Co-opetition Strategy in Volunteer Computing: The Example of Collaboration Online in BOINC.RU Community

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Abstract Volunteer computing (VC) is a strong way to harness distributed computing resources to perform large-scale scientific tasks. Its success directly depends on the number of participants, PC (some other devices) and time of their work. And while the computational aspect received much effective research attention and solutions; the social problem of VC phenomenon – how persuade the owners of widely dispersed smart machines and devices to participate in VC projects, and how figure out ways to speed and expand the capability of donated computer resources, remains largely unexplored. We think that a motive of self-actualization of participants of volunteer computing is not enough to explain why millions of unskilled people day by day participate in scientific computation. Our research indicates that the answer lies at the intersection of self-oriented motivation and the interactional, organizational possibilities emerging through the Internet. In this paper we investigate Russian community of VC and discuss the suggestion that online collaboration can capture people's motivation better than only intrinsic motives.

Keywords Co-opetition, Volunteer Computing, Online Collaboration, Virtual Communities

1. Introduction

The complexity of the tasks facing modern science is accompanied by the complexity of the computations. For solving computational problems, along with supercomputers distributed computing is used nowadays. Technically distributed computing is performed by a number of different processors, which reside in one device (multiprocessor computer) or on different machines. In the last sense computers may be on the same network (the case of clusters), or on networks that are physically

located far away from each other. So, in this paper the distributed computing term will be used to glean knowledge that will deepen our understanding of an emerging type of computer-mediated online communication, which carried out scientific computing.

1.1. Concept of volunteer computing

One of the forms of the distributed computing is the volunteer computing (VC), a specific form of online activity of volunteers, ordinary Internet users, who have no any relation to scientific or professional computer activities, and who do not receive compensation for their participation. So, we use the notion of volunteer computing as a type of a *distributed computing* in which unskilled computer owners can donate their spare computer resources to perform a computation of one or more large-scale research projects. Unlike peer-to-peer (P2P) or grid computing, VC relies on the client-server architecture. (Figure 1).

Figure 1. Scheme of BOINC platform (VC-participation)

As a result, volunteers' desktops, notebooks, mobile phones can be virtually connected to form through Internet a network equivalent to a huge and superpower supercomputer. As a high-performance distributed

computing platform, BOINC brings together about 4,5 millions (157,814 active) participants and more than 1,2 millions (778,490 active) computers (hosts) worldwide processing on average 20.996 PetaFLOPS, as of 31 July 2018 [1].

The concept of VC is based on the ideas of the network organization of communications and the emergence of the paradigm of the network society as a whole [2,3]. The principal technical background of VC is the idea of David Gedye [4], one of the founder of the project SETI@home (“Search for Extraterrestrial Intelligence”), to use dispersed desktops for computing large-scale scientific tasks [5], the software decision to integrate a lot of personal computers of Internet users in a virtual network on a special platform. In 2002, at the University of California, Berkeley the BOINC (The Berkeley Open Infrastructure for Network Computing), an open-source middleware system was designed; an open-source platform dedicated to running volunteer computing projects [6].

As for VC-projects, typically academic-based research assignments, they are based on 3 pillars (Figure 2).

Figure 2. Basic principles of VC-project organization

- *Technical task* (computational): slicing a problem into thousands of tiny pieces which are then allocated (with a help of downloading project software) to a large number of individuals who volunteer their PC (notebooks, etc.) to scientific computing;
- *Social task* (participation): recruiting and retaining a large number of individuals to volunteer their computer resources, time and energy to the project, and facilitating their continuous contribution;
- *Knowledge task* (motives knowing): understanding of motifs to speed and expand the capability of volunteer computer resources to use for performance computing.

And while the computational aspect of VC received much research attention, the participative and knowledge aspects remain largely unexplored. In order to understand the phenomenon of VC we have to look “inside” it. And we find two spaces.

At first, it is a computational VC-space. As it was mentioned earlier, VC relies on the standard client-server

architecture where clients (software programs) “talk” only to the project server and do not talk to one another directly. So, in order to participate in a VC project, a user must download the project software from the VC project website and install it on their computer. Once installed, the project software contacts the project website and is assigned a task. Upon solving the task, the result is sent back to the project server and a new task is downloaded if the user so desires. Look at the arrows in Figure 1.

The implementation of VC project depends on the number of connected (“included”) computers, their resources and time of their work. So, project managers/organizers used a special conditional points accrual mechanism to encourage participation in VC-projects. The project’s server keeps track of how much work your computer has done; the number of accrued points (crédits) depends on the provided capacities, the time of participation in a project and other characteristics of the activity of volunteers or their teams. To ensure that crédits are granted fairly, most BOINC projects work as follows:

Each task may be sent to two computers;

When a computer reports a result, it claims a certain amount of credit, based on how much CPU time was used;

When at least two results have been returned, the server compares them. If the results agree, then users are granted the smaller of the claimed crédits.

As for *social underpinning* of VC-projects, we should note a non-traditional form of VC social structure. Emerging from individual participation at the first stages of VC, nowadays VC-volunteers, instead of traditional scientific research conducted inside a hierarchical institution, form a specific kind of a virtual scientific community which working towards the common goal of scientific research. The whole multitude of VC-participants is not a “sack” of volunteers. Participants in VC projects can either work alone or join a team and work together on the same project. A team typically consists of a group of people with a common nationality (country), thematic or institutional (same university, place of work, etc.) affiliation. As a whole there are 107,503 teams that united more than 4,5 million participants in the VC projects [7]. Mainly VC-teams have their own websites dedicated to the projects; they also host online user groups in social media. So all these online discussion services allow the volunteers cooperate by sharing knowledge and expertise and progress the team and individual team members.

And all VC-projects have their own websites that are used to host the project software, disseminate information about performing the project, and a ranking table of volunteers’ activity. On websites there are also online discussion forums where the volunteers can discuss different aspects and technical problems of distributed computing of a project, attempt to resolve any technical

problems that may arise during the running of the projects.

So, we can say that VC is a dispersed network of teams and individuals, projects' and team sites, online forums and online user groups. As VC projects are by their nature decentralized, the volunteer's virtual communication through online forums, team home pages, and VC-project websites form a *communal virtual place*.

So, the VC-community organizational framework consists of:

- *projects* – typically academic-based research assignments, e.g. search for “Extra-Terrestrial Intelligence”, understand of protein folding and related diseases, learn global warming, discover pulsars; there are 51 most active projects, (<http://www.boincstats.com>);
- *individuals* – Internet-connected low-powered computers = average person or organization (volunteers), not paid for their work, anonymous, working alone (just about 16,9%, survey May, 2018);
- *VC teams* – a long-term strategic alliance formed by volunteers, individual users of PC, in order to participate in solving large scientific computational task (just about 83,1%, survey in May, 2018);
- *Internet resources* – e.g., project websites with statistics in rank tables, discussion forums, etc.

1.2. Motivations for participation in VC-projects

Research on motivation for involvement in collaborative VC scientific projects goes back to the studies analyzing the factors shaping and developing the digital “civil science” [8]. These studies show that “categories of civil science”, in other words, the factors that determine the distribution of participants in voluntary computing, depend on the nature and objectives of the projects. And the whole multitude of volunteers is located in the interval, beginning with the “technical” tasks, in which their participation is reduced only to the provision of computer resources for computations (such as the SETI@home project or the Folding@home project of computer modeling of protein molecule folding) and ending with more complex problems, for the solution of which both collection and analysis of distributed data are required (Stardust@home projects on classification of interstellar dust particles or Galaxy Zoo, project of construction of visual images/images of galaxies). In total, according to researchers, it is possible to describe three types of projects and, accordingly, three “strats” of the participants.

The revealed differences in the distribution of volunteers underscore the need for a detailed study of the motives for participating in such projects. And, first of all, in VC-projects, entry into which does not require

participants to do anything other than downloading the BOINC platform and embedded (“connecting”) computers into a network of distributed resources. Obviously, the implementation of such projects directly depends on the motivations of volunteers to participate in the project, and, accordingly, on the number of “connected” personal computers and on the time of their provision for use in the project. However, the researchers and organizers of VC projects do not have an unambiguous answer to the question: how can a significant scientific project requiring large-scale calculations form an environment that will stimulate the contribution of resources by many volunteers?

According to the researchers of the BOINC community [9-12] the main motivations of VC participants for participating in the projects are:

- Sense of involvement in important scientific research, co-ownership;
- Sense of social interaction, identification with the community, the need for communication with people close to hobbies;
- Sense of struggle, competition, the demand for awareness of social status in the form of assessments of social activity.

At the same time, as noted in the literature, in general, the totality of motives for involving Internet users in VC-projects and for “connecting” computers to a network of distributed resources, as well as preventing the release of volunteers from projects, still requires its solution [13].

So, the main question of the project managers remains unanswered: Why do volunteers decided to participate in VC-projects?

Most sociological studies of the motivations of volunteers' behavior were based on the representation of the VC-community as a set of participants in VC-projects and as a result, the research focuses only on the motivation of individual participants.

But we think that a motive of self-actualization of participants of volunteer computing is not enough to explain why millions of common people regular (day by day) participate in scientific computation. Our research indicates that the answer lies at the intersection of self-oriented motivation and the interactional and organizational possibilities emerging through the Internet. We suggest: online collaboration can capture people's motivation better than only intrinsic motives. And the questions to be answered are:

- Is there any collaboration in volunteer computing?
- Does this collaboration affect a performance computing?

The basis of the conclusions about the motivations of the VC-participants, mentioned earlier, is the result of sociological surveys of the participants of VC-projects. And naturally they are characterized by a high degree of

arbitrariness or subjectivity (albeit involuntary) in the evaluation of volunteers' reasons and motivations of their participation in VC-projects. In this connection, it is important to develop a methodology for verifying the totality of the motives of VC participants based on formalized methods for analyzing their behavior.

The use of clustering methods for the analysis the behavior of the participants in the BOINC.RU community showed that the motives of volunteers to donate their time, financial and technological resources VC-projects, still remain largely uncovered [14]. As a possible factor that determines the behavior and activity in the selection of projects by volunteers, the collaborative interaction that is inherent in participants in virtual communities is considered.

2. Aims, Objectives and Methodology

So, it is obviously that the implementation of VC-project directly depends on the number of participants, PC (other machines) and time of their work, and so we will show that along the project managers, VC-community figures out collaboration ways to speed up and expand the capability of their computer resources for computing scientific tasks. So the focus of our research is the activity of the volunteers that is measured in points (crédits) and indicated how much time and computer resources have been donated for computing in the project.

As a metric of the activity of volunteers (measuring the amount of computational time and resources/efforts donated by each volunteer/team) we used a number of crédits that are charged by project managers to the team or individuals. Statistics of crédits are taken from rating tables posted on the statistical website of BOINC (www.boincstats.com) or websites of VC-projects.

Проект	Тема	Статистика	Описание проекта
Gerasim@home	О проблеме Gerasim@home	56 3,456	О проблеме Gerasim@home
SAT@home	О проблеме SAT@home	15 4,854	О проблеме SAT@home
Anasoft@home	О проблеме Anasoft@home	3 358	О проблеме Anasoft@home
Amicable Numbers	О проблеме Amicable Numbers	3 247	О проблеме Amicable Numbers
OPTIM@home	О проблеме OPTIM@home	1 139	О проблеме OPTIM@home
NetEx@home	О проблеме NetEx@home	6 188	О проблеме NetEx@home
USPEX@home	О проблеме USPEX@home	5 131	О проблеме USPEX@home

Figure 3. Screenshot of the list of Russian projects

In the study we investigate the Russian VC-community at the soft platform BOINC; (www.boinc.ru). In Russia community there 58,047 volunteers, which are united in 823 teams, as of 31 July 2018. Currently, as a whole, there

are 51 active research VC-projects using the BOINC platform, and of a total active VC-projects there are 11 projects that were designed by researchers from Russian research centers (Figure 3). The aims of Russian BOINC projects are to solve mathematical problems, tasks of underwater acoustics, materials sciences, computer-based testing methods for drug development, protein structure modeling, etc. (<http://forum.boinc.ru/default.aspx?g=topic&f=108>).

To conduct a statistical and clustering analysis of the behavior of Russian participants in the VC, we used the data obtained with the websites www.boincstatistic.com and www.boinc.ru. (Figure 4), that includes statistical characteristics of the activity of both individual volunteers and their teams. The information is obtained using the API BOINC. The script for getting data was written in PHP, for data storage MySQL database was used.

Figure 4. The structure of database "Community BOINC.RU"

The database contains unique participant identifiers, participant names, unique project identifiers, project names, number of units (crédits) of participants/teams for the last week, month, year and all the time, participants' ownership of projects, unique team IDs, team names, team memberships.

Networks of Boinc.ru community were visualized with a help of algorithms "Gephi" and "Force Atlas 2".

3. Statistical Characteristics of the Virtual Community BOINC.RU

Since our previous study in 2014 [15] we have the opportunity to compare the results and dynamics of user activity. In comparison with 2013 there is a decrease in the activity of participants in the Russian virtual community BOINC.RU in VC-projects.

According to the 'country' rating, Russia moved from 11 places (in 2014) to 51 – in 2018. A similar decrease was noted in the share of "Russian" points (crédits); from 2.5% in 2014 to 0.4% in 2018. And this is while the indicators of the overall activity of all volunteers increased in 17 times. The decrease in the activity of the

BOINC.RU community participation is observed with the increase in the total number of Russian volunteers from 45 333 in 2014 to 58 044 in 2018 (July 31), as well as the number of projects in which they participate from 135 in 2014 to 178 in 2018 [16].

Significant changes in the statistical characteristics of the activities of Russian participants in BOINC projects, in our opinion, are caused by the "stratification" of the community of volunteers into strata of 'active' and 'passive' participants. In 2018, the group of the most active volunteers (about 200 participants), gaining more than 100 billion points, increased 2.5 times. While the rest of the volunteers (almost all 58 thousand) collectively collect no more than 20 million points.

In the middle of 2018 (July, 31) greater than 4'574'000 participants in BOINC-projects from 252 countries are united in 107'503 teams. Russian participants of the BOINC-project registered more than 58'000 united in 823 teams (Figure 5).

last month	last week	last day	Rank	Team Name	Total credit	Credit / day	Credit / week	Credit / month	Average credit	Over take	Options
04	04	04	1	Russia	29,393,944,997	18,651,872	105,393,769	465,850,969	16,360,214	-	0
04	04	04	2	Russia Team	15,881,014,397	10,260,378	72,999,683	283,590,674	9,902,827	-	0
04	04	04	3	Orsk	9,823,119,725	20,095,917	105,382,655	462,802,453	15,959,625	305+	0
04	04	04	4	TSC Russia	7,548,890,511	2,456,679	16,396,430	64,928,598	2,291,493	-	0
04	04	04	5	Crystal Dream	7,288,682,362	717,397	10,015,160	42,289,132	1,542,639	-	0
04	04	04	6	DC Russian Union	3,114,222,134	12,534,807	65,119,522	276,154,132	9,510,162	305+	0
04	04	04	7	Astronomy.Ru Forum	2,318,348,301	1,029,375	11,840,351	72,421,691	1,993,458	-	0
04	04	04	8	BOINC.RUSSIA	1,971,881,842	520,391	5,398,872	28,021,375	803,579	-	0
04	04	04	9	St.Petersburg	1,916,191,047	238,046	1,685,838	9,185,137	266,190	-	0
14	04	04	10	Sakhalin Russia	1,805,875,704	41,242,846	191,420,242	700,472,089	27,321,402	5	0
14	04	04	11	Vol.Lunkist	1,180,670,781	455,708	4,531,967	19,143,704	680,314	-	0
04	04	04	12	PolarSETI	939,072,567	356,793	1,938,599	4,512,263	182,798	-	0
04	04	04	13	BOINC SETI@home RUSSIA	785,883,159	195,871	1,378,926	5,868,082	183,908	-	0
04	04	04	14	Kugetri	750,152,119	1,913,551	13,102,067	52,338,814	1,822,767	23	0
04	04	04	15	MEPH	531,742,316	8,601	45,331	296,936	8,798	-	0
04	04	04	16	RU-Team	369,521,619	43,232	272,986	1,241,237	40,556	305+	0
04	04	04	17	vgit	327,583,557	0	0	0	1	-	0
04	04	04	18	RAD3DA	266,843,369	154,857	840,102	1,933,693	94,127	305+	0

Figure 5. Screenshot of the list of Russian teams

4. Collaborative Network's Effect

As it was mentioned above, participation in VC is voluntary and participants do not receive compensation for their work. So project managers/organizers in search of a mechanism to encourage participation in VC-projects use conditional points accrual mechanism. The number of these points («credits») depends on the provided capacities, the time of participation in projects, and other characteristics of the activity of volunteers and their teams. The availability of constant statistics for all projects, in addition to tracking various ratings, *provokes* various virtual competitions («challenges») between participants and teams. And many of the projects create an environment for the competitors by volume computations are done, both individually and in the team event. Thus modus operandi of VC – is spirit of competition. If volunteers are members of a team, they are simultaneously competing with the other teams on the project on the more immediate goal of racking up the most contributions and coming out on the top of the table of

statistics documenting contributions.

This form of cooperation and competition individually and in combination (in teams) demonstrates a new type of online scientific collaborative network – co-opetition. This term was proposed by Brandenburger A. M. and Nalebuff B. J. [17] in 1996 year to describe a new phenomenon of cooperative competition of firms. Co-opetition is a kind of interaction of firms when companies interact with partial congruence of interests. As Dagnino G. and Padula Giovanna noted [18], they cooperate with each other to reach a higher value creation if compared to the value created without interaction and struggle to achieve competitive advantage. Often co-opetition takes place when companies that are in the same market work together in the exploration of knowledge and research of new products. Holohan A. and Garg A. [11] used this term metaphorically in their paper to describe a collaboration of volunteers in VC-projects to affect a performance of computing. To prove the possibility of describing the collaboration of volunteers using this term, Holohan A., Garg A. relied a number of theoretical concepts and the results of their sociological surveys. However, they do not describe either the process of co-competition in VC-projects and neither its results that enhances the computing.

I think that nowadays we can use this term not only in a metaphorical or theoretical sense, but also as an actual mechanism for managing volunteer computing.

As an example, we can cite the Russian project SAT@home [18], which is actively supported by national volunteers. The active group of volunteers organizes competitions («challenges») between several teams from different countries. As a result of these competitions the performance of the SAT@home project was increased (Figure 6). For the period of each of these competitions the project's productivity increased by about 7,4 teraflops with the average value in 4,3 teraflops.

Figure 6. The performance of the SAT@home project. The peaks correspond to the moments of the competition among teams of volunteers.

In order to highlight traces of collaborative networks we will allocate links between the active volunteers in a whole Boinc.ru community. The background of looking for the active participants is based on the idea that only a

few participants of virtual communities are the most effective in obtaining the most important results. For example, in the study of the OSS projects was showed that only a small subset is significant, 85-90%% of the code was written by about 15 developers [20].

For determining an active group of participants in VC-projects in Boinc.ru community we have used the accrued credits, assumed that a person took part in the project if he collected at least 50,000 points in it. So it appeared – 200 volunteers, who participated in 2176 projects. To visualize and analyze links (simultaneous participation of two volunteers in a project) between volunteers we use the Gephi software and the Force Atlas 2 algorithm.

Having constructed a connectivity table, where a_{ij} – the number of general projects for two volunteers, we construct a graph (Figure 7).

Figure 7. Visualization of links in active volunteers' group (>50 000 credits, 2176 projects)

Increasing the participation threshold in the project to 100 000 crédits, followed by up to one million crédits hardly changes the picture evaluation of the participation of the 200 most active volunteers. The screenshot of the diagram of a participation in 1 217 projects (Figure 8).

Figure 8. Number of projects for 200 participants with greater than 1, 000, 000 points

For this case we construct a similar graph. The picture has not changed at all (Figure 9).

The density of the new graph is 0.774. Thus, we can

conclude that either there are projects (and we recall, excluded from the links one project SETI @ HOME because more than 24,000 volunteers participate in it) in which all users participate, or we need to increase the threshold of participation in the project again.

Figure 9. Visualization of links in active volunteers' group (>1,000,000 credits greater than 1 million)

In spite increasing the threshold the form of graphs does not change. It means that almost all active users are connected with some projects.

Figure 10a. Distribution of 200 active participants in the projects (> 100,000. points)

Figure 10b. Distribution of 200 active participants in the projects (> 100,000,000points)

Furthermore in spite increasing the threshold the distribution of the participants in the projects are very similar (Figures 10a&10b). And as can be seen from the distribution and height of the peaks, which corresponds to the number of participants in the projects, these active volunteers participate in almost the same projects. The most active users are not inclined to participate in projects "on trial", they thoroughly approach the choice of the project and actively participate in the accruals.

Let's see the connections between users in Russian

projects. From all of them there are 9 on BOINC platform: Gerasim@home, SAT@home, Acoustics@home, Amicable Numbers, Stop@home, OPTIMA@HOME, ODLK@home, AndersonAttack, XANSONSforCOD.

Consider participation in the project with a score of more than 500 (this is due to the fact that many projects launched in 2016-2017). It turned out 2,300 participations for 1800 people - in our opinion, this is a rather modest indicator and we do not have to talk about any serious intersections. It's clear that they will be in the main between the old projects Gerasim@home and SAT@home; 1528 and 557, according to the order of projects.

If we consider the remaining projects, with the exception of the two mentioned earlier - we will get 230 links for 150 people. Since the links here are much less than when studying the active users for all projects, the picture is also more expressive.

If we look for the communication between participants of all Russian projects, and construct a connectivity graph of participants in Russian projects (Figure 11), we see the graph of the links (participation) of volunteers in 7 projects.

Figure 11. Collaborative network; orange cluster is dedicated to the collaborative community

All volunteers were divided into two large groups (shown in color in the figure 11).

Let's see the statistics of participation in projects in each of the groups (clusters) identified on the graph.

Table 1. Number of participations in projects

Projects	Cl. green	Cl. violet	Cl. orange	Cl. rose
Acoustics@home	4	32	18	
Amicable Numbers	2	6	19	27
Anderson Attack		5	11	1
Xansons for Cod		1	10	
Optima@Home	49	1	3	
Stop@Home	1		30	
Odlk			6	

Considering the participation rates of volunteers in new Russian projects, we can argue that the preferences and

actions are fairly coherent. We managed to single out a group of volunteers, which actively participates in several projects (cluster "orange" on the graph). Cluster "orange" is formed at the 'intersection' of clusters "green" and "violet + rose + orange", respectively.

The unification of volunteers into the orange group, without a provocation, shows that these are not only active, but also interested community members who follow the BOINC space, analyze the information and agree on the preference for new projects. Such behavior of the community members testifies, very likely, about their interaction with each other on third-party network resources.

Considering the participation of users in the new Russian projects, we can assert that their actions are sufficiently consistent: we obtained a connected graph, the density of the graph is 0.47. In addition, we managed to identify a group of users who are actively participating in the main of projects (this is the "orange" group of users in the graph, Figure 11), which certainly indicates either that these are active interested users who receive information about new projects, monitor for the BOINC system and, very likely, interact with each other on third-party resources.

5. Features of Team Behavior in BOINC.RU Community

It remains to consider the behavior of participants in the system within the team and check the consistency of the election of projects. The team «Russia Team» was chosen as the research object. In the team, there are 2300 participants with more than 1000 points. The diagram below shows the 20 most popular projects for this team (Figure 12).

Figure 12. The distribution diagram for the projects of the participants of the team "Russia Team"

Considering the data, we can conclude that an important factor after or before joining the team is the joint selection of projects in which to participate (Table 2). This is an important conclusion, which indicates the importance of teams in the BOINC project, that the desire to carry out concerted activities for the sake of achieving scientific results and team victories is an important factor for the participants. This is especially noticeable if we consider the 1000 active users from the team (they have more than 100,000 points) (Table 3).

Table 2. Statistical characteristics of the participation of the team "Russia Team" in popular projects

Project	Number of participants	Points (crédits)
SETI@Home	883	615553359
Einstein@Home	754	2246881460
Rosetta@Home	623	136362985
MilkyWay@home	502	2845666113
SAT@home	367	196251721
World Community Grid	265	230090485
Cosmology@Home	254	88145128
LHC@Home	224	26469540
PrimeGrid	188	3395986927
Climate Prediction	186	31529434
Collatz Conjecture	173	3699396223
Asteroids@home	172	250128360
POEM@HOME	168	1254617928
GPUGRID	165	2649208233
Gerasim@Home	148	88944208
POGS (theSkyNet)	129	123237755
Spinhenge@home	120	19967832
Docking@Home	104	45473601
Enigma@Home	101	15943350

Table 3. Statistical characteristics of the participation of members (which have more than 100,000 points) the team "Russia Team" in popular projects

Project	Number of participants	Points (credits)
SETI@Home	478	609888006
Einstein@Home	475	2241762103
MilkyWay@home	371	2843496091
Rosetta@Home	365	132399871
SAT@home	286	195074054
LHC@Home	206	26201734
World Community Grid	196	228536560
Cosmology@Home	185	87325330
PrimeGrid	161	3395384130
POEM@HOME	155	1254326403
Collatz Conjecture	151	3698634058
GPUGRID	151	2648743627
Gerasim@Home	136	88758612
Asteroids@home	132	249394560
Climate Prediction	129	30896870
POGS (theSkyNet)	117	123045433

The number of participants in the projects has changed not significantly, and where the number has changed - practically did not affect the number of points. You can note: active users in the team participate in more projects

Their actions and the choice of projects are coordinated

this choice is the results of communications in the team, or joining the team - the result of the team's participation in these projects users with a small number of points prefer to choose just the most popular projects

The density of the graph for the team Russia Team for 1000 active users is 0.65. In general, the results are similar to the graph that we considered for the 1000 most active users; only in the team version the users have much fewer points and projects in which they participate. This, again, indicates that the actions inside the team are fairly coordinated and users, presumably, seek to monitor the information within the team.

6. Conclusions

The data obtained as a result of statistical analysis of the behavioral characteristics of the participants in the virtual community BOINC.RU, show that the participation of users in Russian projects and their actions are sufficiently coordinated. Nowadays we can describe of the behavior of Russian VC-community with a help of the notion co-opetition; it is not a metaphorical or theoretical sense, but a real and actual mechanism for managing volunteer computing.

We have obtained a connected graph; the density of the graph is 0.47. In addition, we managed to identify a group of users who are actively involved in several projects. Analysis of the characteristics of the constructed graph allows us to assume that active volunteers get information on new projects and monitor the system BOINC and, very likely, interact with each other on third-party resources. All this gives grounds for presenting, at least, this segment of the BOINC.RU community as a collaborative community whose activities determine not only the behavior of these community members, but is a significant factor in the implementation of projects.

The most active and productive participants in VC exemplify co - opetition – collaboration within the network organization of a VC project.

Our research indicates that the motivation of participation of millions of unskilled volunteers in VC-projects lies at the intersection of intrinsic motivation and the organizational possibilities emerging through the collaboration. In providing the means for channeling participants' motivations to compete and cooperate, VC-projects provide powerful insights into a new type of collaborative network.

So, VC-community model – collaborative network

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