A Robust Framework for Socially Responsive Services: A Constraint-Based Social Network Representation

Kamakhya Narain Singh, Chinmaya Misra, Soumita Seth, Sumanta Kumar Mandal and Biresh Kumar

1 Introduction

NGOs can be defined as non-profit organizations and a group of members who work in some ways for serving the individuals or a community [1]. A well-established literature shows that the service provider and the service receiver influence the behavior of each other and which is highly influenced by social network structure. Therefore, NGOs can be defined as private organizations who work in local level or national level or international levels whose objective is to help or share the resources among needy parts of the society. It is a non-profit community-based organization.

The main goal of NGOs is to share resources [2]. Here resource signifies any types of help that can be provided by the individuals or community. It may be idea, some solution, physical resource, or some kinds of interdependency, and it will satisfy the demands of the user. It should be feasible in true sense; that is, it should

K. N. Singh (✉) · C. Misra
Kalinga Institute of Industrial Technology, A Deemed to be University, Bhubaneswar, India
e-mail: kamakhya.vphcu@gmail.com

C. Misra
e-mail: cmisra@yahoo.com

S. Seth
Computer Science and Engineering Department, Aliah University, Kolkata, India
e-mail: soumita.seth@gmail.com

S. K. Mandal
Department of Computer Science and Engineering, CEB, Bhubaneswar, India
e-mail: sumantab4u2@gmail.com

B. Kumar
Department of Computer Science and Engineering, Amity University, Ranchi, India
e-mail: bkumar@rnc.amity.edu

J. Chattopadhyay et al. (eds.), *Innovations in Soft Computing and Information Technology*, https://doi.org/10.1007/978-981-13-3185-5_14

be technologically, economically, and culturally feasible [3]. Here our main focus is that the distribution should be fair and unbiased. The needy people should get the help. The help may be educational like a fellowship for a poor student, medical help for a patient, or some help for a disabled [4]. Otherwise, we may face the following major problems:

- Overall crisis.
- Requirement of service of needy people.
- Development of poorer section of society.

Galvin et al. [5] propose the concept of resource management and the usage of resources. Resources will be supplied by the assigned agency. Better collaboration and interaction are possible with the advancement of Internet with time. The social network paved its way into popularity by superseding the Internet. Social network analysis is a vast area of research which deals with the understanding and analysis of the behavior of individuals or community. It predicts the prospective existence of the relationships between community members.

Socially Responsive Resource Usage Protocol (SRRUP) defined to standardized social ethics and utilization of resources [6, 7]. This protocol helps to emerge in an improvised environment by providing the way of accessing the resources to needy people. To allocate the resources, more socially distant individual is given more priority than less socially distant individual. Social distance of the user represents the defined logical distance between user and resource [8–10]. A resource has three parameters: place, cost, and constraints, causing prevailing consequences in its usages. Place can be defined where the resource can be availed [11–13]. A person who needs resources pay the price to avail the resources is known as cost. A set of affirmation and considerations measure to a resource usage are the constraints.

In our proposed framework, we have made the following contributions:

- The distribution of resources will be impartial and those resources can be avail for those people who genuinely have the requirements.
- The resource will be available to the persons based on their financial, social, disadvantageous positions, and their locations (remote or rural).

In operating system, we termed user as a process. Process enters in waiting state if it does not get requested resources. Some time waiting, process does not come out from waiting state because requested resources are held by some other waiting process and so on then it becomes deadlock. Such situation occurs for inquiry table distribution of resources. For this work, we have given attention to fair resource allocation. To describe it precisely, best option is to use a directed graph; this is called resource distribution graph. The graph has nodes V and edges E. V is partitioned into $\{P1, P2, \ldots, Pn\}$, the set of active processes and $R = \{R1, R2, \ldots, Rm\}$, the set resource types in the system. Figure 1 depicts the graph where a directed age from process Pi to resource type Rj is referred by $Pi \rightarrow Rj$; it shows that process Pi has requested an instance resource type Rj and is currently waiting for that resource. A directed edge from resource type Rj to process Pi is referred by $Rj \rightarrow Pi$; it means that an instance of resource type Rj has been allocated to process

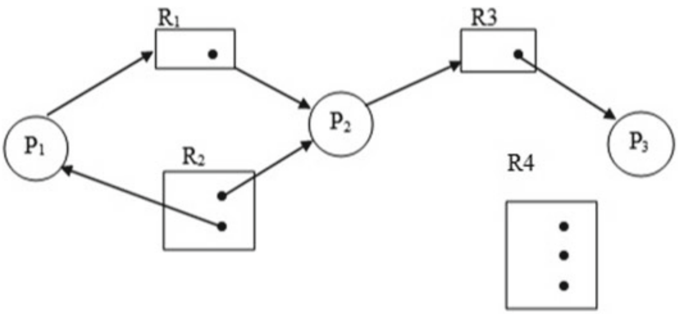


Fig. 1 Resource allocation graph

Pi. A directed edge $Pi \rightarrow Rj$ is named a request edge; a directed edge $Rj \rightarrow Pi$ is named an assignment edge.

Though different resource allocation graph is used in many applications like job processing, hospital management, and real-time scheduling, this is mainly used for avoidance of deadlock where same resources are demanded by multiple processes and others are not releasing the resources [14]. In our proposed research work, multiple instances of resource are possible. Hence, this situation will not raise.

Section 2 presents the working mechanism of the proposed model. The experimental result and comparison studies are presented in Sect. 3. In the last section, future work and conclusions has been provided.

2 Proposed Model

2.1 Concept of the Proposed Model

In our earlier work [1], if a volunteer is not able to provide a support due to lack of resources then he will wait for required resources. To improve the performance by reducing the waiting time of our earlier work, we have proposed a new scheme.

If two volunteers have the less resources than receiver's requirement like volunteers $v_1 < r$ and $v_2 < r$. If $v_1 + v_2 \geq r$ then both volunteers jointly provide resources to that receiver for completion of his job. This way it is reducing the waiting time and utilizing the resources effectively.

In this model, we have designed a network comprised of two layers: one layer represents the service provided by the service provider and other layer represents the members who will receive the services. The services will be received by the weaker sections of the society such as orphans, disabled, poor or needy, and old peoples. The service will be given voluntarily by individual or by a community. Here the volunteers mainly provide two types of services. One is to identify the deserving persons who are willing to take services. Second responsibility is to accumulate the resources to provide services without interruption to the needy, old, disabled, orphan, or persons staying in remote areas. The services required vary from user to user. Some users may require financial help for continuing their study. Some may require physical assistance or medical supervision for their agony and pain. Volunteer also has different resources with different capacities. At a time, more than one service can be provided by volunteer. If a user requires services a volunteer alone is not able to help, then services can be provided by more than one volunteer to the same user.

So the communication is one-to-one (volunteer to receiver), one-to-many (receiver to volunteers), and many-to-one (receivers to volunteer). The volunteers may approach external sources to serve the users because requirements of the user vary. For approaching the external sources, volunteers have to follow system rules: Volunteer cannot take more than user's requirement. Based on resource availability the needed service will be given. Volunteers of a specific group of users communicate with other volunteer if required. User quits the organization or concern volunteer may stop his support to user after fulfilling the requirement.

2.2 Mathematical Representation of the Proposed Model

We have introduced user by u and volunteers by v with appropriate suffixes. Users seek their requirements through $u(x_1, x_2, \ldots x_k)$ and volunteer represents services through $v(y_1, y_2, \ldots, y_p)$ where x_i and y_i represent direct amount that should be non-negative real numbers. It is used to find the strength of the organization on the basis of user need and volunteer service.

Using community detection in social network analysis [5, 6], we organize and find various categories of person with different need and support to run the organization smoothly.

We prefer two types of sorting:

Case I. User-based category.
Case II. Volunteer-based category.

This can be classified to get a real scenario.

Case I Suppose that more than one service can be provided by each volunteer but he has only one service to provide. Then we seize an estimable amount of users to him.

Let $v_1(y_1)$ represent a volunteer with a type of support s_1 (like disables, orphans).

Let a category of users $\{u_{11}, u_{12}, \ldots, u_{1k}\}$ are associated with v_1 with demand of $y_{11}, y_{12}, \ldots, y_{1k}$ where $u_{1i}(y_{1i})$ represents a typical member of this category.

Now there are two possibilities:

Lemma 1 $s_1 \geq \sum_{j=1}^{k} y_{1j}$

(Sum of required is less than service quantum)

Here, either the volunteer or organization v_1 themselves asks for more users to extend this task.

Now we can extend $u_{1k+1}(y_{1k+1})$, $u_{1k+2}(y_{1k+2})$, …, $u_{1p}(y_{1p})$ where $p > k$ and $s_1 \geq \sum_{j=1}^{p} y_{1j}$.

This process goes on till $\sum_{j=1}^{p} y_{1j} \leq s_1 < \sum_{j=1}^{p+1} y_{1j}$.

This improve the performance of v_1. Improvement of v_1 is evaluated on the basis of more users (u_{1j}'s).

Lemma 2 $s_1 \geq \sum_{j=1}^{k} y_{1j}$

In this case, the support of v_1 is not sufficient to satisfy the needs of u_{1k}'s. So either the volunteer himself (v_1) or NGO contacts some other volunteer v_2 of similar task as demanded by u_{1k}'s. Now here options are:

(a) if $\sum_{j=1}^{l} y_{1j} \leq s1 < \sum_{j=1}^{k} y_{1j}$ where $l < k$, we can detach those $\{u_{1l+1}, u_{1l+2}, \ldots, u_{1k}\}$ from v_1 and associate them to v_2 directly. Here v_2 is an existing volunteer of NGO.

or (b) v_2 cannot approach directly to u_1's. NGO will link up v_2 to v_1 so now: $s_1 + s_2 \geq \sum_{j=1}^{k} y_{1j}$

where s_1 and s_2 are the support of v_1 and v_2, respectively. In this case, for purely temporary basis either NGO or volunteer gets a support from outside.

Case II If each u_i needs many services and no one volunteer alone is sufficient to fulfill their needs, then each u will be assigned to a group of v's. Here user represents his needs through $u_1(y_{11}, y_{12}, \ldots, y_{1k})$ and group of volunteer represent their strength through $\{v_{11}(s_{11}), v_{12}(s_{12}), \ldots, v_{1k}(s_{1k})\}$. We expect $y_{1j} \leq s_{1j}$, where $y = 1, 2, \ldots, k$ else NGO has to include more v's to fulfill the needs of u_1.

Lemma 1 Suppose $y_{1j} = s_{1j}\ \forall\ j = 1, 2, \ldots\ k$

Then all the needs of u_1 are fulfilled and u_1 may leave.

Lemma 2 Suppose $y_{1j} < s_{1j}$ for some $y = p\ \leq\ k$.

Then the $v_{1p}(s_{1p})$ can support some other users 'u' also. NGO will utilize $v_{1p}(s_{1p})$ remaining services to fulfill the needs of other user u_2 like $u_2(y_{2p})$ for which $y_{1p} + y_{2p}\ \leq\ s_{1p}$.

This way such v_{1p} are associated with more users. This process repeats until $\sum_{j=1}^{k} y_{1j} \leq s_{1j}$.

Here, the public presentation of the organization possibly is assessed by number of users associated with a volunteer and the number of users leaving the system with satisfaction.

2.3 Algorithms of the Proposed Model

Here, we declare all attributes which exist in this proposed algorithm.

$u \leftarrow$ User.
$y \leftarrow$ Requirement.
$u_{1j} \leftarrow y_{1j}$ Users $(u_{11}, u_{12}, \ldots\ u_{1j})$ with requirements $(y_{11}, y_{12}, \ldots\ y_{1j})$.
$v \leftarrow$ Volunteer.
s $\leftarrow$ Service.
$v \leftarrow s$ Volunteer (v) provides service (s).
$v_1 \leftarrow s_1$, v_1 provides s_1-type service, $v_2 \leftarrow s_2$, v_2 provides s_2-type service etc.

In this algorithm, our aim is to provide services (s) to a user (u), who are registered ($u \leftarrow y$) with requirements (y). Volunteer (v) provides service to user (u) to fulfill their needs. In the first case, the organization is robust, while in the second case the organization asks for improvement.

```
Algorithm 1: Algorithm for Case I
Begin
u1j ← r1j , ∀ j= 1, 2, …..k;
v1 ←s1,  v2 ←s2
if s1 > r11,
|  then v1 supports r11
end
for l=2 to k do
|  if s1 > ∑j=1^l r1j  then
|  |  v1 supports { x11, x12, ……, x1l}
|  end
|  if ∑j=1^l r1j ≤ s1 ≤ ∑j=1^(l+1) r1j  then
|  |  v1 supports { x11, x12, ……, x1l} but not x1l+1
|  end
end
  select v2(s2) such that
 s1+s2 ≥ ∑j=1^k r1j  or  s2 ≥ ∑j=1^k r1j - s1 then
 {v1, v2} supports { x11, x12, ……, x1k}
 End

Algorithm 2: Algorithm for Case II
 Begin
 u1 ← {r11, r12, …., r1k};
 for l= 1 to k do
 |  v1 ←s1l
 end
for l= 1 to k do
|  if r1l ≤ s1l then
|  |  u1 leaves the system as satisfied customer
|  |  {v11, v12, … v1k} supports u1.
|  end
end
Now u2 ← {r21, r22,.. r2k}
for l = 1 to k do
|  if r2l ≤ s1l − r1l
|  |  then u2 leaves the system as satisfied customer
|  |     { v11, v12, … ,v1k} supports {u1, u2}
|  end
end
for p = 1 to k do
|  if r2p ≤ s1p − r1p
|  |  then some v'1p enter the system with v'1p ← s'1p and
|  |  r2p ≤ s'1p + s1p − r1p
|  |  u2 leaves the system as satisfied manner.
|  |     {v11, v12, … v1k,v'1p} supports {u1, u2}
|  end
end
```

This process continues until all u_i's and v_k's are exhausted.

End

3 Experimental Result Discussion

Here, we elaborated our program output. We have taken all possible kinds of inputs and elaborated desired outputs of concerned inputs.

3.1 Experimental Environments

We have implemented these algorithms and tested using all possible desired inputs using a Java program for the preliminary study and executed it on a Lenovo Miix 510-121SK laptop with 2.3 GHz Intel Core i5-6200U 6th Gen processor, 8 GB DDR3 RAM and 256 GB hard disk, Windows 10 with 64-bit operating system and Java1.8. In this program, our objective is to make a communication among various methods. Program works on the basis of client and server program. Client represents the user and server represents the providers. There are three types of user-defined communication methods:

- Volunteer_to_receiver—This method represents the task like one volunteer is alone quite sufficient to fulfill the needs of a user of all type of services.
- Receiver_to_volunteers—This method provides the dependency of volunteers to fulfill the requirements of receiver.
- Receivers_to_volunteers—This method works as services of more than one user can be fulfilled by more than one volunteer. Above communications can be initialized in various ways like users represented by '*u*' and volunteers by '*v*'. The needs of user are represented by y_i, $i = 1, 2, \ldots, n$ and services of volunteers are represented by s_j, $j = 1, 2, \ldots, n$. Table 1 represents the input provided to the system and Table 2 reflects the desired output.

Table 1 User needs table

User/need	r_1	r_2	r_3	…	…	r_n
$u^1{}_{1000}$	1	0	0	0	0	0
$u^1{}_{0100}$	0	1	0	0	0	0
…	…	…	…	…	…	…
$u^2{}_{1100}$	1	1	0	0	0	0
$u^2{}_{1010}$	1	0	1	0	0	0
…	…	…	…	…	…	…
$u^3{}_{1110}$	1	1	1	0	0	0
…	…	…	…	…	…	…
Sum	=4	=3	=	=	=	=
Total =						

Table 2 Volunteer support table

Provider/support	s_1	s_2	s_3	…	…	s_n
$v_1{}^1$	k_1	0	0	0	0	0
$v_2{}^1$	0	k_2	0	0	0	0
…	…	…	…	…	…	…
$v_1{}^2{}_2{}^2$	p_1	p_2	0	0	0	0
$v_1{}^3{}_3{}^2$	p_1	0	p_3	0	0	0
…	…	…	…	…	…	…
$v_1{}^5{}_2{}^4{}_3{}^3$	q_1	q_2	q_3	0	0	0
…	…	…	…	…	…	…
Sum	=	=	=	=	=	=

Notation: u^i is a user (i = 1 to n)

$u^1{}_{1000}$ denotes user wants single resource of y_1.
$u^2{}_{0100}$ denotes user wants single resource of y_2.
$u^1{}_{1100} = u^2{}_{1100}$ denotes user wants two resources y_1 and y_2, respectively.
$u^1{}_{1110} = u^2{}_{1110} = u^3{}_{1110} = \ldots$ represents a user needs three resources y_1, y_2, and y_3.
$u^1{}_{1111} = u^2{}_{1111} = u^3{}_{1111} = u^4{}_{1111} \ldots$ represents a user with four resources y_1, y_2, y_3, and y_4.
$v_1{}^1$ has a strength of single resource r_1 for type s_1.
$v_2{}^1$ has a strength of single resource r_2 for type s_2.
$v_1{}^5{}_2{}^6$ has a strength of five resources r_1 for type s_1 and six resources r_3 for type s_3.
…… ……
$v_i{}^j$ has a strength of j for type s_i where i represents types of service and j represents for some resources.

Simple Case: Assume each user 'u' needs one resource of size '1' only. That is, $y_1 = y_2 = \ldots = y_n = 1$, users with variable requirements, e.g., $u^1{}_{1000}(y_1)\ y_1 \geq 1$.

3.2 *Result of Various Communication Method*

- In this function, we have supplied different kinds of inputs for all the above-mentioned methods. For volunteer_to_receiver communication method, we represent through Table 3. Here $u^1{}_{3000}, u^2{}_{0500}$, and $u^3{}_{0020}$ denotes corresponding user and $v_1{}^5, v_1{}^5{}_2{}^6$, and $v_3{}^8$ the volunteer. Here u^1 wants three resources of type s_1, u^2 wants five resources of type s_2, and u^3 requires two resources of type s_3, while (Table 4) v_1, v_2, and v_3 contain 5, (5 of s_1, 6 of s_2),

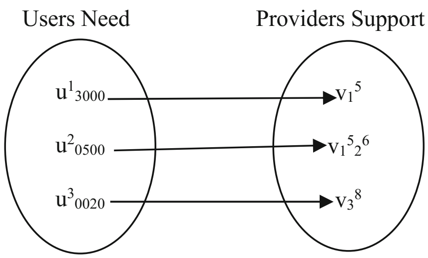
Table 3 User needs table of receiver

User/need	r_1	r_2	r_3	r_4
$u^1{}_{3000}$	3	0	0	0
$u^2{}_{0500}$	0	5	0	0
$u^3{}_{0020}$	0	0	2	0

Table 4 Provider support table of volunteer

Provider/support	s_1	s_2	s_3
$v_1{}^5$	5	0	0
$v_1{}^5{}_2{}^6$	5	6	0
$v_3{}^8$	0	0	8

and 8 resources, respectively. So, v_1 supports three resources to u^1, v_2 supports five resources of s_2 to u^2, and v_3 gives two resources to u^3. Now, v_1 has two, v_2 has (5 of s_1, 1 of s_2), and v_3 has six resources.



Volunteer_to_receiver Communication Method

- For receiver_to_volunteers, we represent through Table 5. Here $u^4{}_{4020}$ is denoted as a user which needs four resources of service s_1 and two resources of s_3. Since (Table 6) v_1 alone is not able to fulfill user need, because it has only two resources of s_1, so v_1 needs help from another volunteer to satisfy user. Here v_1, and v_2 support two and two resources of type s_1, respectively, and v_3 supports two resources of s_3. Now, v_1 has exhausted, v_2 has (3 of s_1, 1 of s_2), and v_3 has 4 of s_3-type resources.

Table 5 User needs table of receiver_to_volunteers

User/requirement	r_1	r_2	r_3	r_4
$u^4{}_{4020}$	4	0	2	0

Table 6 Provider support table of receiver_to_volunteers

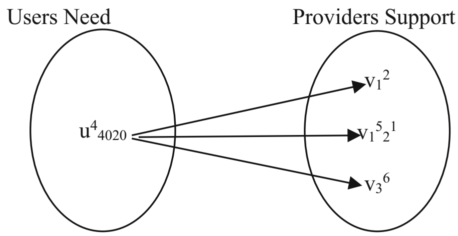
Provider/strength	s_1	s_2	s_3
$v_1{}^2$	2	0	0
$v_1{}^5{}_2{}^1$	5	1	0
$v_3{}^6$	0	0	6

Table 7 User needs table of receiver_to_volunteers

User/requirement	r_1	r_2	r_3	r_4
$u^5{}_{4080}$	4	0	8	0
$u^6{}_{0605}$	0	6	0	5
$u^7{}_{5002}$	5	0	0	2

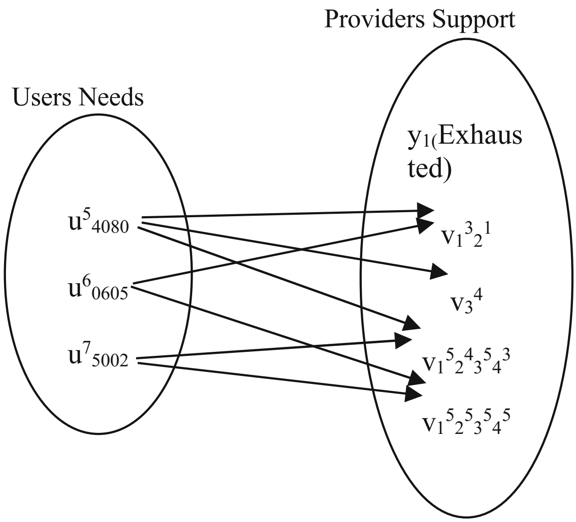
Table 8 Provider supports table of receivers_to_ volunteers

Provider/strength	s_1	s_2	s_3	s_4
v_1	Exhausted	0	0	0
$v_1{}^3{}_2{}^1$	3	1	0	
$v_3{}^4$	0	0	4	0
$v_1{}^5{}_2{}^4{}_3{}^5{}_4{}^3$	5	4	5	3
$v_1{}^5{}_2{}^5{}_3{}^5{}_4{}^5$	5	5	5	5



Receiver_to_volunteers Communication method

- For receivers_to_volunteers, we represent through Table 7. Here, $u^5{}_{4080}, u^6{}_{0605}$, and $u^7{}_{5002}$ represent respective users. In Table 8, two more donors ($v_1{}^5{}_2{}^4{}_3{}^5{}_4{}^3$ and $v_1{}^5{}_2{}^5{}_3{}^5{}_4{}^5$) have been added from external sources. Here $u^5{}_{4080}$ wants four resources of s_1 and eight resources of s_3. From Table 8, $v_1{}^3{}_2{}^1$ supports three resources of s_1, $v_1{}^5{}_2{}^4{}_3{}^5{}_4{}^3$ supports one resource of s_1, and $v_3{}^4$ supports four resources of s_3 and $v_1{}^5{}_2{}^4{}_3{}^5{}_4{}^3$ supports four resources of s_3. Now, $v_1{}^3{}_2{}^1$ has $v_2{}^1$ only, $v_3{}^6$ has exhausted, and $v_1{}^5{}_2{}^4{}_3{}^5{}_4{}^3$ has $v_1{}^5{}_2{}^4{}_3{}^5{}_4{}^3$. User $u^6{}_{0605}$ wants six resources of s_2 and five resources of s_4, but $v_2{}^1$ does not have sufficient resources to support. So it requires support from $v_1{}^4{}_2{}^4{}_3{}^3{}_4{}^3$ and $v_1{}^5{}_2{}^5{}_3{}^5{}_4{}^5$. After giving the resources to $u^6{}_{0605}, v_2{}^1$ exhausted, $v_1{}^4{}_2{}^4{}_3{}^3{}_4{}^3$ has $v_1{}^4{}_3{}^1$ and $v_1{}^5{}_2{}^5{}_3{}^5{}_4{}^5$ has $v_1{}^5{}_2{}^4{}_3{}^5{}_4{}^3$. User $u^7{}_{5002}$ needs five resources of s_1 and two resources of s_4. $v_1{}^4{}_3{}^1$ supports four resources of s_1 and $v_1{}^5{}_2{}^4{}_3{}^5{}_4{}^3$ supports one resource of s_1 and two resources of s_4. After giving the resources to $u^7{}_{5002}, v_1{}^4{}_3{}^1$ has $v_3{}^1$ and $v_1{}^5{}_2{}^4{}_3{}^5{}_4{}^3$ has $v_1{}^4{}_2{}^4{}_3{}^5{}_4{}^1$.



Receivers_to_volunteers Communication Method

The number of satisfied user (u_i's) and number of registering new users (u_i's) measure the strength of the system.

4 Conclusions and Future Work

This framework suggests to provide services to various sections of the society and helps to improve the efficiency, effectiveness, and reliability of the system. It suggests couple of systematic methodologies like one volunteer to one receiver, one receiver to many volunteers, and many receivers to many volunteers to allocate the resources. In this chapter, we have formalized the holistic approach for fair distribution of service from one network to another network. Here one network represents the list of newly registered users and other represents the volunteers with types of services. Services have a broad range of latitude which leads the challenges for the system approaches to a service provider. There are two constraint matters to support a kind of services: identify the needy and supply the services to fulfill their requirements. For identification, either volunteer identifies or user has to approach to NGO. System provides the kind of services with the help of three communication methods. Once the user's needs are fulfilled, then either user might leave or volunteer stops his service. In both the cases, user has to give their feedback to the system. If the user leaves the system with satisfaction, then system is robust else system requires support. In implementation, we tried to assign providers to users on the basis of user's choice (preferential allocation in a prescribed order, say u_1 to v_1 like that).

In future work, user's feedback can be considered for better improvement of the system. We have to make sure best utilization of resources by keeping providers non-idle and consistent use of resources. We need to check the nearness between the resource providers. We should make the user as a temporary provider like increasing the demand of the user like $u^{1}{}_{6000}$ which represents a user with need of $y_1 = 6$. Here u_1 should be a supplier on some conditions but there is no provision for y_1 in the existing system.

References

1. Singh K.N, Misra C, Seth, S., Mantri J.K, and Dash S. R., "A Framework for Social Service Volunteers: A Social Network Representation". International Journal of Pure and Applied Mathematics Volume 114 No. 10, 11–23, 2017.
2. Eric D. Werker and Faisal Z. Ahmed.: What do Non-Governmental Organization do?. Journal of Economic Perspectives, 2007.
3. Rout, A.,: A UML Framework for Socially Responsive Resource Usage Protocol, IJCCT, Vol-3, Issue-2. 0975–7449, 2012.
4. Mohanty, H., "Socially responsive resource usage: a protocol". In International Conference on Distributed Computing and Internet Technology, pp. 243–254. Springer Berlin Heidelberg, 2011.
5. Silberschatz, P. B. Galvin and G. Gagne, Operating System Priciples, WSE, Wiley India Pvt. Ltd, 2006.
6. Bhattacharyya, D., Seth, S., and Tai-hoon K., "Social network analysis to detect inherent communities based on constraints". Appl. Math 8, no. 1L, 385–396. 2014.
7. Seth, S., Bhattacharyya, D., and Tai-hoon K., "CBACCN: Constraint Based Community discovery in Complex Networks". International Journal of Applied Engineering Research 9, no. 23 18115–18127, 2014.
8. Yamakami, T., "Servicenics approach: A social service engineering framework." In Digital Information Management (ICDIM), 2013 Eighth International Conference on, pp. 358–362. IEEE, 2013.
9. Nepusz, T., A. Petróczi, and F. Bazsó. "Multigraph Approach to Social Network Analysis." 2012.
10. Yamakami, T., "A two-layer view model of service engineering: Implications based on service engineering in mobile social games in Japan." In Information Science and Digital Content Technology (ICIDT), 2012 8th International Conference on, vol. 3, pp. 562–566. IEEE, 2012.
11. Fogg, B. J., Cathy S., David R. D., Leslie M., Julianne S., and Ellen R. T., "How do users evaluate the credibility of Web sites?: a study with over 2,500 participants." In Proceedings of the 2003 conference on Designing for user experiences, pp. 1–15. ACM, 2003.
12. Barik, R. K., Dubey, H., Samaddar, A. B., Gupta, R. D., & Ray, P. K. FogGIS: Fog Computing for Geospatial Big Data Analytics. arXiv preprint arXiv:1701.02601, 2016.
13. Goswami, V., and Misra C., "Discrete-time modelling for performance analysis and optimisation of uplink traffic in IEEE 802.16 networks." International Journal of Communication Networks and Distributed Systems 10, no. 3: 243–257, 2013.
14. Das, Satya Ranjan, and Sanjay Mohapatra. "Social and public impact of ICT enabled education." Information Technology, 2008. ICIT'08. International Conference on. IEEE, 2008.