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IDENTIFICATION AND MECHANISMS FOR BRIDGING THE DIVIDE IN DIFFERENT TYPES OF SCIENTIFIC COMMUNICATIONS

The relevance of the study stems from the fact that the free circulation of knowledge and access to it is the most critical prerequisite for the advancement of science, which makes communication a determining factor and a "living" social fabric of science. The paper considers the scientific communications (SCs) not only as an interaction within the scientific community, but also as an interaction of science with business, government and society. Each type of SCs can feature specific contradictions, the so-called communication divides, reducing their effectiveness.

The aim of this paper is to systematize and structure various types and forms of SCs, existing in social relationships, make their structural analysis, identify and evaluate communication divides related to such typology, with proposing mechanisms for their efficient bridging.

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The information sources for this are research papers of the leading Ukrainian and foreign scientists, findings of empirical research, including Stanford University reports. The Hegel's principle of ascending from the abstract to the concrete as well as the general scientific methods of cognition (analysis, synthesis, generalization, scientific deduction and induction) became the fundamental methodological tenet of the study. The paper is of interdisciplinary nature.

Findings. Four types of SCs (by addressees) are highlighted: Science-to-science (communications in the scientific community), Science-to-government (communications between science and government), Science-to-business (communications between science and business) and Science-to-society (communications between science and society). The authors suggested their own classification of SCs, encompassing the standard (oral and written) and virtual (individual and mass) types of SCs. The characteristics of the key types of SCs enabled to access their development and identify the communication divides and the causes of their occurrence. Based on this classification, the authors suggested the mechanisms for bridging these communication divides by type of SCs (with identification of the divide and the way to bridge it). In the course of the study and substantiation of the authors' recommendations, special emphasis is laid on the capabilities for the development of SCs, created by the information technologies.

The conclusions are made about the need to build a single communication space for SCs using new forms of interactions, arising from virtual communications. For illustrative purposes, the paper suggests a model of the specialized web service designed to facilitate the process of SCs, with demonstrating its elements (in particular, database and knowledge base) and arrangement of information for various users. In the authors' opinion, such services will become a step towards noosphere.

Keywords: *noosphere, scientific communications, communication divides, information transfer channels, types and forms of communication, web services, virtual communications, information technologies.*

Introduction. Science is impossible and inconceivable without communications. They are a "living" social tissue of science. The transition to noosphere without an access to the extensive knowledge and free flow of knowledge is out of question; it is a prerequisite for an emergence of the noosphere society [1]. Even introduction of the term "scientific communications" (SCs) is an evidence of their significant role in the development of science [1]. Such communications take place not only within the scientific community, but also between representatives of science and other societal strata: engineers, industrialists, entrepreneurs, government officials and general public. In each case, SCs have their own distinctive features and differences depending on the participants and mechanisms. This demonstrates the existence of different types of SCs, and this also has a major impact on the development of science and society in general. They are, in turn, overlapped (and partially determined by them) with different forms of implementation (in fact, information transfer channels) of such kinds of communications. But along with the well-established SCs, there emerged new forms of SCs linked to information technologies (IT), especially the Internet. It is an indication of a radically new level achieved by SCs, which requires a more comprehensive study and thorough analysis. It has to be related to the issues of SC intensification and bridging the

[1] It should be noted that communications in a scientific environment are valuable per se as they allow for sharing experiences, addressing problems from various perspectives, highlighting new issues and ideas, encouraging the participants to clearly formulate their ideas.

divides specific to different types of SCs. This article makes an attempt to systematize and structure diverse types of SCs and their social forms, in order to identify communication divides and propose a mechanism for their effective bridging.

Literature review. The transformation of science into a crucial productive force of society and its democratization naturally aroused an interest to SCs as its part. It concerns the phenomenon of SCs itself as well as its typology and forms of implementation. The growing scales of IT and the ongoing globalization only increased such interest and raised a number of new questions before us [2, 3]. These questions are elaborated on in [2, 4—14]. One of the core questions of SCs study concerns with the addressee and the social groups involved in SCs. A detailed answer to it is given in [11, 12]. The key actors of SCs are four fundamental institutions (societal groups): science, government, business and society.

It should be noted that communication is not similar to scientific communication. It is quite clearly described in [4], where the existing interpretations of “communication” and “scientific communication” are systematized, with distinguishing the normative and descriptive aspects of SCs analysis. At the same time, it is quite reasonable from the methodological point of view that a definition of SCs is proposed and may be further used in a constructive manner.

A detailed review of the existing approaches to the interpretation of SCs is given in [13]. The author systematizes the key forms of scientists’ interactions in the course of scientific activities, defines the specific features of the socio-humanitarian sphere, which have an impact on SCs in it. Unfortunately, no mention is made of the distinctive features of other scientific spheres, which is natural as it narrows down the nature of the suggested conclusions related to SCs.

Some researchers [15—18] pay great attention to the popularization of science. This trend can be characterized as interactions between science and society [2] (Science-to-society). Such communication between science and society is most often implemented by means of science journalism. This diagram of SCs is most clearly and generally demonstrated by C. Könneker [19], the Chief Editor of German edition of the scientific journal Scientific American. The question may be raised: why such an attention, or even high priority, is paid to this particular type of communications — the interaction between science and society? In our opinion, the most convincing answer is given in the report of Stanford University, which emphasizes the main points of scientific developments: “to communicate your developments to the world, change the world by means of your ideas and, thereby provide opportunities for scientific development” [20]. Moreover, the relevance of this is evidenced by the fact that the first in the Russian Federation Faculty for training of specialists in the area of SCs was established in Saint Petersburg.

According to J. Braha, scientific communities play a significant role not only in linking research to practice, but also in attracting public audience. The commu-

[2] For this kind of interactions, special abbreviation SC (science communication) is widespread in the West, in contrast to the interactions within science, i. e. “Science-to-science”, for which the term “scientific communication” is used.

nities start maintaining the contacts between scientists and audiences, and they also enable scientists to draw attention of general public. This is achieved within special strategies and through the mechanisms for interaction of the members of scientific communities with the audience [21].

SCs between science and business (Science-to-business) are of crucial importance. The scientific environment, by virtue of its specifics and due to a disintegration of the processes of scientific researches, especially fundamental ones, is beyond the sphere of economy. For its part, business environment is too tough for poorly predictable process of creating the innovations and developing their market based on the findings of exactly these studies. This means that the interaction and communication between science and business encounter numerous contradictions, which should be allowed, as science more and more becomes a direct productive force in the economy [12]. There is an urgent need for support of science by business, but business is not always ready to invest in the spheres with a high level of uncertainty related to such support — their goals are too contradictory. This issue is especially relevant for post-Soviet space, where the "market" models and mechanisms to fund science do not yet exist. By the way, it should be noted that today we have to speak about an interaction between science and business, taking into consideration the arising opportunities for scientific and technological cooperation, when it becomes more and more global and intensive, and closely related to the increasing competition (competitive race) [22]. The global SCs between science and business are a feature of the modern paradigm of innovative processes.

The next aspect is related to the interaction within the group science-to-government. According to our information, there are not enough studies of this subject, and those that were carried out do not provide a complete picture of the existing contradictions [12].

The issue of the forms of SCs implementation is critical, although, de facto, it is about the information transfer channels [3]. It is evidences by the increasing number of publications on the subject. Bellow, we will discuss some of them, providing the most vivid and clear description of the issues related to SCs implementation. Here, it should only be noted that it is not a simple question, as it may seem, because IT have currently penetrated into this domain in all their expanding diversity, which completely changes the picture: instead of the traditional well-established "frozen" forms, represented by conferences, symposiums and publications, the globalized world faces the emerged and continuing to emerge new virtual forms of SCs, which have an immense potential, but still are far from the real-life outcomes and, at the same time, have an impact on the very essence and content of SCs. It is online forums and conferences, webinars, professional (science-community.org, phdtree.org, researchgate.net, nauka.in.ua), social (facebook.com, linkedin.com) and expert networks (direct2experts.org) [23].

[3] Hereinafter we will not make difference between the expressions "form of SCs implementation" and "information transfer channel", and, whenever required, a more appropriate expression will be used.

Actually, here, we directly face the dialectics — the form of SCs implementation affects its content and vice versa.

Traditional forms of SC. The role and forms of SCs in the digital age and highlighted in [14]. The author addresses the changing role of SCs in development of science in the course of the development of information society. Personal and indirect SCs are compared; conclusion is made about the extensive capabilities of electronic communication among Belarusian scientists.

One of the most prospective trends in SCs studies is to explore the communication forms at the level of formal and informal interaction among scientists. This is the point of view of A. Rudi [9]. The author suggests that it is SCs that ensures an interaction between the key mechanisms of scientific development — a combination of continuity and innovations, integration and differentiation.

I. Zamoshchansky et al. dedicated their paper [2] to the contemporary socio-communicative practices within a scientific community. The need for mainstreaming SCs, with regard to the specifics of modern sociality, was justified. The communicative characteristics of the modern scientific community were provided. The role and importance of SCs were demonstrated, discussing the innovative approach [4] to training of academic staff.

Virtual channels of interaction. Prior to development of IT, scientific communications were implemented exceptionally by the way of personal communication, by means of seminars, conferences or meetings of scientific communities, or through then-traditional channel of SCs, such as the scientific journal [6]. Currently, the virtual channels of interaction are widely used, and they are not only scientific journals, libraries or archives, but also a creation of the innovative web-services for the effective interaction and collaboration of scientists [13]. However, as mentioned in [28], the analysis of such forms of communication is still poorly developed.

It has been found out that the large scientific communities working in the same field almost do not refer to each other, and about 90 % of references in their papers are to the citations of the colleagues in their working group or self-citing. It demonstrates the lack of a well-established mechanism for SCs, which usually consists not only in sharing the ideas and knowledge and, importantly, in an impact on the course of scientific research; the lack of such mechanism reduces the level of development of science in general [23].

A virtual environment, in contrast to the traditional communication channels, enables implementation of a number of mechanisms to improve an interaction between the communicators. For example, [11] suggests the models of a single open information space, where the communication processes between its participants can be implemented. According to C. Romm, N. Pliskin and R. Clarke, the virtual communities are the groups of people which communicate between each

[4] It is about the need to expand such components of scientist's successful activities as an interaction between education system and production sphere, an ability to create commercially attractive product and represent it.

other by electronic means. The virtual communities are quite new phenomenon and they play an extended role in organizing SCs and in public life [24].

A. Ryazanov [10] gave a detailed description of the new forms of SCs — virtual communications. It provides the key features of such communications, which are comparable to the features of Big Data. The author also highlights the advantages of virtual communications. One of such benefits is creation and implementation of the original tools to enhance the efficiency of scientists' work, which itself is a prospective trend in the field of SCs.

D. Pauleen and P. Yoong consider the issues related to facilitation of interaction between the members of virtual team through the Internet and regular communication channels, which is required to enhance the efficiency of collaborative work. In order to build online relationship between the members of virtual teams, it is possible to engage mediators, using the Internet channels and traditional electronic communication channels, where a varying degree of effectiveness should be taken into consideration [25].

V. Lomovitskaya [6] provides a very interesting historical study of SCs development. The author raises a very important issue of the dependence of new knowledge generation[5] on information and scientific communications. V. Lomovitskaya comes to the conclusion that the use of IT meets the demands of time; these technologies create a new space for scientific communications; scientific activities of a modern scientist are impossible without them, but the issue of generation of the fundamentally new knowledge when using IT and computer networks remains open. As a result, a very important and fundamental question is raised: does the communication work and, if yes, how it works in the network space to increase knowledge?

The virtual teams which also use virtual tools (S. Marlow, C. Lacerenza, E. Salas [33]; J. Webster, W. Wong [34]) arise in the context of virtual communications. The major challenge is the virtuality itself and its impact on the quality of SCs and scientific activities. There are still no unequivocal assessments in this sphere, including the assessments of virtuality and productivity. There is uncertainty about the relationship between different mechanisms of virtual SCs [33].

Relatively new digital mechanisms, i. e. scientific gateways, virtual laboratories and virtual research environments aimed to satisfy a range of virtual communities' needs, in particular to provide access to resources, including software, data, tools for collaborative work and computational capacities, are investigated in [26]. Such environments have contributed to a great many fields of science, facilitating thereby more efficient and open SCs. Taking into account the cumulative effect and the growing global impact, it is necessary to discuss their future development.

D. Liu et al. [27] examine the information role of two types of laboratories in the educational process: the virtual laboratory and the physical laboratory. The authors also highlight the great potential of three-dimensional virtual laboratory games to support teaching and learning of natural sciences. Three-dimensional

[5] Here and below "knowledge" is used as a denotation of "scientific knowledge"; we believe that its most appropriate definition is given in [32, p. 20].

virtual environments ensure immersion in education content and interaction within the framework of scientific principles, reducing organizational and logistical efforts [27].

Currently and, probably, in the nearest future, the success of any economy will depend on how close it is to the innovative economy, or knowledge economy [8, 29, 30, 31]. And this is where SCs play an essential role. It is emphasized in [11] that lack of the required information and communication infrastructure nullifies all the other governmental efforts to create the innovative economy, affecting in this way the remaining groups (business and science). In fact, the full impact of SCs on the development of innovative economy is explicitly noted.

More and more often, the complexity of scientific problems requires not only interdisciplinary cooperation to generate knowledge, but also cooperation in science at the global level, which gradually becomes rather a norm than an exception, that is evidenced by the increased number of scientific papers with the international co-authorship [31].

Problem setting. The above analysis demonstrated that SCs involved a very large number of participants at a variety of social layers, and were implemented in a variety of forms. Of course, in this case, having such a number of participants, representing different types of social institutions, and in such a variety of the forms of interaction, for various reasons, the participants of SCs inevitably encounter with certain misunderstanding and even total lack of mutual understanding and dialogue, which can be called a communication divide [35]. It is the divides that, in many aspects, do not allow modern society to take full advantage of the scientific knowledge as well as to ascend to a new, more sophisticated level of development, especially, taking into consideration the application of IT. Therefore, an identification and analysis of communication divides in a finite set of types and forms of SCs, aiming at their further bridging among different participants of SCs, is a major challenge both in terms of using the methods of scientific knowledge [6] and building a successful economy as well as changing the world. This problem is still poorly studied, as the communication divides in the full spectrum of types and forms of SCs have not been studied systematically before, due to their uncertainty and "fuzziness", being associated primarily with the lack of appropriate typology and structuring. The specified problem is emphasized by the issue related to an emergence of absolutely new mechanisms for communication based on the use of the state-of-the-art IT and, at the same time, enhancing the cognitive abilities of a human (scientist).

The objective of this paper is to systemize and structure various types and forms of SCs existing in the social relations, to make their structural analysis, to identify and analyze the communication divides related to such typology, and specify the mechanisms for their effective bridging, to single out the most prospective ones [7],

[6] The primary objective of science is to obtain or mine new knowledge, and bridging such divides will facilitate addressing the primary objective of science.

[7] While keeping in mind that SCs, when using the advanced information technologies, should primarily work to increase the scientific knowledge.

taking into consideration the latest advances in IT, which are able to facilitate generation of new knowledge.

Research methods. The methods of structural, functional and comparative study are used in this study. For further study, it would be better to rely on the definition of scientific communication, which, on one hand, would be quite general and, on the other hand, would be quite clear, in order to use it in specific cases without loss of generality. After analyzing a number of papers in this field, the following seemed to be the most applicable, in our opinion, and met the two above-mentioned basic requirements to such definition [30]: "The scientific communications will be understood as communication processes, where at least one of the parties, addresser (sender) and/or addressee (recipient), is a representative of the scientific community". For the purpose of our study, SCs are defined as communication processes, where the addresser (sender) is a representative of the scientific community, and the subject is representation and sharing of new scientific knowledge. In our study we will rely on this definition of IT. At the same time, as shown in [36], SCs are based on the dialogue, which is also their essence. This dialogue involves both sharing of information and the emergence of new information, i. e. knowledge, and it is also used to exert influence to the other participant.

Usually, we have the Addresser and Addressee in the communication models, including SCs models. Our research is focused on the case with one Addresser — a representative of scientific community, and a few Addressees. The review of the above publications was made exactly from this perspective, and it allowed singling out two basic groups of the fields to be studied in SCs of the specified type. The first group is related to the addressees of SCs [8], the second one — to the forms of implementation (actually, information transfer channels) of SCs, where this essence of SCs is represented and integrally linked to the Addressee.

Research findings. The analysis demonstrated that the following addressees of SCs [11, 12] could be distinguished in the first group:

- Science-to-science: interactions among scientists, teams of scientists, and science management bodies.
- Science-to-government: interactions among scientists and government bodies.
- Science-to-business: interactions among scientists and business.
- Science-to-society: interactions among scientists (science) and society.

Concerning the form of SCs implementation, based on the analysis, we suggest singling out the traditional SCs [9] and, due to a widespread use and expansion of the role of IT, virtual SCs [10].

[8] Participants of the dialogue that the information, coming from the addresser, is intended for, i. e. representatives of science.

[9] By traditional SCs we mean the well-established forms of SCs before emergence of the modern IT [23].

[10] Ye. Mirskaya defines this term as "information technologies, which ensure instant obtaining of remote information and its sharing, relying on the global computer networks" [37, p. 127].

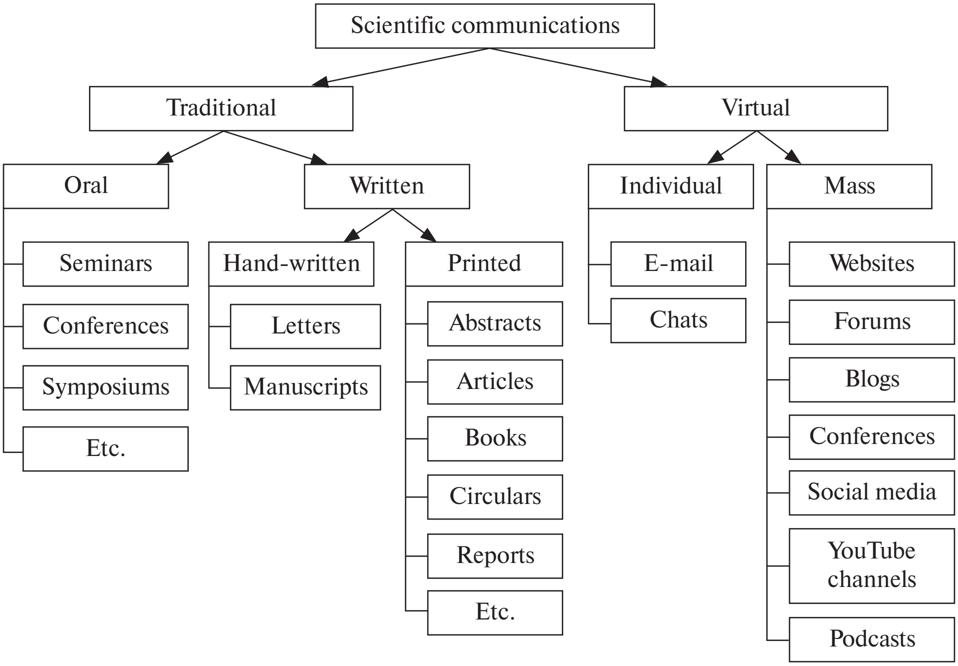

Fig. 1. Types of scientific communications
Source: developed by the authors.

Figure 1 shows these types of SCs. Their brief description is given below.[11]

Traditional types of SCs. In the "oral" segment, a scientific seminar[12] or conference is admittedly the most common oral scientific communication and the most effective type of SCs in the segment of oral communications[13]. In the "written" segment, it is abstracts of papers/speeches or scientific papers, which currently can be considered as a basic form of SCs[14]. This is because the scientific research is followed and completed by creation of a scientific paper as the primary scientific product. The paper allows for determining the scientific authorship and it is subject to scientometric analysis.

[11] Here we do not confine our discussion to formal or informal communication, although they add "color" to the outcomes and quite often have significant impact on them. The details can be found in [38].

[12] Scientific seminar is a discussion by a comparatively small group of participants on the scientific speeches and messages, which is held under the direction of the leading scientist, specialist. Seminars are usually held within one scientific organization or one educational institution.

[13] "...if we speak about the communication, which is used by the researcher as a source of motivation for his work, and a source of data, making his/her work possible, about 80 % of this information flow is provided from other researchers at the stage, which is prior to formal communication, via the communication channels — conversations over a glass of wine, conferences, seminars, preprints and other components of 'invisible college'" [38, p. 96].

[14] This is well said in [38] that we already mentioned.

Virtual communications. In the “individual” segment, the most common SCs are e-mails accelerating growth and intensive sharing of scientific information. In the “mass” segment, it is forums and special social media, and means for public discussion of research findings or teamwork (i. e. generation of new knowledge); but a number of problems are involved, the copyright problem in particular.

In view of the above, it seems appropriate to summarize the two groups of SCs using the principle of ascending (formulated by Hehel) from the abstract to the concrete [39] in Table 1, with presenting the authors’ evaluation of the SCs development by three ranking categories: “good”, satisfactory” and “poor”. This evaluation is based on analysis of various data related to SCs, provided in the abovementioned literary sources. The summary is obtained by the following principle: SCs is an abstract category, which, as a result of moving to the concrete, is divided into concrete groups and types, etc. without losing sight of the main point — general form and category of SCs. [36] demonstrates that SC is based on the dialogue between the concerned parties, and this dialogue can serve as an abstraction in relation to other concrete types of SCs.

Table 1 summarizes the abovementioned groups of SCs and demonstrates the existence of a various extent of communication divides in interactions between the addresser and addressees of SCs, while using different forms (channels) of such interaction.

Using the same Hegel’s principle of ascending from the abstract to the concrete, the **generalized model of SCs** (in the previously mentioned sense) could be suggested in form of multidimensional table T_{HK}, which, in this case, can be more easily presented as a formula [15], which is a multidimensional cube of the areas of scientific researches in SCs [16]:

$$T_{HK} = <Addressees, Channels, \ldots>$$

The causes of the communication divides in case of Science-to-science, Science-to-government, Science-to-business and Science-to-society are quite fully represented in [8, 30, 40]. We are going to systematize them and consider one by one.

Table 1. **Communication divides in scientific communications**

	Traditional type of SCs	Virtual type of SCs
Science-to-science	Good	Satisfactory
Science-to-government	Satisfactory	Poor
Science-to-business	Poor	Poor
Science-to-society	Good	Satisfactory

Source: the authors’ assessment based on the research findings in [8, 10, 12, 40].

[15] If we do not take into account the value of (scale) axes.

[16] For example, we can consider the age group as the third group, “center—periphery” as the fourth one, etc.

The causes of the communication divide in case of Science-to-science:

• Closed academic culture (this is particularly the case for socio-humanitarian sciences and representatives of metropolitan science);

• Poorly established mechanism for communication between the teams of developers (researchers) and specialized subdivisions of the administration (higher academic institutions or academic institutions).

The causes of the communication divide in case of Science-to-government:

• Excessive administering; as a result, there is a monologue of authority;

• An absence of flexible mechanisms for administrative structures to respond to the changing external conditions, including market conditions (to a significant extent), i. e. contradiction between management system aimed at scientific and educational activities and the required market basis for managing the commercialization of innovations.

The causes of the communication divide in case of Science-to-business:

• In general, this divide is determined by the key contradiction, which consists in the fact that science is initially altruistic, and its outcomes are an external heritage of the whole society. As for the market principles, they are based on individualism and primacy of personal benefit. Therefore, a synergy based on the unity of interests, goals and incentives is manifested only with an emergence of the scientific product (development) of product attributes (innovations) [12].

• On the part of science: inability to "translate" from scientific language to the commercial one, to present scientific and technological advances as a commercially promising project, an absence of business competencies.

• On the part of business: unwillingness to gain insight of scientific and technological advance, and, hence, inability to fully assess its prospects; low tendency to take risks in case of long-term investment in the process of new knowledge transformation into innovation.

The causes of the communication divide in case of Science-to-society:

• On the part of science: lack of the well-established mechanism for communicating various aspects of scientific activity and its outcomes to the general public and, as a result, an absence of the support from the government sector;

• On the part of society: absence of intuitions providing feedback, even if it is indirect.

The ultimate goal of all types of SCs is to have an impact on the addressee (science, government, business or society), but, for this purpose, it is necessary to preliminary bridge the communication divides, i. e. eliminate or alleviate the reasons that caused them. In our case, it is desirable to highlight the most promising mechanisms, which enable to eliminate or diminish the causes of communication divides within each structure, taking into account the advances and opportunities of IT as possible catalysts of knowledge increasing in the course of SCs.

Mechanisms for bridging the communication divides.

Science-to-science. Two-dimensional type of clustering (Fig. 2) can serve as a good visual model of academic closeness.

In some cases, especially when a team is small and not well established, such closeness can play a positive role: we can recall scientists like K. Tsiolkovsky, S. Fedorov, G. Ilizarov, to mention just a few. However, for further development we need a mechanism for bridging the divide [41]. Such mechanism can be represented by special channels for sharing and free circulation of knowledge, ideas, technology, and, thereby, influences between the clusters (Fig. 3).

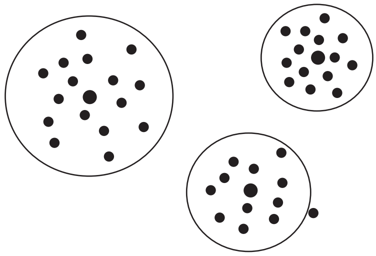

Fig. 2. Two-dimensional type of clustering to demonstrate the academic closeness
Source: developed by the authors.

In the current context, such channels, besides using traditional types of SCs, should be primarily based on using new virtual forms of SCs, which enable to promptly and efficiently organize SCs in all their diversity: forums, special social media, web-conferences, and web-services. The advantages of the virtual forms have already been mentioned in the previously cited paper [10]. In some cases, such mechanisms are capable of having a real impact on the generation of new knowledge. Therefore, such mechanisms should be created and developed as well as made a heritage of the scientific community with certain powers and a widespread dissemination of information on such kind of new opportunities; then it will have a beneficial (including competitive) impact on carrying out new research. It is well known that science is not only communications, but also, first and foremost, influence.

Science-to-government. Firstly, the mechanism for bridging the divides should be based on the dialogue rather than on the monologue of the government. Such dialogue, as a must-have of democratic society, would be better to organize based on the virtual forms of SCs, as discussed above. Here, the key goal is to turn the interaction from monologue into dialogue as an entity of SCs.

Secondly, concerning R&D management system, apart from traditional forms of the dialogue between science and government, such mechanism can be represented by new scientific institutions: engineering centers or schools [42], where the developments are brought to the level of prototype, and which should be supported and favored by the government, possibly with a certain support from business as it takes place, for example, at the Imperial College in the Great Britain [8]. It means that there should be one more participant in the cluster "science-to-government", which would be someone who brings the developments to the level of prototype and exhibits it in the virtual environment to in-

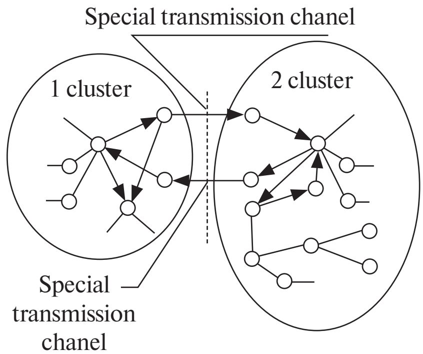

Fig. 3. Model of scientific communications between the "clusters" (groups)
Source: developed by the authors.

Table 2. **Mechanisms for bridging the communicative divides in SC**

Divides, causes and mecha-nisms; SCs	Divide	Bridging: **what** do we bridge	Bridging: **how** do we bridge, bridging mechanism
Science-to-science	Closeness within the groups	"Parochialism" of these groups	Special channels for sharing and free circulation of knowledge, ideas and technologies between clusters
	Poorly established mechanism for interaction between administration and teams of developers	Monologue of administration	The mechanism involves dialogue. There should be arranged a feedback from researchers to administration to be taken into account by administrative side.
Science-to-government	Excessive administering	Lack of independence	Vesting scientific organizations with great powers, decentralization and de-bureaucratization of scientific institutions
	Absence of flexible mechanisms to respond to the changing external conditions, including the market ones	Developments management system should be flexible	Creation of new institutions in science like engineering centers or schools, where modeling takes place as well as bringing scientific developments to the level of prototype, communicating these developments via Internet (special services, etc.), which should be supported and supervised by the government, probably, with a certain support from business, as it works, for example, at the Imperial College in the Great Britain.
	Contradiction between management system aimed at scientific and educational activities, and demanded market mechanisms for managing commercialization of innovations	Absence of commercialization of scientific developments	
Science-to-business	On the part of science — inability to "translate" from scientific language into the commercial one On the part of business — unwillingness to gain insight of scientific and technological advance, and, hence, inability to fully assess its prospects; low tendency to take risks.	Absence of relationship between venture business, sciene and market of high-tech products	
Випуск Випуск	Absence of well-established mechanism to communicate various aspects of scientific activity and its outcomes to general public	Information divide between science and society	Government support of mass media which cover scientific advances. Training and creation of the appropriate human resource capacity, including establishment of the specialized departments and specialties.
	Absence of institutions which provide feedback from the society	Absence of dialogue between society and science	Creation of websites, where the citizens (as part of the society) can participate in discussions, illustrative experiments, learning and self-learning, contacting in this way with the scientific community.

Source: developed by the authors.

form government officials in the first place as well as business about a new potential product.

Science-to-business. A description of the relationship between venture business, science and high-tech market is given by V. Ivanov: "...it is necessary, on one hand, to have almost ready technology on the way, and, on the other hand, a producer who will buy this technology and, of course, a market that will consume the finished products manufactured according to this technology. In the absence of these conditions, the activity of venture capitalist makes no sense" [43, p. 53].

We have already mentioned this mechanism (engineering school), i. e. in this case, one more participant, also mentioned above, is needed in the cluster "science-to-business" — the one who brings the developments to the level of prototype and exhibits, and brings it into the public eye to inform the representatives of business, namely, engineering schools. The establishment of engineering schools and similar organizations is reasonable to facilitate modeling and/or prototyping aimed to speed up the turning of scientific developments into innovations. This can be ensured using web-services aimed to facilitate the processes of communicating the created prototypes to business. Actually, it is an implementation of virtual SCs in the cluster "science-to-business".

Therefore, if the government undertakes this role (probably, with certain participation of business) and the risks inherent to this case (that business refuses to undertake), in that event, it is possible to resolve major contradiction between the science management system, aimed at scientific and educational activities, and the demanded market principles for managing commercialization of innovations.

Science-to-society. We believe that the mechanism for bridging the divide involves: (i) efficient communication of scientific advances to general public, a function taken on by scientific journalists themselves and heavily depending on their education, background, experience and journalistic skills; (ii) creation of conditions for such translation, mostly through government support of the mass media, which cover scientific advances; (iii) training and creation of the appropriate human resource capacity, including the establishment of specialized departments and specialties.

The above mentioned should be illustrated in the table format (see Table 2).

An example might be the service designed for medical use as a tool for processing of cell images (there can be other medical imagery) aimed to establish diagnoses based on the verified database (DB) and knowledge base (KB) with an open access for scientists; it will enable building the appropriate teams of researchers around, uniting the whole community of specialists and carrying out the innovative developments, which can be almost immediately analyzed by the other parties of SCs (on the part of government and business) and, in case of meeting the set criteria, can be in demand (Fig. 4). Such diagram of SCs actually includes all relationships of SCs: "science-to-science", "science-to-business", "science-to-government" and "science-to-society", and, to a certain degree, it can be even standard.

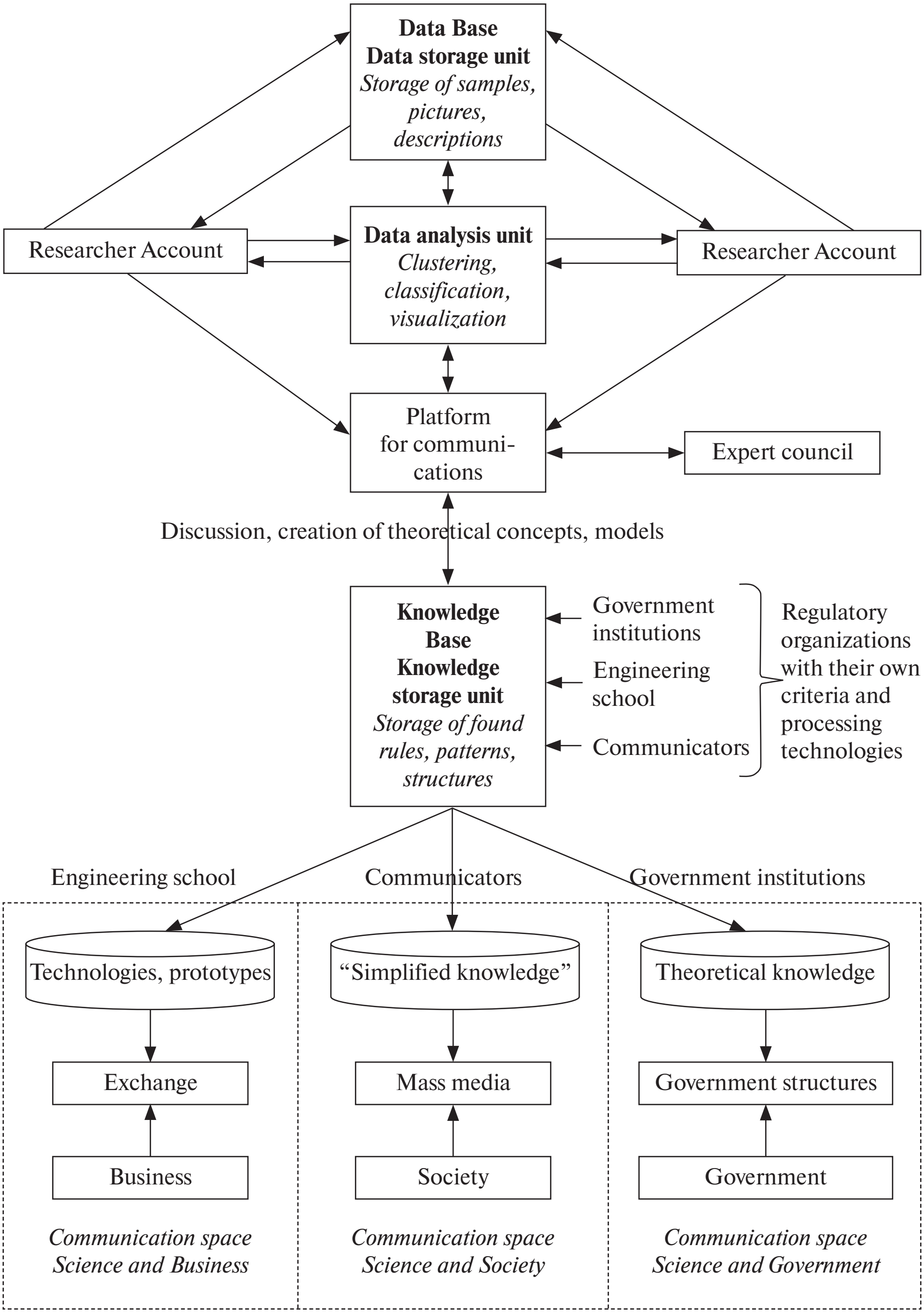

Fig. 4. Diagram of SCs via special medical-purpose service for image processing to establish diagnosis
Source: developed by the authors.

There can be lots of unscheduled DB in various areas of research. At the same time, communicative actions between these players, which are critical in view of the set goals, will be aimed at innovative development.

It is very important not to lose sight of the main point — what all this is done for? At the very beginning, we have already mentioned a fundamental need to build noosphere as the next stage in the development of civilization. And building of the full-fledged SCs, including all their types, should become one more step towards creation of noosphere and noosphere society.

Conclusions and prospects for further studies. The analysis enables us to draw a number of conclusions. In order to bridge the communicative divide within different groups, SCs need to have a single communication environment.

In the era of digitalization, it can be logically assumed that communicative processes should for the most part be implemented in a virtual environment. In order to considerably improve the circulation of scientific information and remove barriers to disseminate knowledge, and speed up its practical application, a use of the specialized web-services can be suggested as a part of communicative process. Such web-services arrange information for various groups of users, i. e. a huge amount of work is preliminary carried out to formalize thinking operations (being the basis of the designed web-services). At the same time, scientists do not need to learn programming, but, in this dialogue, a scientist plays a very important role, which still cannot be performed by any computer, and which is performed by a scientist better than by any computer, because a scientist formulates the goals of the research and takes final decisions.

Future studies will be devoted to the applied aspects of IT applications in SCs, including various fields of science, and the capabilities and limitations of the respective information systems.

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ІДЕНТИФІКАЦІЯ І МЕХАНІЗМИ ПОДОЛАННЯ РОЗРИВІВ У РІЗНИХ ТИПАХ НАУКОВИХ КОМУНІКАЦІЙ

Актуальність дослідження обумовлена тим, що вільна циркуляція знань і доступ до них є найважливішою передумовою розвитку науки, що робить комунікацію визначальним елементом і «живою» соціальною тканиною науки. Наукові комунікації (НК) розглядаються не тільки як взаємодія всередині наукового співтовариства, а і як взаємодія науки з бізнесом, державою та суспільством. Кожному типу НК можуть бути притаманні певні протиріччя, так звані комунікаційні розриви, які знижують їх ефективність.

Мета статті – систематизувати та структурувати різноманітні типи та форми НК, які існують у соціальних відносинах, здійснити їх структурний аналіз, виявити та оцінити комунікативні розриви, пов'язані з такою типологію, та вказати механізми їх ефективного подолання.

Джерелом інформації для дослідження є наукові праці провідних українських і зарубіжних вчених, результати емпіричних досліджень, включаючи звіти Стенфордського університету. Основним методологічним постулатом дослідження став гегелівський принцип сходження від абстрактного до конкретного, а також загальнонаукові методи пізнання (аналізу, синтезу, узагальнення, наукової дедукції та індукції). Робота має міждисциплінарний характер.

Отримані результати. У статті розглянуто чотири типи НК (за адресатами): Science-to-science (комунікації у науковому колі), Science-to-governtment (комунікації науки з державою), Science-to-business (комунікація науки з бізнесом) та Science-to-society (комунікації науки з суспільством). Авторами запропоновано власну класифікацію НК, яка охоплює стандартні (усні та письмові), а також віртуальні (індивідуальні та масові) види НК. Характеристика основних видів НК дозволила оцінити їх ступінь розвитку, встановити комунікаційні розриви і причини їх виникнення. На підставі цього авторами запропоновано механізми подолання цих комунікаційних розривів за видами НК (з визначенням розриву і способу його подолання). В процесі дослідження і обґрунтування авторських рекомендацій особливу увагу приділено можливостям для розвитку НК, створюваним інформаційними технологіями.

Зроблено висновки щодо необхідності формування єдиного комунікаційного простору для НК з використанням нових форм взаємодії, які породжуються віртуальними комунікаціями. Для наочності запропоновано модель спеціалізованого веб-сервісу, покликаного полегшити процес НК, показано її елементи (зокрема бази даних і базу знань) та організацію інформації для різних користувачів. На думку авторів, такі сервіси стануть сходинкою до ноосфери.

***Ключові слова**: ноосфера, наукові комунікації, комунікаційні розриви, канали передавання інформації, види і форми комунікації, веб-сервіси, віртуальні комунікації, інформаційні технології.*