could deal without a search engine? Would you like to renounce to mobile devices through which we are always reachable, which provide *apps* that help us in a thousand of things, from finding directions to keeping in touch with friends? And, besides personal aspects, how could we manage financial data, control industrial processes, ensure safety of flights and so on without IST? Things have changed so much and are so hard to reverse that talking of "revolution" makes sense – IST is identified as one of the factors of the third industrial revolution next to come [10].

Tracing the whole history of IST, we can find many revolutionary changes, and not only in recent times. The *Victorian Internet*, i.e. the telegraph network, has brought distances to nought: knowing what was going on the other side of the Earth changed from a matter of months to a matter of seconds [11]. Or the aforementioned mechanical calculators, operated by skilled *human computers*, have revolutionized the accounting, making possible to raise the size of companies by a couple of orders of magnitude. Again, the tabulating machines made it possible to overcome the impasse of too much information [12] and gave off a completely different way of understanding the control and management of information – not without introducing also disquieting consequences [13].

However, there are cases in which IST are applied but, while constituting a useful development, the extent of their contribution is not revolutionary. An example that closely concern us is the management of cultural heritage. In this context, we only partially take advantage of the wealth of tools provided by IST: they are mainly used for managing the assets and for making them accessible on different channels [14]. The mighty power of IST is not yet exploited to manage, make explicit and convey the complex web of knowledge that is the essence of cultural heritage.

Certainly, the computerization of museum catalogues is a major achievement, but in almost all cases it is simple data management. For example, in Italy, there is a long tradition of cultural heritage management which, on many occasions, has been the forerunner of innovative concepts like protection [15] as well as inclusion of all that is of cultural interest [16]. Cataloguing, as the way of knowing and managing cultural heritage, has always been a primary goal. The *Istituto Centrale per il Catalogo e la Documentazione* (Central Institute of Cataloguing and Documentation) continuously studies and promotes standards for cataloguing the whole Italian cultural heritage [17]. Such standards have, however, a flat structure "one piece - one cataloguing record": while implemented using IST they just replicate the structure of the old archives based on paper files. It is an evolution, but it has nothing revolutionary. And,

as an information system, it is insufficient for a context – cultural heritage – which is not a simple list of things, but a complex and extensive web of knowledge.

In addition, each museum is responsible for his own collection, and although computerized, the collection tends to remain localized without allowing the sharing of the knowledge among all the stakeholders – museums, research institutions, interested people, everyone.

The absence of a radical change is also noticeable in the presentation of the collections. Improvements have certainly been introduced by "virtual museums", e.g. the chance of visiting (or revisiting) the museum from home, the access to more documentation than what can be presented in the spaces of traditional panels and labels, the amazing ability to get very close to the works, virtually freed from safety distances thanks to high-definition digital reproductions or stunning 3D models.

However, the possibility of accessing all the knowledge that surrounds a piece still does not exist. The curator of an exhibition decides the information which are presented; as original, correct and useful they can be, such information remain bounded to that particular exhibition. There is no way to access the similar pieces, the pieces of the same author or the pieces inspired by or otherwise related to the piece on display but belonging to other collections. Neither is allowed accessing any other relevant information. Even if IST is used, cultural heritage is managed in a traditional and in a strongly localized way. No revolution happened in this field.

The question concerns all kinds of cultural heritage. In some cases relations about pieces and other linked information are crucial to allow visitors to fully enjoy a piece of culture. For instance, in modern art, the movements, the membership of an artist to a circle, the mutual influences given by affinity or contrast, are all keys to understand the work of art.

The importance of the surrounding knowledge is even more important when we focus on technical and scientific collections, such as those related to the history of IST. First of all, the cultural purpose of an exhibition in this field concerns also the public understanding of science and technology [18], so there is another level of information to be conveyed to the visitor. Moreover, the collections are about serially manufactured pieces, designed by project teams, produced by companies, often sharing technologies and components. The knowledge to be managed and made accessible is even more extensive, complex and crucial for understanding the context.

The IST revolution for cultural heritage is making available all this knowledge, going beyond the local management currently adopted by museums. Noteworthy, it is a possible revolution, as it mostly relies on IST technical solutions already available.

4. A Knowledge Base for the History of IST

A radical change in the way of managing the cultural heritage is to abandon the current local data management and focus instead on *global knowledge management*. It is certainly an ambitious goal, but there are no true technological limits, and there are many precedents in which the application of IST was, since the beginning, thought *in the large* – search engines, for example, have always dealt with the indexing of the whole internet.

To be prudent, however, we could start from a specific cultural domain. Our case study is the IST history, now preserved in collections dedicated to science and technology (such as, among the best known, the *Science Museum* of London [4], the *Deutsches Museum* in Monaco [19], the *Conservatoire National des Arts et Métiers* in Paris [1], the *Museum of Science and Industry* in Manchester [5]) or in museums specifically dedicated to IST (like the *Computer History Museum* in Mountain View [20], the *Heinz Nixdorf Museumforum* in Paderborn [21], or the already cited *National Museum of Computing* at Bletchley Park [6] and the *Centre for Computing History in Cambridge* [7]).

Our proposal does not simply concern the union of the catalogues, but their reorganization into a single KB able to preserve and explain all the complexity of the domain. The typical museum catalogues are focused on the *pieces* in the collection, like the exemplars of the *Apple][*. In the KB there are, of course, objects that hold information about pieces, but they are different from the KB objects which hold information about the *products*. The KB object of type `piece` maintains information on a particular Apple][exemplar, such as the serial number, the state of preservation and the provenance. The KB object of type `product` maintains information common to all Apple][: technical specifications, dimensions, historical notes. There will be as many Apple][in the KB as there are in the museum collections, each one with its `piece` object, but all of them will refer to the unique Apple][`product` object. Objects in the KB are typified so it is possible to grasp the distinctions among *versions*, *variants*, *special series*, *production batches*, as well as among different categories of products like *workstations*, *personal computers*, *home computers*, and so on. IST provides many theoretical and practical solutions to deal with type hierarchies [22].

Besides pieces and products, other kinds of objects managed by the KB are the used hardware *components* (like processors), the technological *solutions* adopted (from architectures to standard communication protocols and interfaces). *Software* (from operating systems to applications) is another huge branch in the type hierarchy of the KB as well as *documentation* (blueprints, manuals, but also brochures and promotional videos), *people* (researchers, engineers, entrepreneurs, designers, programmers) and *companies.*

KB objects of type `piece` correspond to pieces in the collections: machines of course but also components, photos, original documents, software on the original media. Other KB objects are pure elements of information, like `product` or `person` and all their subtypes. In addition, objects may link to virtual instances of the real pieces, like digital copies of documents, photos and other contents, as well as 3D models or software simulators of hardware systems.

The KB maintains much more information than would be possible using the traditional organization of catalogue records, no matter how much detailed you can conceive the record schema – in this sense a quite anachronistic example is made by the Italian ICCD standards [23] which are continuously updated by adding fields and fields in the vain attempt to catalogue every piece belonging to the scientific and technological heritage by using the same record schema.

The information in the KB is structured and factorized: there is no replication. The KB itself is a useful tool for museum keepers to facilitate the identification of pieces and to carry out their cataloguing duties. On the other hand, curators and other experts

from the scientific community of IST historians contribute to the growth of KB by adding objects and by creating relations among the existing ones. Sharing and constant peer reviewing of the contents grant the KB authority. In this perspective, the KB can be seen as the *virtual warehouse* of a *Global Museum of IST* which, virtually, assemble all the collections in the World.

The KB is navigable. The search features are tools for researchers and enthusiasts. Picking from the warehouse, curators may set up virtual exhibitions useful to guide the wide public to the discovery of the IST history. The KB can be used to virtually rebuild a visit to a real collection or exhibition, but it is also possible and maybe more interesting to build thematic paths through the contents of the KB, these will include pieces from different collections and suggest visiting the real museums to experience the thrill of being in front of the originals.

5. Enhanced Storytelling: from the Apple-1 to the KIM-1

Fig.1 shows a view of a possible portion of the KB. Each icon or image in the figure corresponds to a KB object. Most of the objects are elements of pure information, two of them do refer to actual pieces: an *Apple-1* and a *KIM-1*, respectively belonging to the *Bolaffi* [24] and the *Old-Computers.Com* [25] collections.

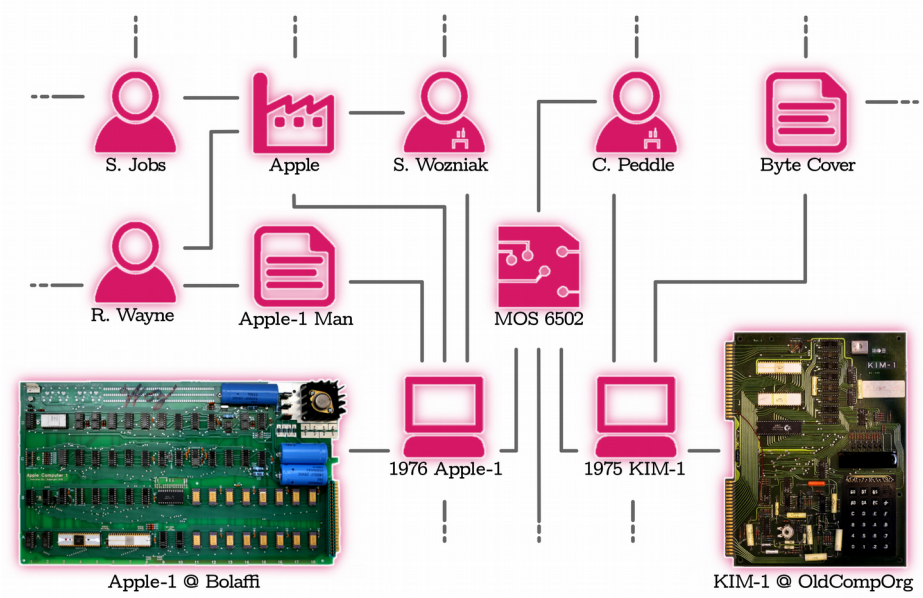

Fig. 1. A sketch of some of the knowledge surrounding the *Apple-1* and the *KIM-1*

The KB object of type `piece` corresponding to the Apple-1 in the Bolaffi collection is linked to the KB object of type `product`. The first maintains information of the specific piece: the serial number, the state of conservation, special notes like the signature of Steve Wozniak. The second one contains information common to all Ap-

ple-1: the dimensions, the release and withdrawal dates, the technical characteristics, historical notes and so on.

The keepers of the collections are in charge of editing the KB objects of type `piece`. A scientific community (i.e. keepers, curators and other invited experts) manage the editing of all other types of objects in the KB. Thus, the content of the KB is authoritative and the KB is a tool that helps in the cataloguing of new acquisitions – the Apple-1 is a simple case, but other IST artifacts have versions, variants, production batches and are quite difficult to be properly identified.

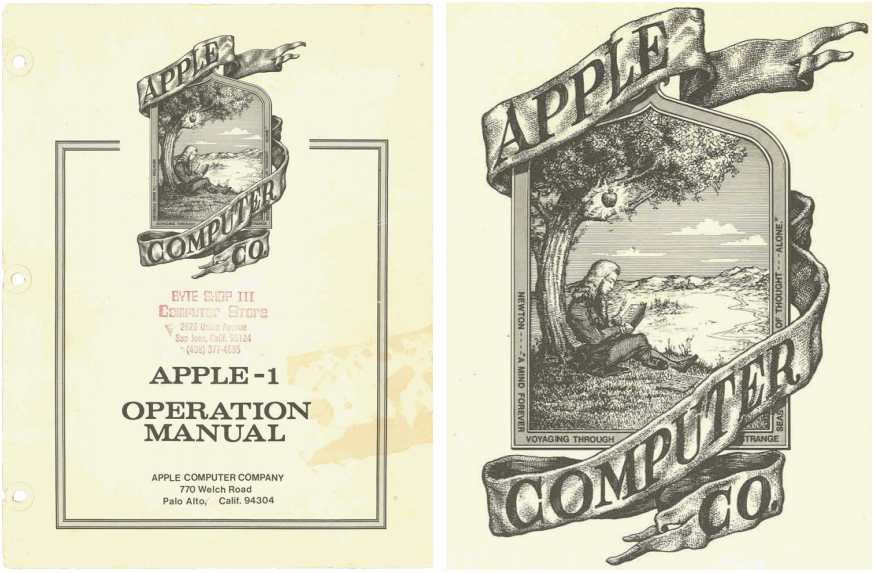

Fig. 2. The cover of the *Apple-1* user manual, and the detail of the logo

The Apple-1 `product` object is linked to objects of other types. In this example we have a `company` (Apple), a `designer` (Steve Wozniak), a `document` (the user manual). The links maintain and make explicit the relations among the information objects. For example, the different roles of the protagonists in the company foundation and in the birth of its first product: besides the aforementioned Wozniak, there are also `person` objects for Steve Jobs and Ronald Wayne – the third, often forgotten, partner which also wrote the Apple I user manual.

Information technology is modular: different pieces of its history share technologies and components. It is a characteristic of the domain that cannot be overlooked because of an antiquated cataloguing scheme. In our example the adoption by the Apple-1 of the *MOS 6502* microprocessor is made explicit by the link to the corresponding `component` object.

Following the relations linked to the 6502, the KB leads to the discovery of another `product` object, the *KIM-1* (an exemplar of which is preserved in the Old-Computers.Com collection). Like the Apple-1 the KIM-1 was a motherboard which hobbyists completed with power supply, keyboard and various peripherals. The KB

also maintains the information that the KIM-1 was the work of the same `designer` of the 6502 – namely Chuck Peddle.

The `document` objects can correspond to actual pieces, like copies of manuals in the museums or libraries. They naturally are a way to access digital copies of the documents, preserved forever, accessible to all and capable of bringing new levels of reading to the IST history.

For example, the cover of the Apple-1 manual (fig. 2) reveals a company logo very different from the elegant and minimalist one known to everyone. The first Apple logo was definitely baroque and full of references from the Newton's apple to the citation of William Wordsworth – and, in the KB, the quote of the English poet may become a link with a famous *Infocom* video game of the Eighties.

Fig. 3. The cover of the December 1976 issue of *Byte* and the detail of the Santa's list

The KIM-1 links also to the cover of *Byte* (fig. 3, the December 1976 issue), which is an even richer contribution for understanding a chapter of IST history. The cover shows Santa Claus and his helpers checking a "toy" list that testifies the desires of the computer hobbyists of the time. In addition to KIM-1, there are the *Altair 8800* and its clone *IMSAI 8080*, the *Sphere 500*, the *Poly-88* by Polymorphic Systems, the *8001 Compucolor* by Intelligent System Corporation. The list also includes some basic components (CRT monitors, keyboards, processors, memory chips), peripherals (floppy drives, printers, teletypes like the popular *Teletype ASR 33*), software (like the assemblers for *Fortran* and *Basic*), calculators (the legendary *HP 65*). Of course, there is also a subscription to Byte itself. In such a long and rich list the absence of the Apple-1 is blatantly evident. It was released in April 1976 but, according to Byte, it had no place in the wishes of the IST enthusiasts of its times. It helps to assess the historical importance of the Apple-1: it is not in terms of absolute technological or mar-

ket value, but its merit lies in being the starting product of a company that, later, has got to leave many signs in the history of IST.

A KB that makes available all the information and the relations among them, allows telling the history of IST in all its complexity. It also helps to overcome the habit of telling simplified stories – an indeed rooted use because it is easier, because following the trend is rewarding, sometimes because it is instrumental to the promotion of the brands that dominate the present.

The example is partial, many links are omitted. For example, via the `person` Jobs will be possible to reach other companies of which he was one of the founders, such as *Next* and *Pixar* and better understand his role as an entrepreneur and visionary. Via the `company` objects will be possible to reach all their products and, of course, each `product` object is connected to all the `piece` objects describing the pieces preserved in the collections. The Byte cover will be linked to the Byte issue, the Byte magazine and to all the products cited in the Santa list.

The graph in two dimensions shown in fig. 1 helps to convey the idea, but cannot grasp the wealth of information, especially in terms of links, that the KB maintains and makes available (moreover the example does not touch software...). The amount of information maintained by the KB requires new presentation ways, which must overcome the panels and labels on which the traditional exhibitions still rely. "In place" presentations in physical exhibitions use the KB to enhance the visiting experience, for instance customizing the information shown on digital labels according to visitor interests. By "in cyberspace" presentations, the visitor of a virtual exhibition explores the KB either freely or following suggested discovering paths. In both cases, the KB provides access to an organized and authoritative quantity of information that radically changes the approach to IST storytelling.

6. Technical Feasibility

The proposed approach relies on a KB as a viable and effective way to collect, manage and make usable all the information about IST History, thus it goes beyond the traditional vision of catalogues as inventories of pieces. The KB should be managed by an international consortium, founded and supported by some leading players of the sector, and with the involvement of a number as large as possible of stakeholders in the IST History – including private collectors and enthusiasts.

The description of the KB's idea given in the discussion in Section 4 and in the example in Section 5 is intentionally informal. There is already a considerable work done in the field of ontologies for cultural heritage. Just to give some examples, there are well known proposals for the integration of information related to heterogeneous domains of the cultural heritage, such as the *Conceptual Reference Model* [24] developed within the *International Committee for Documentation* of the *International Council of Museum*, later acknowledged as a standard by ISO [25]. For a complete dissertation on the state-of-the-art about ontologies for the cultural heritage, see [26].

There are also works about ontologies focused on the specific domain of IST; e.g. [27], born as a framework for curricula of informatics studies, which anyway is a reference and a possible starting point.

Defining the KB structure is obviously not in the scope of this paper: some research and a considerable effort are needed. Yet, the project is affordable if undertaken by a consortium of competent and authoritative partners, committed on the task of building the KB and also able to bring a great contribution to populate it.

Furthermore, while the model could be applied to many domains of cultural heritage, we are going to focus on a single one. Compared with other attempts that tried to catalogue every possible typology of cultural heritage (such as *Europeana* [28]), addressing the defined domain of IST History greatly helps the feasibility of the venture.

Finally, it is not necessary, or better is not required for a full exploitation of the result, to aim since the beginning to a complete and definitive ontology of the IST History. As a first target it is sufficient to define a reasonable categorisation of the main object's classes and the fundamental relations between products (hardware and software), people, companies, documents and so on. This suffices to be a decisive change in comparison with the current situation, stuck in flat and scattered archives.

Refining the structure of the KB is a research issue which the consortium will be involved in, thus giving to the community of experts a further element of scientific interest, in addition to the "mere" peer reviewing of contents.

Moreover, various technologies are available to provide content to the KB by browsing different sources. *Text mining* and *knowledge discovery in text* are research fields in rapid expansion [29]. Many approaches combine text analysis, natural language processing, and machine learning to integrate the results into an ontology framework [30]. Applications of these technologies are already in place to provide information services to enterprises [31].

Defining the KB schema and populating it to build the Global Virtual Museum is a challenge that can be won. The needed base technologies are available, it is mainly a matter of will, effort and coordination among all the stakeholders.

7. Conclusions: a Possible Mission

We propose to create a Global Virtual Museum of IST able to include, in a structured and consequently usable way, all the complex web of information that characterizes this particular field of cultural heritage.

There are already some experiences in this direction. The *MINF project* [32] brings together French Museums and Institutions devoted to the preservation of the history of computing. *Collections on line* [33] gathers the collections of four British Museums and maintains some basic relations between pieces, people and digital contents. Our proposal overcomes the national boundaries aiming at a single project which highlights the nature of IST as a worldwide cultural heritage.

In order to guarantee full chances of success to such an international and ambitious project as the Global Virtual Museum of IST, there must be a group of prominent founders, able to give credibility to the project and attract the necessary funding to the initial research and to start-up the consortium.

Undertaking the creation of the Global Virtual Museum of IST also implies to address its sustainability over time. Part of the required effort is already included in the institutional activities of museums and in some cases the work of the keepers and cur-

ators is even facilitated. On the other hand, there are extensive management and support activities which need adequate economic support.

To assure the full sustainability of the Global Virtual Museum of IST in the future, part of the initial research will develop a business model based on the exploitation of the contents and the management of the intellectual property rights – from images to digitized material, software and so on. Other sources of support may come from the offer of services to the wider public and from the use of its attractiveness for direct sponsorship or as a medium for advertising. In this sense, being the Global Virtual Museum of IST able to become a well-organized and worldwide renowned institution, probably it will be even capable of bringing additional funding for the traditional activities of the participating museums.

We believe that a sound consortium of stakeholders which includes at least few of the most important Museums in the field might be able to collect funds to start the project. Sponsorship of Associations such as IFIP, IEEE, ACM could guarantee the scientific validity of the results. Funds could be collected either from Public Institutions (e.g. cultural heritage programs of the European Union) or from private companies strongly tied to IST.

Our proposal related to IST History can be seen as a first case study for a new approach – based on worldwide catalogues of cultural heritage managed as knowledge bases – that actually is general. From this point of view the Global Virtual Museum of IST can be seen as a portable pilot experiment.

Lastly, apart of the intriguing recursive closure of applying IST to the preservation of IST History, we actually feel that preservation and dissemination of IST History deserve a special attention: we need to exhibit to a wider audience its complexity and wealth of international contributes and to contrast the oversimplification operated by the mass media.

Acknowledgments

The idea of a KB to manage all the information related to IST History has been previously presented at the *National Conference of the Italian Association for Digital Humanities* [34] and originates from a local experience within the *HMR Project* [35]: we wish to thanks Giuseppe Lettieri for the many fruitful discussions as well as the students who worked on the *CHKB* prototype. Many thanks also to the Hyperborea staff, in particular Luca Piaraccini, Cecilia Poggetti, Sauro Salvadori and Norma Zanetti, for their contribution both on the project vision and on the technical issues.

The images of the Apple-1 and the Kim-1 used in fig. 1 are taken from the websites of the cited collections [36, 37]. The image of the Apple-1 manual is taken from the Computer History Museum website [20]. The image of the Byte cover is taken from the Internet Archive [38].

References

1. Conservatoire national des arts et métiers, Paris, http://www.cnam.fr (last accessed February 2016)

2. Gottfried Wilhelm Leibniz Bibliothek – Niedersächsische Landesbibliothek, Hannover, http://www.gwlb.de/ (last accessed February 2016)
3. Museo Galileo, Florence, http://www.museogalileo.it (last accessed June 2016)
4. Science Museum, London, http://www.sciencemuseum.org.uk (last accessed June 2016)
5. Museum of Science and Industry, Manchester, http://msimanchester.org.uk (last accessed June 2016)
6. The National Museum of Computing, Bletchley Park, http://www.tnmoc.org (last accessed June 2016)
7. Centre for Computing History, Cambridge, http://www.computinghistory.org.uk (last accessed June 2016)
8. Laboratorio Museo Tecnologic@mente, Ivrea, http://www.museotecnologicamente.it (last accessed June 2016)
9. All About Apple, Savona, http://www.allaboutapple.com (last accessed June 2016)
10. Rifkin, J.: The Third Industrial Revolution. St. Martin Press (2011)
11. Standage, T.: The Victorian Internet: The Remarkable Story of the Telegraph and the Nineteenth Century's On-Line Pioneers. Bloomsbury (1998)
12. Beniger, J.R.: The Control Revolution, Harvard University Press (1986)
13. Luebke D.M., Milton, S.: Locating the Victim: An Overview of Census-Taking, Tabulation Technology, and Persecution in Nazi Germany, in *IEEE Annals of the History of Computing*, Vol. 16, No. 3 (1994)
14. Rengman, H. (ed.): Knowledge Management and Museums, Abstracts of the 23th CIDOC Conference, Sibiu, 4-9 September 2011.
15. Italian Law n. 364/1909 (1909)
16. Italian Law n. 1089/1939 (1939)
17. Istituto Centrale per il Catalogo e la Documentazione, http://www.iccd.beniculturali.it (last accessed June 2016)
18. Bauer, M.W.: The evolution of public understanding of science - discourse and comparative evidence, in *Science, technology and society*, Vol. 14, No. 2 (2009)
19. Deutsches Museum von Meisterwerken der Naturwissenschaft und Technik, München, http://www.deutsches-museum.de (last accessed June 2016)
20. Computer History Museum, Mountain View, http://www.computerhistory.org (last accessed June 2016)
21. Heinz Nixdorf Museumforum, Paderborn, http://www.hnf.de (last accessed June 2016)
22. Angles, R. and Gutierrez, C.: Survey of Graph Database Models, in *ACM Computing Surveys*, Vol. 40, No. 1, (2008)
23. Istituto Centrale per il Catalogo e la Documentazione, Normativa PST – Patrimonio Scientifico e Tecnologico, v. 3.01 (2014)
24. Doerr, M.: The CIDOC CRM – An Ontological Approach to Semantic Interoperability of Metadata. In AI Magazine, Vol. 24. No. 3 (2003)
25. ISO 21127. Information and documentation – A reference ontology for the interchange of cultural heritage information (2014)
26. Doerr, M.: Ontologies for Cultural Heritage. In Staab, S., Studer, R. (eds.): Handbook on Ontologies, pp. 463-486. Springer (2009)
27. Cassel, L.N., Davies, G., Fone, W., Hacquebard, A., Impagliazzo, J., LeBlanc, R., Little, J.C., McGettrick, A., Pedrona, M.: The computing ontology: application in education. In

Proc. of *ITiCSE-WGR '07 Working group reports on ITiCSE on Innovation and technology in computer science education*, pp. 171-183. ACM, New York (2007)
28. Europeana Collections, http://www.europeana.eu, (last accessed June 2016)
29. Piskorski, J., Yangarber, R.: Information Extraction: Past, Present and Future. In Poibeau, T., Saggion, H., Piskorski, J., Yangarber, R. (Eds.): Multi-source, Multilingual Information Extraction and Summarization, Springer (2013)
30. Wimalasuriya, D.C., Dejing, D.: Ontology-based information extraction: An introduction and a survey of current approaches. In *Journal of Information Science*, Vol. 36, No. 3 (2010)
31. Dandelion API – Semantic Text Analytics as a Service. http://dandelion.eu/ (last accessed June 2016)
32. Musée de l'Informatique et du Numérique, http://musee-informatique-numerique.fr (last accessed June 2016)
33. Collections Online, Science Museum Group, http://collectionsonline.nmsi.ac.uk (last accessed June 2016)
34. Cignoni, G.A.: CHKB: dare struttura (visitabile) alle collezioni tecnico-scientifiche, talk at the *IV Conferenza Nazionale dell'Associazione per l'Informatica Umanistica e la Cultura Digitale*, Torino, 17-19 december (2015)
35. Computer History Knowledge Base, http://hmr.di.unipi.it/CHKB.html (last accessed June 2016)
36. Bolaffi Collections, Torino, http://www.bolaffi.com (last accessed June 2016)
37. Old-Computers.com on-line Museum, http://www.old-computers.com (last accessed June 2016)
38. Internet Archive, http://archive.org (last accessed June 2016)