Dr hab. Marek Nahotko
Jagiellonian Univ., Cracow, Poland

Global Digital Library as part of e-Research infrastructure and Science 2.0

Research publications are fulfilled with information about changes, both positive and negative, made in scientific communication in XX and XXI centuries. One of important result of these changes is the emergence of a global (scientific) digital library, by which I mean a worldwide resources of scientific digital objects, collected, developed, described, stored and disseminated in a distributed, not based on institutions[1] and remote manner in the global network. The global digital library is a networked one – without the Internet it may not exist. Network and the global nature of the digital library cause changes in the ways of implementing basic scientific library functions that are closely linked with the directions and pace of change in social communication in general and scientific in particular. Its digital and network character is a reason for necessity of new tools and methods of implementation of these functions. In the rest part of the paper I will define and describe the Global Digital Library and its contemporary environment: cyberinfrastructure (e-Science) and Science 2.0.

1. E-Science infrastructure and Science 2.0

The rapid development of computer hardware performance, resulting in an annual doubling of many indicators of its effectiveness[2], caused a widespread of awareness that the hardware, even the most powerful, is not a sufficient condition for computer-aided research. Scientists want an access to intelligent software, tools for visualization of processes, middleware[3] and scientific applications created and used

[1] I say "not based on institutions" in the sense of lack specific institution managing global digital library as a whole, although its individual resources can be institutional in nature.
[2] Within a slightly more than 25 years (1980-2006) eight generations of computer processors were arisen. During this period, the access time to RAM dropped from about 50 ns to 2 ns (25 times), and the number of transistors in the CPU increased from approximately 29,000 in 8086 to 300 million in the Core 2 Duo and about 1 billion in Core i7 (doubling approximately every 18 months). Manuel Castells gives similar data regarding the performance of integrated circuits [Castells 2008, p. 54]. Growth of this type (exponential) is observed in the development of most elements of hardware, which is consistent with the so-called Gordon Moore's, co-founder of Intel, law, formulated in 1965 and still current.
[3] Middleware is a type of software used to communicate user applications with databases or other servers/services. It is located between the network and applications. This software allows for the connection

by interdisciplinary teams. In addition to the necessary technical progress new organizational models are also expected to be developed, the rules for the designation of processes and marginal economic conditions to be determined.

The extraordinary success of the Internet demonstrates the great role which is played by advanced IT infrastructure, which serves the development of innovation in the broadest sense, facilitating cooperation, exchange of data, modeling and simulation, communicating ideas, combining research with their applications and technological innovations with social innovations. According to Brian Kahin, the role of Internet in this area can be compared only with the electricity network, acting as an example of equally high developed infrastructure [Kahin 2007]. Transformations of the Internet are caused by the interaction and synergy with other forms of infrastructure - scientific infrastructure, telecommunication, and for the purposes of trade. The Internet is thus a combination of infrastructures: commercial, public and social. Internet will transform each of them, with the result in form of the networked information society[4]. These transformations are similar to changes caused by the development of other infrastructures, although changes occur faster in this case, and have broader range.

Integration, cooperation and interdependence of tasks of modern science in the field of information necessitate its treatment in terms of the infrastructure called cyberinfrastructure or e-Science, which is created today in order to exploit the rapidly changed and ever-changing information technology used in scientific research.

U.S. National Science Foundation (NSF) uses the term ‘cyberinfrastructure’ for an infrastructure of distributed computer, information and communication technologies [Atkins et al. 2003]. In the U.S., it allows the integration of various tools on the network (especially the Internet), such as computing equipment (data processing and networked), digital sensors, observatories, equipment for conducting experiments and other research instruments and associated services and software

between the networked resources, which without it are separated from each other. The use of middleware facilitates application development, as it makes them independent of the type of database. It is created to facilitate access to and dissemination of resources such as computers, data, networks, instruments, and to assist cooperation and communication in scientific research and education. Now, towards the development of multilayer applications, middleware is gaining in importance.

[4] According to Piotr Sienkiewicz, new structures of this society are formed parallely to the continuum of data-information-knowledge-wisdom. New social classes include the "proletariat", functioning at the level of data, employing ICT in order to carry out basic functions; "professionals", "middle class", acting at the level of information, for whom ICT is a tool, and "nomenclature", for whom access to knowledge and wisdom is a means of implementing far-reaching objectives [Sienkiewicz 2006, p. 69].

tools which are sets of application software and middleware. An equally important element of e-Science infrastructure, if not the most important, are appropriately trained people: multidisciplinary teams and information technology specialists with experience in designing algorithms, system analysis and application development, who can take full advantage of this infrastructure to create, disseminate and archive of scientific data, information and knowledge. All together it creates the conditions for collaboration of technology, social practices, work organization and standards. The creators of the American cyberinfrastructure conclude, that like the physical infrastructure is essential for the industrial economy, IT infrastructure is needed for the knowledge economy.

Daniel Atkins' report indicates two levels of e-Science infrastructure: technical and organizational, describing it as follows:

- Technical infrastructure consists, among others of middleware, applications, protocols of data exchange and is (or can be) used in all fields of knowledge.
- Organizational infrastructure is created by the institutional politics within science and is more influenced by principles of law and social norms - here we can enumerate the intellectual property regulations, creation and adaptation of standards in their field and beyond, tools and services, and professional education and training of people creating and using e-Science infrastructure [Atkins et al. 2003, p. 12].

As Peter Freeman writes, this infrastructure is the foundation, an abstract construct, upon which other are created. It can be called specialized infrastructures or knowledge ecologies. e-Science infrastructure is a complex system, proposed as an open system [Freeman 2007]. It consists of thousands of partially overlapping communities of collaboratories or Grids[5], created for specific domains or applications, customized at the application level, but in very broad terms sharing a common infrastructure, which should include:

- computer networks and services, clusters and high-powered computers, along with advanced scientific software,
- computing centers Grids,

[5] Grid (network, similar to the electricity grid) is system that integrates and manages resources under control of different domains (from the institution to operating system) and linked with computer network; it uses standard, open protocols and interfaces of general purpose (discovery and access to resources, authorization, authentication) and provides the services of appropriate quality. The creator of the term and concept of Grid is Ian Foster [Foster 2002].

- domain Grids of nationwide importance (specialized service platforms, "virtual[6] laboratories"), created for specific areas of research, however, using the universal elements of e-Infrastructures,
- common Grid software layer providing easy access to computing resources and the ability to build cohesive domain Grids,
- resources of different kinds of digital objects, such as electronic publications and software,
- multidisciplinary, managed and integrated scientific data resources, databases, in that bibliographic and factual,
- data storage systems,
- thousands of online instruments and vast sensor arrays,
- sets of friendly and efficient tools for retrieving, modeling and interactive visualization,
- tools for cooperation between physically distributed teams of people who apply the above-mentioned items.

e-Science infrastructure, like most infrastructures, is not intended, or constructed in a strictly planned manner, in the sense of full control and management of the process. Therefore, the ultimate development of infrastructure is difficult to predict, and in any case it does not arise directly from the initial conditions [Jackson et al. 2007].

Interesting results may bring connecting the rules of functioning e-Science Infrastructure and Science 2.0, based on Web 2.0 systems. In such cases, where it is possible, to that infrastructure can be adapted the typical approach of Science 2.0. For example, not all computing services must work in conjunction with strong authentication access, used in Grid systems, and the reducing of requirements of this kind will cause scholars gaining new opportunities arising from the prevalence of bottom-up initiatives [Pierce et al. 2006, p. 267]. This combination of institutional science, providing access to major research facilities, with free, bottom-up organized dissemination of research results in social systems, such as Wiki or blogs, is important characteristic of modern science [Wheeler 2008, p. 109].

[6] I mean the adjective "virtual" as it is recognized from the viewpoint of data processing: as a potential universe comparable with use of the digital model and input assisted by the user (information technology related to digital models [Lévy 1996, p. 37]), which is not in colloquial meaning (unreal, imaginary, existing only on a computer screen [Golka 2008, p. 100]) nor philosophical (ontological structures of the virtual projects as possible worlds) [Konik 2009, p. 83].

By Wikipedia[7] Web 2.0 concept has emerged in 2001 and is associated with Web applications that facilitate participatory information sharing, interoperability, user-centered design, and collaboration on the World Wide Web. A Web 2.0 site allows users to interact and collaborate with each other in a social media dialogue as creators (prosumers) of user-generated content in a virtual community, in contrast to websites where users (consumers) are limited to the passive viewing of content that was created for them.

Web 2.0 usually is defined from two perspectives: its specific features and technology or the ability to organize local communities. According to Tim O'Reilly Web 2.0 applications are based on the platform of created earlier Web (Web 1.0), and create new communication environment [O'Reilly 2005]. According to its proponents, a global network undergoes a thorough makeover. Systems built according to the "philosophy of the Web 2.0" in a much greater extent than previous ones open new perspectives for users own activities. To build such systems new technologies are used - such as wiki or weblog (blog) - providing mechanisms that allow Internet users to easily create and add content on the Internet and teamwork over the content of the system[8].

Web 2.0 principles of operation affect the operation of science; for these applications the distinct term ‘Science 2.0’ is even used. Compared with the traditional scholarly communication tools they enable a significant expansion of coverage and scope of the discourse. An article in the journal presents the positive results of research and experimentation, but usually it is not possible to find information about what went wrong and how this affected the implementation of the experiment. Science 2.0 enables free discussion in Open Access mode of any aspects of the work carried out (including the mistakes), which greatly accelerates their implementation. Scientists present the findings to colleagues on an ongoing basis, every day, from the first notes in the laboratory notebook to the article in the journal, which characterizes the so-called Open Science, slowly locating interest among scientists. As in other applications of Web 2.0, openness and participation are important [Whyte, Pryor 2011, p. 209]. There is even talk about the so-called *Open Notebook Science*, named after notes created in a laboratory computer notebook

[7] http://en.wikipedia.org/wiki/Web_2.0
[8] That interaction, rapid feedback and team spirit of the work are the reason why Web 2.0 is called a social network.

commonly available, both for humans, as well as computer systems. Despite having to make public the results of scientific investigations even before their formal publication, all parties of such a dialogue are benefited, as it changes the competition between scientists in collaboration [Waldrop 2008]. Thanks to that, arising Science 2.0 is not only more collective than a traditional, but also much more efficient, because it uses the ability of virtual communities of scientists to use the talents of all its members [Jenkins 2007, p. 31]. Studies have shown that scientists cooperating with other scholars also more often use the tools of Science 2.0 [Procter et al. 2010, p. 4044].

Implementation of the Science 2.0 into research process is followed in respect of:

- Broader science communication for the dissemination of research results, development cooperation, elimination of barriers between disciplines;
- Changes in understanding what is "scientific", caused by modification of evaluation parameters (collaborative filtering[9], tagging, reblogging[10]), the status of publication, the methodology of disciplines;
- Formation of virtual communities of scholars and the new authorities within them;
- Organizational outcomes resulting in intermediality, interdisciplinarity, interactivity, digitization and processes of digital born data and information resources;
- Application of specific tools - blogosphere, discussion panels, Wiki-like systems, MySpace, Facebook, Mendeley and others, specific to Science 2.0;
- In the end, change of the paradigm of science and scientific criteria, the research methodology will be based on linking science research with social science methods [Solska 2009, p. 136].

What is worth emphasizing, Science 2.0 is not supported by large investments in scientific infrastructure (as in e-Science), but on a bottom-up initiatives. There are even some authors, like Alexander Bard and Jan Söderqvist, who argue that it is a reaction to the overgrowth of administration and intellectual snobbery of traditional

[9] Collaborative filtering is the process of extracting information or typical patterns of the examined phenomena realized in a cooperation of many agents on large data resources. The result may be, for example, bestseller lists, or recommendations.
[10] Reblogging consists in providing the information found on the Internet, especially on blogs, on the next blogs. Such action allows almost all of the programs used to run blogs. Number of messages indicates the popularity of the blog.

science [Bard, Söderqvist 2006, p. 234]. Scientists willingly use free tools typical for Web 2.0 to communicate in the community of scientists dealing with similar problems, what indeed results in a rapid expansion of relations and development of cooperation. This is because the principles of Science 2.0 seem to be a natural way to proceed by scholars. Since the time of the scientific revolution they develop their knowledge through participation of many researchers in the general debate, enabling the selection of the theory best to describe reality. So we can say that Science 2.0 corresponds well to the way science works, except for special cases which may be subject to secrecy or research leading to the patent claims, although in the latter case, the problem seems to be of the organizational nature[11].

2. Definition of Global Digital Library (GDL)

New rules for the organization of science, which manifestation is the e-Science infrastructure, also require new approaches to the creation, collection, development, dissemination and archiving of data and scientific information and its use in the research process, and therefore to the functioning of scientific communication. The development of electronic media and their application in the processes of communication in science is integral to the development of science as such. Scientific digital communication is realized on different economic principles; expectations are often associated with the popularization of the principles of Open Access, in its various forms, including those promoted by commercial publishers. In this context, we can talk about electronic publications and digital library.

The term "digital library", just like the term "library", can be interpreted differently[12]. This may be an institution or some institutions, or group of technological solutions, used for digitization. Digital libraries could be also considered as one of the new ways to implement scientific communication and the spread of knowledge, through its global acquisition, organization, information about it and circulation. Then the understanding of digital library goes far beyond the processes involving the digitization of printed materials, even if it is accompanied by organizational actions, providing addition of electronic versions to existing traditional resources. Also the fact

[11] The idea is to recognize the primacy of the invention by patent offices based on the date of sending the information to a social system, such as Wiki.

[12] See for example definitions presented by Marek Nahotko [Nahotko 2004, p. 37] and Dariusz Grygrowski [Grygrowski 2001, p. 159].

of cooperation and joint digitization, conducted by several institutions, does not provide qualitative change. The real difference is that if the library or some libraries are placing of digital resources in the Net, it ceases to be a local library (institutionalized), and becomes a part of the global circulation of information. As a result of the implementation of these functions, yet common to all libraries, in the digital wide area network environment, a new quality arise, which can be called a global digital library[13].

Part of the definitions of digital libraries, despite the fact that they concerned institutionalized digital libraries, contain elements good amenable to the concept of a global digital library. An example would be the bisegmental definition, created by a team of specialists in 1996 [Borgman et al. 1996]. A small modification of this definition is sufficient to adapt it to the needs of a global digital library. Then the global digital library is:

1. **Electronic resources** and associated technical capabilities for creating, finding and using scientific information. In this sense it is development and improvement of systems for search of scientific information, allowing the manipulation of digital data in any format (text, multimedia, simulations), operating in a distributed network environment. Global digital library contains scientific data (primary and processed) and various kinds of metadata (including descriptive and structural metadata in OPACs of research libraries, which are "switches" between print and digital resources).
2. **Set of information systems**, created by and/or to a local community of scholars (forming altogether a global community of users) and providing information **services** for them. The functions of information systems are implemented for meeting the information needs of this community. GDL is a part of the community in which individuals, groups and local communities interact with each other when using global digital library systems, its services, resources, data, information and knowledge and their organization systems. GDL is a development and integration of multiple information systems,

[13] As Wanda Pindlowa has written, in this case we should rather consider it more as universalism than globalism, and so talk about universal digital library [Pindlowa 2005, p. 45]. Universalism is striving for broad dissemination of some ideas, to include all people into some activities, and embrace a whole. Substitution of universalism by globalism is misleading. Universalism in recent times has been structured as metaphilosophy, the theory and the prospect of synthesizing all of science, important philosophical directions, national and continental cultures. Despite the temptation to use the word "universal" in relation to the digital library, however, I remained with the word "global" because of its high prevalence in literature.

managed by institutions, associations and individuals that create, select, collect, organize, archive and give access to resources for science, serving users' needs[14].

This definition combines two complementary ideas. The first of its elements points out that the GDL is a continuation and extension of existing information retrieval systems, operating in the area of science, containing all kinds of data and metadata; in the second part emphasizes that the practice of GDL should take into account the social context in which it operates, providing relevant services and carrying out appropriate functions. The role of the convergence of information and communication technologies, operating in global networks and global e-Infrastructure is stressed here.

3. Features of GDL

GDL understood in such a way, unlike a traditional library, can be equated with the entire system of scholarly communication, including its parts serving formal and informal communication. A global digital library is not a research library in the traditional sense, but rather a global organization, infrastructure of networked systems, in which academics and researchers, playing different roles and following complex patterns of interaction, use modern and advanced technologies to create and disseminate information in the Net [Fuhr et al. 2007, p. 24]. It is a component of the global e-Science Infrastructure, understood as a structure in which communication networks provide high quality services for people communicating and sharing scientific information. GDL is that part of the e-Science Infrastructure, which provides access to scientific information[15]. Disseminated information may constitute a description of scientific findings, but may also additionally contain source materials, raw scientific data or results of current research. This infrastructure has its own structure (architecture). A particularly important feature of the global digital library architecture is its openness, which allows everyone to interconnect and exchange

[14] The authors of the 1996 definition in the remainder of their paper enumerate various institutions, which digital library is a development and an integration: traditional libraries, museums, archives, schools, offices, scholar’s workshops, housing, public areas. If we add publishers (original definition did not predict creation of data in a digital library), we get enumeration of most of the systems of the global digital library. The enumeration is omitted in my definition due to the diminishing role of the institutionalization of the global digital library.

[15] Therefore, the demarcation of the boundary between the GBC and the e-Science Infrastructure requires a proper definition of the concept of "information".

data [Borgman 2003, p. 26]. Essential are hypertext structures understood as a medium for formulating and communicating ideas [Conkling 1988, p. 454].

Global digital library as a global infrastructure serves the dissemination of knowledge, being a network of scientists who create and make available information in the form of digital information objects. By analogy with the e-Science Infrastructure, representing an abstract construct, which consists of real and specific specialized systems, also the GDL, considered on the highest level, is an abstract base upon which interoperable systems are built, each of which is designed, created and managed locally (at the lower levels of GDL).

It is necessary to distinguish between the GDL system and services performed by the library. The first is a place on the Internet, where resources of digital objects are placed and functions, mentioned in the second part of the definition of a global digital library, are carried out. Services are understood as in Grid applications; by Robert Kahn and Robert Wilensky they are functions that can be performed on or with one or more digital objects located in the GDL system [Kahn, Wilensky 1995]. So the placement, dissemination of a digital object in GDL information system (for example in the repository), as well as creating and sending queries and executing search, are examples of services offered by this system. Implementation of services in the GDL information system usually creates value added to the digital object. GDL information systems take over many functions (and thus the services) from traditional libraries, museums and archives, often combining the functions of many traditional institutions in a single system; from this point of view some systems, such as Web search engines may be considered as a new incarnation of the bibliography [Haider, Sundin 2010]. Jeffrey Pomerantz divided services[16] into two groups:

- Technical services, which, as the functions performed on the documents, change the status or conditions of its use. These functions are necessary for the operation of the GDL system. These services may be however imperceptible to users, because they use them only indirectly.
- Users services - these are functions carried out on documents, resulting in only indirect change of a state or conditions for use of the document or they

[16] Sometimes it is difficult to distinguish the GBC system from services performed by it. That is, for example, in case of social systems, which operate within the Web 2.0, such as Flickr, which is a system (service?) used to collect, categorize and share digital photos. Jeffrey Pomerantz believes that Flickr is not the GDL system, but rather the service assisting users in organizing the private collections of photographs, enabling the creation of an additional level of service by adding labels to photos of other users [Pomerantz 2008].

remain unchanged. As a result of these services occur changes in the state or functional conditions of the user [Pomerantz 2008]. An example would be the search, localization, ordering and delivery [NISO Web Services and Practices WG 2006, pp. 10-11].

GDL itself, as a complex infrastructure is rather the result of specific historical processes, interdependence, innovation and joining together of smaller parts like on a collage. Do not think of it as a machine or system that you can build or design. Such thinking diminishes the importance of various social, organizational, legal, cultural and other non-technical problems, which must be solved in a distributed but consistent manner. Paul Edwards warns against attempts to strictly control the organizational structures, developed thanks to the possibilities of emerging technology: even if such ideas look interesting, such structures simply do not work [Edwards et al. 2007, p. 6].

In the global digital library objects are created and managed (published, archived) locally (although often as the result of cooperation in an over-regional, sometimes even global scale), and made available globally, without space-time restrictions, although with the economic and legal constraints: some resources are available for a fee. This collision of resources created locally and available globally as well as the massy external resources, operating in a global network, don't have to be destructive, and in science, which is global in nature it should be really useful. According to the views presented by Jacek Wojciechowski, global and local content does not necessarily eliminate each other, because they may be subject to a common assimilation. The local context and awareness are together the local frame of reference, according to which external content is assimilated. There is a convergence of content, which occurs by adding to the local content of processed external components. Both areas of communications, local and global co-exist with each other without the need of mutual competition. Network technologies allow for mass customization to individual needs [Barney, 2008, p. 82]. This phenomenon is called glocalization [Wojciechowski 2008, pp. 231-232] or fragtegration (stands for fragmentation + integration) [Bard, Söderqvist 2006, p. 173]. Within the GDL is mediated communication, in which some messages are available without the need to share common space [Mikułowski-Pomorski 2006, p. 102].

In GDL, there are only digital objects, however, it also contains the surrogates (metadata) of printed (and other non-electronic) documents so that it can act as a hybrid library, that provides digital objects directly (preferably free, but also commercially), and traditional documents through metadata (located in the OPACs and databases). It makes possible to use GDL to identify and locate physical objects, stored in scientific libraries, archives, museums, places which belong to the authorities at various levels, enterprises and all other places where resources important for science are stored. In addition, almost every type of traditional (analog) document can be and is digitized. As a result, more or less complex digital objects are being formed, resulting in steady growth of hybrid stocks.

Digital objects are becoming increasingly different from traditional documents such as printed books and journals. Their content is still mainly text, but they also include data collections, audiovisual and multimedia materials, simulations, software applications and other non-textual objects. They can be characterized by any of the formats, often modified dynamically. There are being created new types of documents, what forces the creation of new technologies for their distribution, archiving, visualization and search [Breure, Voorbij, Hoogerwerf 2011].

Many authors, writing on the digital library, apply the concepts from the period of traditional libraries. Librarians often imagine it as institutionalized, the local digital resource, often digitized documents (i.e. copied from printed originals), to which metadata and searching tools are attached [Arms 2000]. Even when they talk about a global digital library, they usually have in mind many institutions related by contracts, or otherwise formally federated, with the central coordinating institution [King 2004]. This type of resource can be described as the digital library in the narrower sense, and include rather to the area of electronic publishing, including electronic journals, repositories and other modes of dissemination of documents on the Internet. They represent distributed systems in total consisting of a global digital library. In this sense, it may be said, for example, that there exist multiple digital libraries, while it is appropriate to treat all the different resources as a single, world "library" - a global digital library in the proper sense. This library is sometimes called a virtual library, probably to indicate its "intangible" nature, which is not entirely true. Global digital library consists of many types of electronic publications and “places” on the Internet - information systems that provide them in a very different way from the point of view of access organization - from completely informal, 'private' websites and scholars blogs to more institutionalized and formalized forms of organization, such as institutional repositories (often implementing the policy of institution’s government) and digital libraries (for which digitization plans have been created similar to the collection acquisition policy existing previously for traditional libraries). Due to the fact that there are many places - the systems storing digital resources (storage is organized in a distributed manner) in every place providing such data and information consistent and uniform methods of its sharing should be carried out.

From the user point of view, where possible, there should be an uniform digital library system; the user sees the Internet as one big computer with huge computing and information resources, as an universal database [Dobrowolski 2004, p. 76], which can be used in a unified and almost unlimited way [Muraszkiewicz 2002, p. 30; Hofmokl 2009, p. 188]; such an approach is consistent with the idea of so-called metacomputer[17]. Large role in the perception of the Internet plays a strong unified way of presenting information, and therefore a consistent user interface, that allows unifying search and displaying information [Lagoze, Fielding, Payette 1998, p. 134]. In terms of Web site layout and navigation between them and the appearance of such details, like buttons and terms used in the menus, there are many stylistic conventions common to all GUIs. Standardization in this area, even if informal, allows user to easily start using any global digital library system, even if he has never had contact with them before. However, despite the fact that these conventions are very important, they operate only on the surface of Web. A user, who tries to actually work with the information available online, quickly finds that seemingly similar GDL systems differ significantly in the semantic layer. The illusion of uniformity of services is however very helpful and useful in a decentralized, distributed environment, which the GDL is.

Global digital library, like the global market, is not an institutionalized creature, organized hierarchically by any single "center of power", although it also includes institutions such as research libraries, museums, archives, schools and universities as well as publishing houses. It is rather organized by bottom-up initiatives of experts from specific fields, groups of persons defined, for example, by a common interest or use of the same language (e.g. the language of their discipline). They create organizational mechanisms that implement their needs. With millions independent, but interrelated decisions taken by them, there is being created a remarkably unified

[17] This term refers to computing resources transparently available to users in a networked environment. It is a network of heterogeneous computing resources associated with the software in such a way that the user may not notice the difference between the work of local resources and metacomputer [Smarr, Catlett 2003, p. 825].

structure. Its elements can, despite the absence of traditionally conceived "institutionality", be considered as a new type of institution, typical for the Network; Kazimierz Krzysztofek calls them ‘web native’ [Krzysztofek 2008, p. 14]. They are in a growing part of cooperative technology products, self-organized the techno-personal networks, what are not subject to control [Bojar 2009, p. 18], such as communities of Grid computing or collectives of knowledge.

Just as the entire Internet, the GDL is ruled rather by processes typical for chaotic systems. Such processes, often occurring in self-organized systems, are based on natural principles, and the probability of cases. These systems are the result of mutually adapting processes associated with multiple interactions between objects and relationships created in this way. Spontaneously self-organizing systems which complexity arises from simplicity, and higher order out of chaos, achieve extraordinary results [Castells 2008, p. 82]. Web self-organization can be seen in the aggregated structures of the links forming clusters of Web pages distinguished thematically, while showing interest of their users groups. This type of link aggregations may concern research activities, for example, a group of related Web pages of scholars and their research projects, publications and scientific institutions operating in the field. Other clusters of Web pages can group together GDL information systems, such as portals or repositories. In this sense, the GDL is similar to the complex social networks, that do not have designed architecture, but are self-organizing on the basis of local interactions of a large number of members and their groups [Björneborn 2004, p. 3].

The concept of distance in space much changed its meaning. Currently, little importance has the fact who is a person placed the document on the network and what specific place, on what server it is situated. Much more important is that this document could be found and made available to the user who needs it, in what a much greater role play consistent protocols and other tools to assist in finding and presenting information.

This picture of the global digital library corresponds to the concept of "boundary objects", i.e. those that instead of strengthening differences between social groups and communities (for example, between groups of scholars), allow the agreement between groups over the borders and differences. They are defined as objects that simultaneously belong to several groups (communities) and will fulfill the information needs of each of them [Bowker, Star 2000, s.30]. They can be easily adapted (customized) to the needs of any group, what means that they have considerable flexibility. At the same time they ensure uniformity of operations across multiple applications. This is possible thanks to a weak structuring of boundary objects at a general level, with the possibility to complement and clarify the structure at the level of individual services. Such objects facilitate communication, but without obliterating the differences between the groups; those even tend to be emphasized. They may be material objects, organizational forms, procedures, and conceptual spaces. Boundary objects are the organizational forms such as a standard data and metadata structures, and tools that implement these standards. They enable the exchange of data and documents between different groups. They also play an important role in the processes of change taking place within groups; changes in boundary objects cause the modification of one group's social infrastructure, and this entails the possibility of changes in other groups, together utilizing the object.

A global digital library is an excellent example of a boundary object, because its content may be used by many communities. Data collected in a single information system to meet the needs of particular group of researchers can be used by other groups, which members often carry out research in another field. Each of this group interprets the data in a specific way, despite the fact that it gets from a common resource [Borgman et al. 2005]. For the GDL that model indicates two levels of knowledge exchange between different cultures: the syntactic level, a common language and a dictionary to combine these cultures, and semantic - databases and thesauri to eliminate communication barriers between cultures. The effect of removal of these obstacles is the emergence of new cultures in which there are innovative ways of behavior, facilitating breaking down barriers and crossing borders. In this sense, the GDL is not only a resource of information, but mainly a place where new knowledge is constantly being created [Mason, Hart 2007].

Despite the lack of traditional organizational structures, and thus the possibility of hiring specialists, librarians and information workers also find their place in the global digital library, in one of its particular system. They have their part in creating the analysis and cataloging, both subject and descriptive, what means the creation of metadata, which are used for indexing by search engines. This applies to metadata on documents published on the Web, in various repositories and digital libraries (their formation is another task of librarians), and metadata stored in the library OPACs, and concerning the traditional documents. It follows from this that the thesis sometimes put about risk what these tools create for the future of libraries, and therefore also for digital library, is wrong. On the contrary - both resources and information systems of digital library created by librarians, as well as new indexing tools should reap benefits from their coexistence and cooperation. This coexistence should give interesting effects related to the unification of GDL information environment, such as the concept so-called "Amazoogle"[18] or OPAC 2.0. One of them can be total change in the work of librarian (a specialist in information science), because it makes most sense in the digital environment if they perform their duties in a distributed manner, without rigid organizational framework, but in close connection with the group for which they carry out their activities, including the form of telework[19].

In Tab. 1, I set the basic elements and functions of traditional scientific library, digital libraries as an example of a GDL information system and global digital library. As you can see, the functions performed by the library of each type are similar, their implementation is a value-added produced in the library. There are constant elements of libraries, including scientific libraries, having impact on their functions, such as:

- users along with the study and implementation of their needs,
- resources, regardless of form, the carrier, and location,
- services of resources organization, search and circulation,
- librarians (information specialists), their role in a huge, distributed GDL environment changes, but does not decrease.

The differences are mainly due to two reasons:

- use of new electronic medium of digital documents, which creates new opportunities in the delivery of library services;
- use of combined global and local networks (intranets, extranets) to circulate these documents.

These have significant influence on the change in the role yet unspecified stabile (traditional) library element, which is the library building and its equipment.

[18] According to Lorcan Dempsey from OCLC, one of the manifestations of changes in librarianship is the new expectations of users due to opportunities that provide tools such as Google and Amazon. Dempsey asks the question "why the information search tools used in the library may not be functioning in such a way as Amazon/Google?". Such a kind of changes in the expectations he called Amazoogle effect [Holmström 2004].

[19] Telework unfortunately does not necessarily mean a smaller dimension of work - on the contrary, as Marian Niezgoda writes, along with the development of teleworking, the category of leisure time becomes even more illusory [Niezgoda 2006, p. 113].

Library buildings, devoid of resources made by atoms and the physical presence of the users and staff, changing their function, becoming a meeting place, educational and office buildings and even dining. This reflects the declining role of the library (traditional) as a place [Sennyey, Ross, Mills 2009, p. 253].

The transition from the traditional libraries to the GDL depends to a lesser extent on changing what is done in them (services, functions and activities), and more of how this is done (organization, methods, tools, standards). Jane Greenberg, who described the similarities between libraries and the semantic Web in the scope of functions draws attention to this aspect; the term "collection development" she replaced by the term "Semantic Web selection", "cataloging" by "Semantic Web ‘semantic’ representation", "reference" by "Semantic Web service" and "circulation" by "Semantic Web resource use" [Greenberg 2007, p. 215 et seq.]. It is worth to pay attention to the important role of new technologies in the process of transition from resources to services. Information skills and technological competence of information specialists are becoming more important than their knowledge of the contents of information resources [Sennyey, Ross, Mills 2009, p. 256].

Librarians need to "interfere" into the composition of research and teaching teams, and become an integral part of them [Marlino, Sumner 2008, p. 194]. Digital librarian's new role will involve the direct participation in the process of research and teaching. There will be some kind of diffusion of functions of the digital library and research/teaching unit. The librarian will become a researcher and teacher by virtue of actually performed tasks. Similar functions and responsibilities were previously assigned to subject librarians, operating in a traditional centralized library. Digital librarian will become a member of the virtual collaboratory, the research team operating in cyberspace, with the task of handling the information services providing for the team: information necessary for the proper work of the team, as well as information about team’s work and achievements; these changes have already begun in the form of so-called embedded librarians [Siess 2009]. Just as Gutenberg's invention freed monastic scribes from busy rewriting of texts, in the same way digital library allows librarians to fully focus on the digital publishing, searching for information, its sharing and in general on work with the user.

		TRADITIONAL LIBRARY	DIGITAL LIBRARIES - GDL INFORMATION SYSTEMS	GLOBAL DIGITAL LIBRARY
LIBRARY ELEMENTS	COLLECTIONS	Local, centralized, traditional, small number of digital resources, mainly for non-network media, library owned	Local, partly scattered: placed on the servers of one or several institutions, digital objects are the property of the digital library	Distributed in the network, a large variety of forms (from the traditional to the previously non-existent), many forms of ownership, including the Open Access
	LIBRARIANS	Work centralized, hierarchical organizational structures, knowledge related with the specificity of library processes	Work centralized, structure similar to a traditional library, the new occupation specialty	Telework, freelance, digital librarians, "non-institutionalized", members of research teams, computer skills needed
	USERS	Specific group of well-defined needs, easily identified (no anonymous)	Well-defined target group of users, the possibility of the emergence of casual users	Potential users (everyone who is connected to the Internet), geographically dispersed, with different needs, difficult to identify, co-operating with each other
	PLACES	Defined place in physical space, specialized library construction	Specialized areas (e.g. server rooms), lack of space for a user services	Decentralization, digital librarians workshops freely distributed geographically, the library as a portal, "place" on the Web
LIBRARY FUNCTIONS AND SERVICES	ACQUISITION	Policy of acquisition, acquisition of printed resources, available mainly in book trade and antiquarian	Creating a digital collection on the basis of printed collections, selection for digitization (politics); complement the collection with "born digital" resources	No collection policy in the traditional sense - search and locate the Web resources that meet certain quality criteria, "collection" on a global scale, social collecting of resources by interested users
	DESCRIPTIVE CATALOGUING AND SEARCH	Library catalogs, including automated, bibliographic data in one of the few formats - worldwide standards such as MARC 21, indicating a specific physical object by a call number	Metadata database, created by librarians; the increased number of metadata schemas, metadata indexed by search engines	Distributed metadata resources (multiplicity of schemes), used by various searching tools, linked data; search terms appear in the context; navigate in the global resource; search engine full-text indexing as a process of integrating the resources of metadata
	SUBJECT CATALOGUING	Inf. language as the basis for subject catalog. Subject descriptions created in the selected inf. language(s)	Inf. languages taken over from traditional libraries, ontologies	Full text as the basis for indexing. Every word of text and metatext (metadata) as retrieval element; inf. languages and other tools used locally in GDL systems, new tools like ontologies and folksonomies
	STORAGE	Local, in library stacks	Local, on the digital library disks	Scattered in various types of GDL systems, specialized systems for archiving
	CIRCULATION	Local, traditional, free: loans, reading rooms. Interlibrary loan. The multitude of interfaces (OPAC, databases, analog and digital resources)	Global, through a web browser unified interface; individually designed search capabilities	Remote and scattered, 7/24, according to different principles (free of charge, paid by the various licenses); unified interface: Windows and search engine interface
	REFERENCE	About the own resources and other libraries resources	About the own resources, digitized, and for digitization	About resources selected from the web due to their quality, the large role of factual information

Table 1. Elements and functions of traditional libraries, digital libraries and the GDL.

Digital library environment and electronic publishing strengthen the role of scholars in relation to other participants in the scholarly communication chain. An example of this trend may be the Public Library of Science, where researchers are not only authors, reviewers and editors, what happens also in the traditional environment, but also deal with the issuance and distribution of scientific publications. So the earlier model of the chain of information, in which each participant has a particular role to play, ceased to be valid [Owen 2002, p. 276]. Differentiation of functions of the author, publisher and librarian disappears, while the responsibility of scientists increases.

4. Conclusions

Current solutions provide opportunities to transform the conduct of research in many fields of science, and even allow creation of new areas of research, often interdisciplinary. The main objective of the work described here, was a system that supports research and scientific communication, which would use the opportunity enough effectively so that it can be used intuitively, and its function has remained transparent to users. The result is e-Science infrastructure that supports large and diverse (from the information needs point of view) user groups, but supplemented by the tools of Science 2.0, allowing for the existence in the network small groups of researchers, affiliated by common objectives. The resulting system is close to the vision of Memex by Vannevar Bush [Bush 1945]: device allowing to record electronically everything that is possible to hear, see and read, and even experience in a digital or real; indexing, searching and processing the data on demand; and finally presenting the results in a personalized way, depending on the needs and opportunities (for example, the availability of equipment) and providing data and information archiving.

GDL has an increasing impact on scientific, as well as economic and social life, because thanks to it everyone has the ability to create, search, select, organize, archiving and reuse digital content into different, new and effective ways. Thus, it is a simple way to increase productivity, innovation and creativity. It is even believed that the productivity of information activity, since beginning of the century until 2012, may increase twice [Larsen, Wactlar 2003, p. 25]. GDL information systems provide tools for integration of information at a higher level (global digital library level), which facilitates better management of resources at lower costs. To take full advantage of emerging information resources, however, it is necessary to ensure the interoperability of the great resources of information with small, personal digital libraries, in such a way, that everyone can download the data he needed for its processing (mashup) and distribute their resources (raw scientific data, processed data – publications and metadata).

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