TO OPTIMIZE THE PERFORMANCE OF TRUST MANAGEMENT SYSTEM

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ABSTRACT
Social Internet of Things is a social network of virtual objects which act as service provider as well as service requester. To choose the trustworthy and appropriate service provider, we need an appropriate service recommendation system and feedback method. In Social Internet of Things, Service Composition is collection of smaller services to form the larger service. Thus, the main objective of service composition is to arrange services in such a way that it results in assigning one service for each task. In this work, we have discussed about advantages and disadvantages of various Trust Optimization Techniques, Service Composition, Service Interaction and Service Oriented Architecture. We have also discussed the technique to optimize the performance of trust management system.

Keywords: *Social Internet of Things, Service Composition, Service Oriented Architecture, Virtual Objects, Service Provider, Service Consumer.*

DOI: 10.31838/ecb/2022.11.11.69

1. INTRODUCTION
Internet of things has integrated various technologies and devices to form a heterogeneous network to gather and share the information among different gadgets around the globe. Many of the devices such as refrigerator, cameras, television, AC, washing machine, car etc. could be connected to the world via Internet. These devices becomes the part of Internet of Things (IoT) by providing information which can further be used by some of the applications and these devices are identified in the cyberspace via Radio Frequency Identification (RFID) tags, actuators, smart phones, PDAs or sensors [1]. Smart objects with sensing ability can provide environmental information, body conditions etc. which can remotely be accessible.

For example, Internet of Things based applications can be part of smart home to keep track of the switched ON devices and the power consumption of these devices at any particular time. Many of these devices offer same set of the services with different parameters such as low response time, high reliability and low cost [2]. The Virtual Objects (VO) with heterogeneous characteristics need to work together to finish a particular task. Another characteristic of the Internet of Things is that intelligent objects are either being human-carried or human related devices. Atzori et al. [3] have introduced the Social Internet of Things (SIoT) notion and has analyzed the various types of the social relationships such as co-location, co-work, and parental object relationship among various objects. Basically, social network of smart objects is called Social Internet of Things (SIoT), which is a mapping between cyberspace and social network of humans. This architecture helps in resolving the IoT future problems which are basically related to the composition and service discovery based on the trustworthiness of the users by maintaining the social relationship between the objects/devices and allowing these devices to interact with each other in same way as human being do. In SIoT, the objects have the ability to behave in social manner. They request and provide services in an efficient way by sharing the resources and services. Further, smart devices in Internet of Things are often get expose to the public areas and can communicate through the wireless media. Hence, in Internet of Things objects are often getting exposed to the malicious attacks [4].The structure of Social Internet of Things is inspired by Fiske's theory [5] which represents the social relationship among the human beings. Fiske has studied the human relationships and has established a relational model of the social interactions. This model represents four types of relationships among individuals which are Authority Ranking Relationship, Equality Matching, Market- Pricing and Communal Sharing Relationship. In the Environment of SIoT, each virtual object can act as service provider as well as service requester [6, 7]. The large number of exchanged services among the devices represents a challenge of choosing the appropriate service for which we need service recommendation system and feedback method to select the best service provider. Most of the people tend to share the resources among social circle members and also rely on the recommendations received from the persons whom they trust.

2. Advantages, Disadvantages and Behavior of Trust Optimization Techniques

S.No.	Technique Name	Advantages	Disadvantages	Behavior
1	**Genetic Algorithm**	• Solution space is wider. • The fitness landscape is complex. • Easy to discover global optimum.	• The problem of identifying fitness function. • Premature convergence occurs. • The problem of choosing various parameters like the size of the population, mutation rate, cross over rate, the selection method and its strength.	Genes
2	**Particle Swarm Optimization**	• Insensitive to scaling of design variables. • Easily parallelized for concurrent processing. • Derivative free.	• Low quality solution. • Need memory to update velocity.	Bird Flocking
3	**Ant Colony Optimization**	• Can be used in dynamic applications. • Effective for traveling salesman problem. • Inherent parallelism.	• Sequence of random decision. • Theoretical analysis is difficult. • Coding is not straightforward.	Ants Colony
4	**Eigen Trust**	• Reduces number of inauthentic files on the network. • Robust to malicious peers. • Low overhead.	• Difficult to detect malicious behavior in a peer-to- peer network. • No means of measuring negative trust.	Experience
5	**Cuckoo Search**	• It can hybridize with swarm-based algorithm. • Easy to implement. • Deals with multi- criteria optimization problem.	• Lower rate of convergence • It easily falls into local optimal solution.	Cuckoo Bird
6	**Tidal Trust**	• Calculates trust value between two users that are not directly connected. • It dynamically determines threshold value of trust.	• The Tidal trust doesn't consider the dynamic properties of trust. • This trust is not subjective • Trust values have no upper bound.	Inferred Trust in social network
		• It assigns different trust values to	• Need memory to update	

7	**Discriminative-Aware Trust Management**	each Object. • It calculates trust value more precisely. • It penalizes the rating credibility of an object that sends false rating.	credibility rating. • Low quality solution. • Difficult to calculate trust value.	Discriminative Behavior

Table.1. Trust Optimization Techniques

3. Service Composition (SC)

Service Composition is basically a collection of services where various smaller services are combined to form one larger service. This process allows the interaction among the user's requirements and smart objects of the Internet of Things environment.

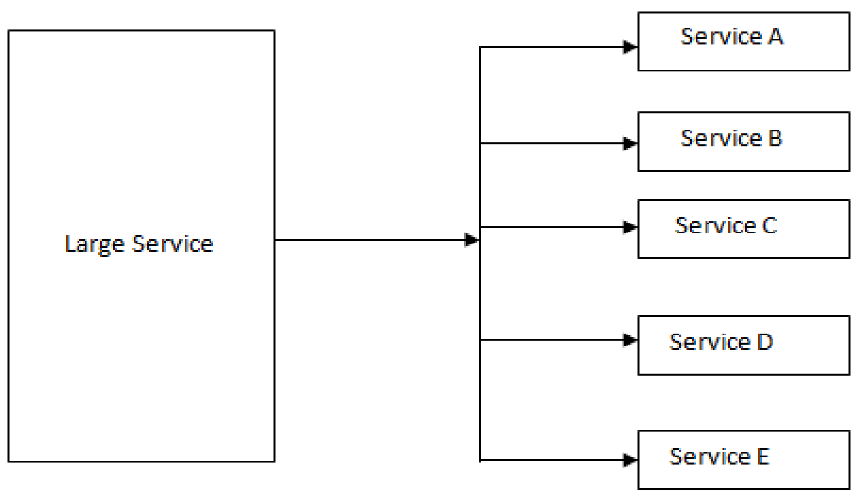

Fig.1. Service Composition

In the above fig1, Service A, Service B, Service C, Service D and Service E are smaller services. Large service is made up by combining the various services A, B, C, D and E together.

These services can communicate with each other via a network. So, the solution for this problem is obtained by consolidating the various accessible services. Thus, it encourages the service reuse, proficient application development etc. The main objective of the service composition is to make an arrangement of the services that is one service for every task resulting in addition of service to the composite service which addresses to the user's request [8]. As per the studies the Service Composition can fulfill the user requirements. Therefore, various Quality of Service (QoS) attributes can be used to characterize the services of the web.

The QoS parameters [9] are defined as follows:

1. **Execution Time:** It is the time between the requests is sent from user and the request is executed.
2. **Response Time:** It is the average time between users request for the service and the user receives the response.
3. **Reliability:** It shows the ability of the service to respond steadily and correctly.
4. **Availability:** Availability means percentage of the time interval during which a service can be accessible.
5. **Cost:** It is the price that requesters have to pay on receiving the required service.
6. **Scalability:** It is the capacity of the IoT environment to get altered in different situations.
7. **Reputation:** Reputation is an indicator of the average scores received which shows the level of satisfaction.

From the above discussed QoS parameters there are three main types of QoS parameters which are execution time (t), service cost (c) and reliability (r) [10] which have helped in solving the SC problem.

For the set of ‘n’ tasks to fulfill the requirement of the user.

$G = \{g_1, g_2, g_3 \ldots, g_n\}$

Each task has ‘k’ numbers of service candidates which can provide the same functionality,

$G_i = \{S^1_{i,} S^2_{i,} S^3_{i,, \ldots,} S^k_{i,}\}$ for all € 1,2,…n

Here, ‘i’ is a class group with similar service and the ‘C’ represents Composite Service to represent group of the tasks.

$C = \{S^a_{1,} S^b_{2, \ldots,} S^k_3\}$ for all a,b,c € [1…k]

Thus, the objective functions are as follows:

$$F1 = \sum_{i=0}^{n} t_I \quad (1)$$

$$F2 = \sum_{i=0}^{n} c_I \quad (2)$$

$$F3 = \prod_{i=1}^{n} r_i \quad (3)$$

Here, t_i is the time of i^{th} instance, C_i is the cost of i^{th} task instance and r_i is the reliability of i^{th} task instance. Thus, by giving same weight to each parameter, equations (1), (2) and (3) are merged to form single objective function.

$$F = \text{minimize } (w_1 f_1 + w_2 f_2 - w_3 f_3) \quad (4)$$

Such that $\sum_{i=0}^{3} w_i = 1$

4. Service Interactions

A service is defined as a stand-alone function that symbolizes a functional unit. Information from one service may be exchanged with another service. It is independent of how well another service is performing. An interaction is a depiction of a conversation between two or more people. It might represent a telephone conversation between an agent and a client, a client's incoming email or a chat conversation between agents and clients. There are two major aspects of the composition which are Composition Design and Composition Topologies.

4.1 Composition Design

It is concerned with designing a particular solution to a set of existing services and to fulfill the request of the client. According to “Service-Orientated Composition in BPEL, W5” there are two design approaches to the composition interactions.

a. **Hierarchical Composition:** In this type of composition the implementation of the service is completely opaque to the consumer [11, 12]. Here, consumer invokes the service, waits for its execution and then it uses the results.

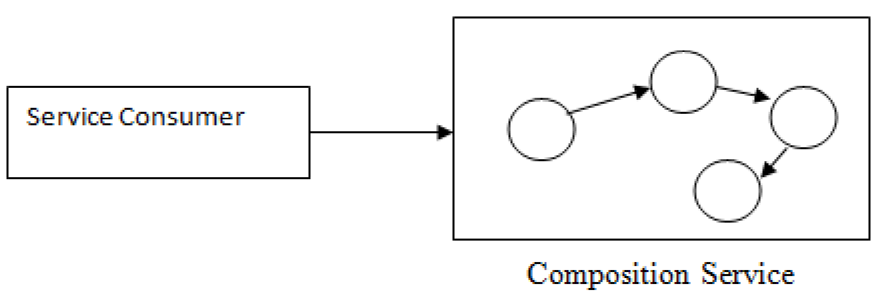

Fig.2. Hierarchical Service Composition

b. **Conversational Composition:** This composition is achieved by providing multiple types of interfaces to service consumer. Here, the interacting consumers and providers act as peers and they exchange control signals and data [13].

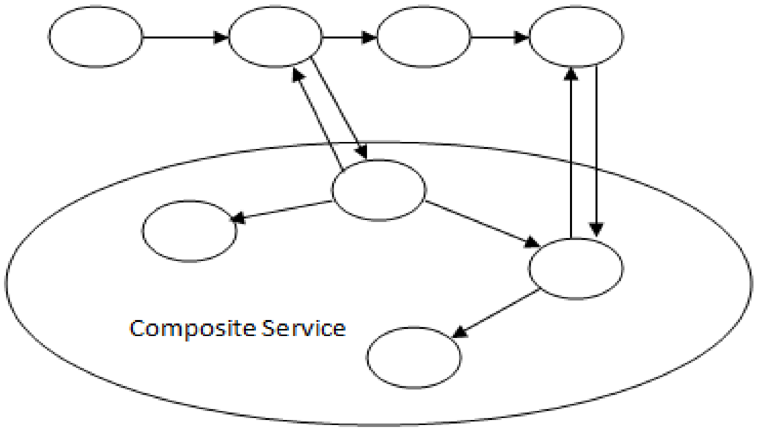

Fig.3. Conversational Service Composition

4.2 Composition Topologies

The composition design requires set of components and topologies for its implementation [14]. Thus, two major design approaches are as follows:

1. **Mediator Based Topology:** In this topology, mediator interacts with the service consumer and also controls the execution of the other participating component services. In Mediator-based hierarchical services, the mediator is responsible for the implementation of an orchestration schema that defines the sequence of components to get the services, so as to achieve the goal within specified constraints [15]. But, in case of Conversational Services, the mediator implements service states and transitions, based on the input received from the consumer.

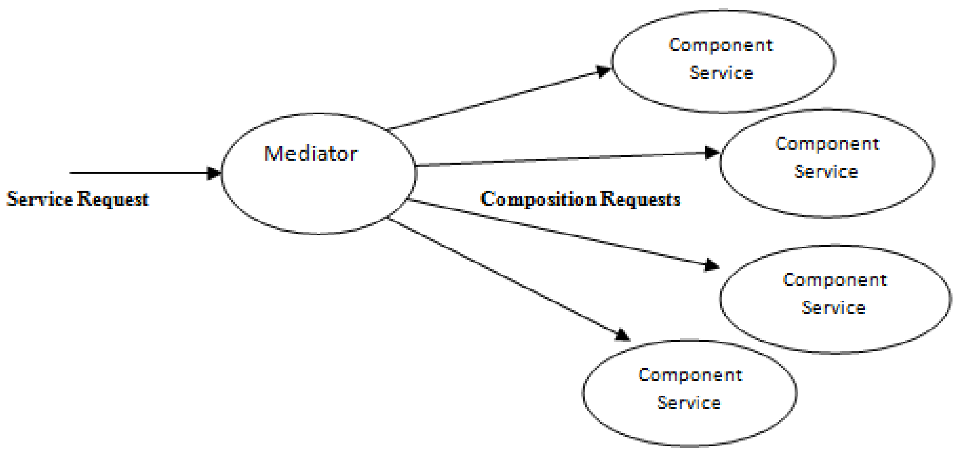

Fig.4. Mediator- Based Composition Topology

When using mediation-based hierarchical services, the mediator implements an orchestration schema that specifies the order in which component services should be invoked in order to accomplish a specific task within a given set of limitations.

When using mediator-based conversational services, the mediator implements service states and states transitions based on input from the user. Finite state machines or transition systems are the foundation of a typical mediator implementation.

2. **Peer-to-Peer Topology**: In this topology, there is no mediator. Every composite service can partially execute the service. Composition is described as a communications template to which component services can be connected. Due to lack of the mechanisms necessary to maintain the conversational state, this topology is often used for the implementation of hierarchical services.

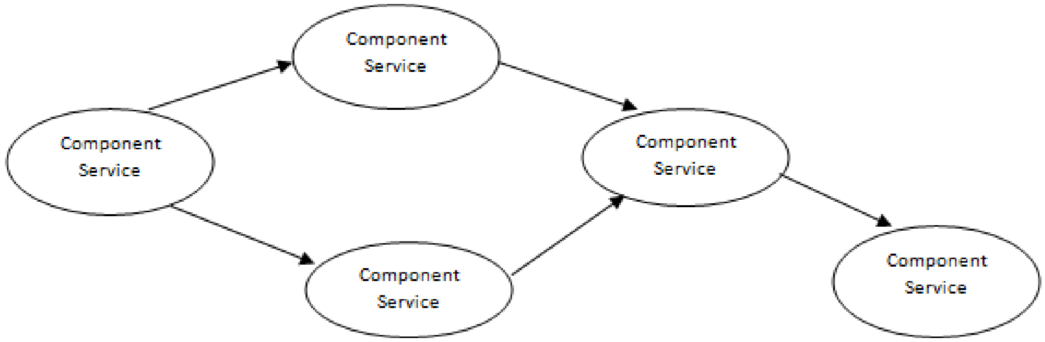

Fig.5. Peer-to- Peer Composition Topology

5. **Service Oriented Architecture (SOA)** Service Oriented Architecture is a framework which is used to integrate the various business processes. It supports the IT infrastructure as the standardized components which can be reused or combined as per the changing business priorities [16].

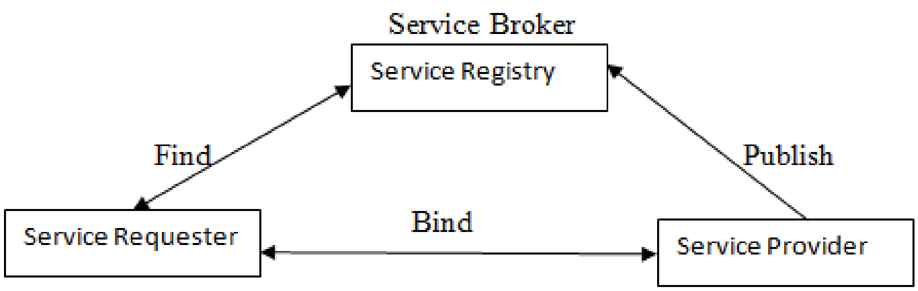

Fig.6. Service Oriented Architecture

The interaction roles in SOA [17] are explained as follows:

a. **Service Provider:** It implements and controls the access to the services.

b. **Service Requester**: The Service Requester is an application where the client can invoke and look for the service.

c. **Service Broker**: Service Broker is responsible for the grouping of all the services and maintaining the registry of the available services.

d. **Service Registry**: It is a directory in which various services are published by the providers and are searched by the requestor.

Three operations in SOA are explained as follows:

a. Publish: In the publish operation; the providers of the services can publish their services into the registry.

b. Find: In the find operation, requester searches and finds services from the service registry.

c. Bind: In the bind operation, requester can invoke the service at the run time using the technical information provided by the Web Services Description Language (WSDL) file to bind to the services.

Thus, in Service Oriented Architecture, service requester can select the services from different service providers. But there are many services that have similar functionalities; requesters need to differentiate between them. So, trust has been used for service selection [18, 19]. Based on trustworthiness, a service requester can select a service from the service provider. Moreover, trust is less expensive approach for the service selection than Service Level Agreements (SLA).

The service composition in IoT architecture consists of five layers which are as follows:

1. **Perception Layer:** This layer is a physical layer that includes virtual devices and sensors to collect the data from Internet of Things environment. This layer senses the physical parameters and also identifies the smart objects in the Internet of Things environment.
2. **Network Layer**: The network layer is responsible for providing connection to the servers, sensors and network devices. It is also used for processes and transferring the gathered data from the perception layer.
3. **Cloud Layer**: Cloud layer is responsible for providing various sub-services by public or private cloud.
4. **Service Composition Layer:** This layer is responsible for coordinating the delivered requests by sending and selecting the sub-services to form desired composited service [20].
5. **Application Layer:** The application layer provides composited/application specific services to the users according to their request. It basically defines various applications which can be deployed in smart homes, smart health and smart cities.

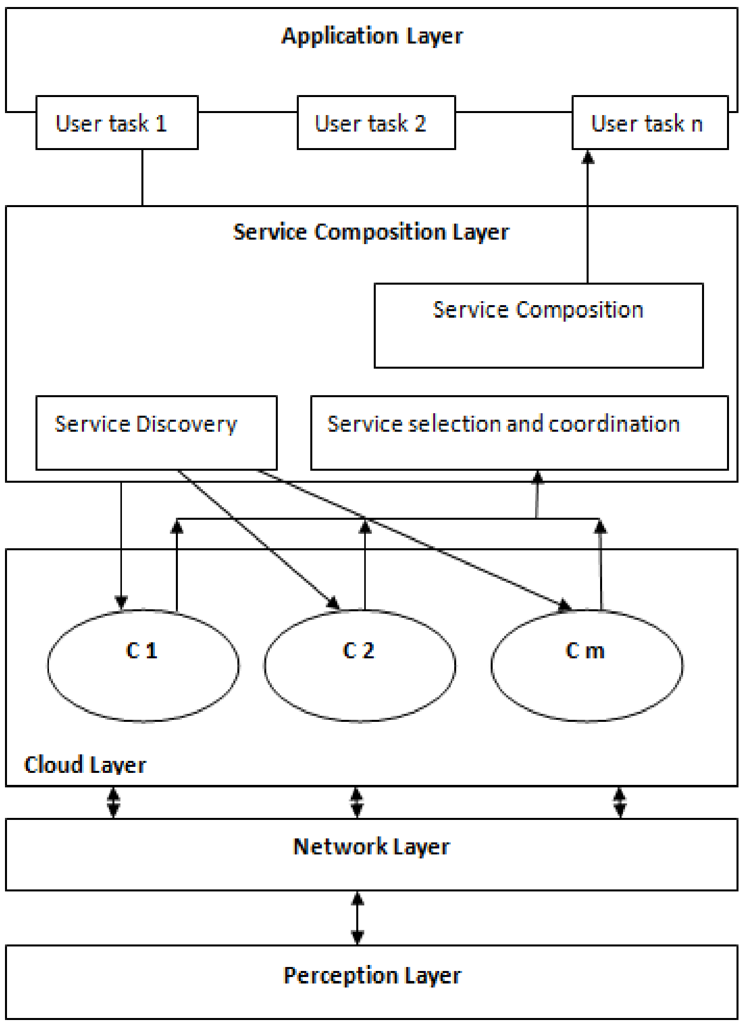

Fig.7. Architecture of Service Composition

6. Proposed Technique

Optimization refers to the process of determining the best values for a system's particular parameters in order to satisfy all design objectives while considering the lowest cost. In 1989, Gerardo Beni and Jing Wang introduced the concept of swarm intelligence (SI). It simply refers to combining the collective knowledge of objects (people, insects etc.) to find the optimized solution to a given problem.

It is based on research of how people interact in self-organized, decentralized networks. The term "swarm" refers to a group of things such as people, animals, and insects. Example of swarm intelligence is act of schools of fish and flocks of birds work as group, without any guidance or instruction from a single leader [21]. The behavior of the entire group can be quickly changed by input from any one component. Swarm Intelligence (SI) comprises of network of endpoint devices which are capable of processing and generating the data at source. Data that fits the predetermined conditions can be immediately shared across the network. Thus, allowing an individual to process the input from their peers without being dependent on centralized data. Such as self-driving cars that can collect and process the traffic information may, share such data with other vehicles. Thus, allowing other vehicles in the same traffic system to respond to changing traffic circumstances in real time. This would allow them to modify their speed and routes to avoid traffic dangers or obstructions. In other words, if we give a problem statement to a person and instruct him/her to think about it before providing a solution, it means that we will consider that person's solution. The problem with this is that the solution provided by that person may not be the best solution or may not be suitable for others [22]. So, to prevent this situation, we assign the problem to a group of people ("swarm") and ask them to come up with the best solution and then add up all the responses to arrive at the best solution, thus in this case, we are using the group knowledge to reach to the best solution.

To prove that collective knowledge is better than individual persons knowledge let take the example of jar with 400 marbles in it. The challenge is to estimate the number of marbles in the jar without touching them. Suppose we take response from one person and in his/her opinion the jar holds 300 marbles. Since the difference (error) is only 100, we can infer from this result that the estimation of that person is not bad, but this is not the best solution. So we will gather responses from more than one person instead of just one person. Let, say we will take response from 6 people.

P1	P2	P3	P4	P5	P6
400	**500**	**550**	**450**	**398**	**488**

Table.2. Person Responses

So, after collecting responses from 6 people, we can take average of the responses, which is calculated as follows:

Avg = (P1+P2+P3+P4+P5+P6) /6

Avg = (300+400+420+370+380+380)/6

Avg = 375 (marbles in jar)

From the combined predictions from 6 different persons, we have arrived at solution those 375 marbles in the jar which is very close to the actual outcome of 400 marbles. Thus, swarm intelligence allows for a more optimized solution to a given problem. As a result, it can be applied to a variety of real-world situations, such as forecasting and determining which policy is best for a company. In order to find a solution to a problem, we need the "Brain of Brains". The swarm of bees, ant colony, and flock of birds, fish schooling, bacterial growth, and microbial intelligence etc. are a few examples of swarm intelligence and the main idea of swarm intelligence was taken from the nature [23].

Ant Colony is one of the methods which were inspired by the behavior of ant colonies. Ants are social insects that live in colonies or groups rather than alone. They communicate through pheromones. Ants from the same colony can detect the chemicals, or pheromones, that they emit on the soil and follow instructions. Ants travel the shortest route from the food source to the colony in order to obtain the food. Ants searching for hidden food release a pheromone, which other ants follow to take the quickest path, Particle Swarm Optimization is an optimization technique based on how swarms move and function. The idea of social interaction is utilized in PSO to resolve a problem. It uses a swarm of particles (agents) that move about the search space in quest of the best answer, Swarm of Bees which was introduced by Karaboga in 2005 [24]. It is an optimization technique which is based on the foraging behavior of the honey bees for numerical optimization problems [25, 26]. The artificial bee colony (ABC) technique has been applied to solve various problem domains such as training of artificial neural networks, solving constrained and unconstrained optimization problems. Artificial Bee Colony works with population of bees. These bees are divided into three groups:

a. **Employed Bees (EB)** – These are responsible for exploited of food source and keeps the data such as distance, richness and direction from the hive. In other words, we can say that employed bees are responsible for finding new solutions.

b. **OnLooker Bees (OB) –** They perform analysis of information to establish food source for them.

c. **Scout Bees** – These are responsible for finding new food sources when current food source get exhausted.

In this technique, the environment represents the search space and point in search space corresponds to a solution that the bee exploits. The quality of food source is the value of the function to be optimized. Initially, Employed Bees and Scout Bees decide to exploit the food source it has found. Thus, the number of EB's corresponds to the number of food sources that are being exploited in the system. EB's communicate about their food source to the OB's. Based on food source quality, OB's decide whether to visit it or not. If the food source is good, it will attract more OB's. Once an OB has chosen the food source, it flies and then tries to find better location by using local search strategy [27]. But if the quality of food source in the new location is better than location originally communicated, then EB will change its location and promote the new source else EB remains on its current food source location. If for certain number of steps, the solution of EB has not been improved, then EB will abandon the food source and scout for a new one.

Artificial Swarm Intelligence same as swarm intelligence but in this optimization technique we choose the participants randomly for the real-time system and ask them to come up with a solution to a specific problem on their own [28]. The final solution is then computed after collecting responses from each participant, and it is then presented. This final solution is more optimized than the one that was derived from one participant. This technique is also known as Human Swarm.

8. METHODOLOGY

The goal of this research is to strengthen the current trust or reputation-building process. The research work to integrates Machine Learning and Swarm Intelligence into reputation building. In addition, the behavior of trust management system will be normalized using the parameters of the service context.

The work flow of proposed methodology is as under:

Step 1. Trust evaluation starts with the deployment of number of users in the network followed by the service providers.

Step 2. Users broadcast their requirements against which the service providers relay their responses.

Step 3. If the budgets requirements are satisfied by the service provider, the job gets allocate otherwise the response of next service provider is evaluated.

Step 4. The information of budget suitable allocation is then added to the repository for future reference. Over the time, the allocation information of the service providers gets aggregated in the repository.

Step 5. Swarm Intelligence (SI) fitness function is used to identify the feedback of the service providers evaluated over the allocation information present in the repository.

Table.3. Work flow of trust management system

This is because of the fact that over the time, the quality of service that reflects the trust in the service provided by the service provider may improve or even deteriorate. Therefore, the feedback mechanism plays a central role in trust evaluation in social networks.

CONCLUSION

The objective of Internet of Things is to integrate the devices and technologies so as to form heterogeneous network that can share the information among the gadgets. Thus, the social network of these virtual objects forms the Social Internet of Things. The objects in Social network have various types of the social relationships such as co-work, co-location, parental, co-device and QoS. In this work, we have discussed about Service Composition which is basically the collection of services where various smaller services are combined to form one big service. These services can communicate via a network. The large numbers of services among devices represent challenge of choosing best service among the provided services. So, trust plays an important role for the selection of the service. Trust is a relationship between two parties for a particular action. It is believed by one subject that another agent can perform an action. In this work, we have used performance optimization technique to build a Trust Management System; so as to evaluate the best service provider based on the feedback provided on the service delivered by the providers.

REFERENCES

[1] L.Attzori , A. Lera ,G.Morabito , " SIoT: Giving a social structure to the internet of things" , IEEE Commun. Lett. 15, 1193-1195, 2011.

[2] I.R.Chen, F.Bao, J.Guo, "Trust-based service management for social internet of things systems", IEEE Trans. Dependable Secur. Comput., 2015.

[3] D. Giusto, A. Iera, G. Morabito, L. Atzori , "The Internet of Things", Springer. ISBN: 978-1-4419-1673-0,2010.

[4] N. Gershenfeld, R. Krikorian, D. Cohen, "The internet of things", Scientific American 291 (4) 76–81,2004.

[5] J. Breslin and S. Decker. " The Future of Social Networks on the Internet". IEEE Internet Computing. Vol. 11, No. 6, pp.: 86–90. June 2007.

[6] L. Ding, P. Shi and B. Liu. The Clustering of Internet, Internet of Things and Social Network. Proc. of the 3rd International Symposium on Knowledge Acquisition and Modeling. October 2010.

[7] A. P. Fiske. The four elementary forms of sociality: framework for a unified theory of social relations. Psychological review. Vol. 99, pp.: 689 – 723. 1992.

[8] H.Al-Hamadi, I.R. Chen, J.H.Cho, "Trust management of smart service communities", IEEE Access. 7, 26362- 26378 , 2019.

[9] Adomavicius, G., & Tuzhilin, A. "Context-aware recommender systems". In Recommender systems handbook (pp. 217-253),Springer US, 2011.

[10] De, S., Barnaghi, P., Bauer, M., & Meissner, S. "Service modelling for the Internet of Things". In Computer Science and Information Systems (FedCSIS), pp. 949-955. IEEE, 2011.

[11] Blackstock, M., Lea, R., & Friday, A." Uniting online social networks with places and things". In Proceedings of the Second International Workshop on Web of Things (p. 5). ACM, 2011.

[12] Ma, J., Y. Zheng, and L. Wang," Nash Equilibrium Topology of Multi-Agent Systems with Competitive Groups". IEEE Trans. Industrial Electronics, 64(6): p. 4956-4966, 2017**.**

[13] D. Guinard, M. Fischer, and V. Trifa. "Sharing using social networks in a composable Web of Things". Proc. of IEEE Percom ,2010.

[14] Y. Huang and G. Li. "A Semantic Analysis for Internet of Things". Proc. of the Intelligent Computation Technology and Automation Conference. May 2010.

[15] Son N. Han, Noel Crespi, "Semantic service provisioning for smart objects: Integrating IoT applications into the web", Future Gener. Comput. Syst. (2017).

[16] N. Truong, H. Lee, B. Askwith, and G. M. Lee, “Toward a Trust Evaluation Mechanism in the Social Internet of Things,” Sensors, vol. 17, no. 6, p. 1346, june 2017.

[17] E. Ahmed, I. Yaqoob, A. Gani, M. Imran, and M. Guizani, “Socialaware resource allocation and optimization for D2D communication,” IEEE wireless communications, vol. 24, no. 3, pp. 122–129, 2017.

[18] M. Nitti, G. A. Stelea, V. Popescu, and M. Fadda, “When social networks meet D2D communications: A survey,” Sensors, vol. 19, no. 2, p. 396, 2019.

[19] D. Wei, H. Ning, Y. Qian, and T. Zhu, “Social relationship for physical objects,” International Journal of Distributed Sensor Networks, vol. 14, no. 1, p. 1550147718754968, 2018.

[20] Chen, J. Guo, and F. Bao, “Trust management for soabased iot and its application to service composition,” IEEE Transactions on Services Computing, vol. 9, no. 3, pp. 482–495, 2016

[21] S. Rengasamy and P. Murugesan, ‘‘PSO based data clustering with a different perception,’’ Swarm Evol. Comput., vol. 64, Jul. 2021.

[22] G. Abbas, J. Gu, U. Farooq, M. U. Asad, and M. El-Hawary, ‘‘Solution of an economic dispatch problem through particle swarm optimization: A detailed survey—Part I,’’ IEEE Access, vol. 5, pp. 15105–15141, 2017

[23] P. Moradi and M. Gholampour, ‘‘A hybrid particle swarm optimization for feature subset selection by integrating a novel local search strategy,’’ Appl. Soft. Comput., vol. 43, pp. 117–130, Jun. 2016

[24] Y. Gupta and A. Saini, ‘‘A new swarm-based efficient data clustering approach using KHM and fuzzy logic,’’ Soft Comput., vol. 23, no. 1, pp. 145–162, Jan. 2019

[25] Yang, X. S. (2011). Optimization Algorithms. Computational Optimization, Methods and Algorithms, 13-31.

[26] M. Dorigo, M. Birattari, and T. Stutzle, “Ant colony optimization”, Computational Intelligence Magazine, IEEE, 1(4):28–39, 2006.

[27] P. W. Tsai1, J. S. Pan1, B. Y. Liao1, and S. C. Chu, “Enhanced Artificial Bee Colony Optimization,” International Journal of Innovative Computing, Information and Control, Vol. 5, pp. 1-14,Dec. 2009.

[28] Kamalam Balasubramani and Karnan Marcus, “Artificial Bee Colony Algorithm to improve brain MR Image Segmentation”, International Journal on Computer Science and Engineering (IJCSE), Vol. 5 No. 01,Jan 2013