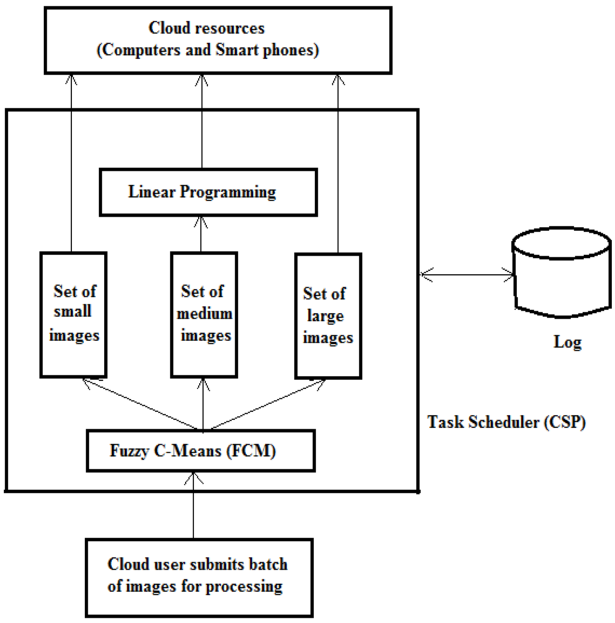

Figure 2: System architecture of proposed task scheduling

Now while applying linear programming, first we have to represent this scheduling problem into the linear programming equations. The linear programming equations for our system are:

Objective function:

Minimize,

$$z = (C_{Smart\ phone} + C_{Computer}) \quad (6)$$

Subject to:

$$T_{Smart\ phone} + T_{Computer} \leq T_{User} \quad (7)$$

$$I_{Smart\ phone} + I_{Computer} = I_{Total} \quad (8)$$

Non-negativity constraints:

$$I_{Smart\ phone}, I_{Computer} \geq 0 \quad (9)$$

Where,

$C_{Smart\ phone}$ = Total cost charged by smart phone resources.

$C_{Computer}$ = Total cost charged by computer resources.

$T_{Smart\ phone}$ = Total time required for smart phones for execution of the images scheduled for them.

$T_{Computer}$ = Total time required for computers for execution of the images scheduled for them.

T_{User} = User submitted time within which execution of his tasks must be completed

$I_{Smart\ phone}$ = Total number of images processed by smart phone resources

$I_{Computer}$ = Total number of images processed by computer resources

I_{Total} = total number of images submitted by user

Equation 6 represent a objective function in terms of execution cost that we want to minimize. Thus goal is to minimize the total cost as represented in objective function under the time constraint provided by user as shown in equation 7. While equation 8 states that all the user submitted tasks (images) must be processed.

4. Experimental Results

The results of the proposed system are calculated in terms of cost required for execution of different sets of images (cloudlets). Each resource (computer and smart phone) processes the images by demanding specific price per pixel. In order to testing the performance of the proposed system, it is assumed that smart phones and computers demands different cost per pixel. In this experiment, each smart phone processes images by taking 5 units of cost per 1000 pixels from user. While each computer resource demands 10 units of cost per 1000 pixels for the processing of images scheduled to it. The results in terms of cost of proposed scheduling are compared with the results obtained by First Come First Served (FCFS) scheduling by giving same set of images and with the same setup. Therefore as shown in table 1, same five sets of images (cloudlets) are used to compare the results in terms of cost required for execution.

Table 1: Cost comparison of proposed and FCFS scheduling

Sr. No.	*Number of cloudlets*	*Cost required in FCFS scheduling*	*Cost required in proposed scheduling*
1	3	3290	2910
2	6	6720	5135
3	9	8730	7960
4	12	10940	8820
5	15	15280	12835

Cost graph of proposed and FCFS scheduling is as shown in figure 3.

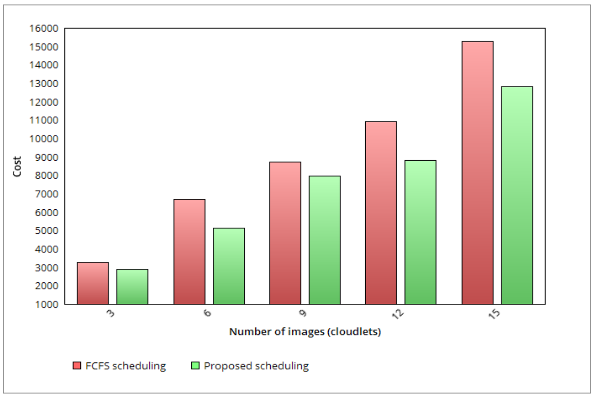

Figure 3: Cost comparison with FCFS scheduling

It shows that the cost required to execute number of tasks (image processing task) for proposed system is less than the First Come First Served (FCFS) scheduling.

5. Conclusion

Task scheduling plays vital role in managing and sharing cloud resources among the different tasks of cloud user. An efficient task scheduling policy provides proper resource utilization, load balancing and optimization of execution cost and time. Therefore today task scheduling is main research topic in the area of cloud computing. In this paper, we have proposed the task scheduling using Fuzzy C-Means (FCM) and Linear Programming approach. Main objective of this system is to schedule the user submitted tasks among the cloud resources in such a way that it minimizes the cost that user (task submitter) required to pay to the cloud owner without exceeding execution time limit (constraint) provided by him. We can conclude from obtained results that by using well known linear programming approach as optimization technique along with Fuzzy C-Means as clustering technique, the objective of cost and time optimization is achieved.

6. Future Enhancements

The proposed system has successfully achieved its objectives of execution time and cost optimization. While applying linear programming, this proposed system can be improved by considering more number of parameters like resource utilization, load balancing, power consumption etc.

References

[1] Sokol Kosta, Andrius Aucinas, Pan Hui, Richard Mortier and Xinwen Zhang, “ThinkAir: Dynamic resource allocation and parallel execution in the cloud for mobile code offloading”, Proceedings IEEE INFOCOM, IEEE 978-1-4673-0775-8/12, PP: 945-953, 2012.

[2] Borko Furht and Armando J. Escalante, Handbook of Cloud Computing, ISBN 978-1-4419-6523-3, Springer, 2010.

[3] Vaishali H Pardeshi, “Cloud Computing for Higher Education Institutes: Architecture, Strategy and Recommendations for Effective Adaptation”, Symbiosis Institute of Management Studies Annual Research Conference (SIMSARC13), Elsevier, 2014.

[4] Mahesh S. Shinde and Anilkumar Kadam, “Survey of Recent Task Scheduling strategies in Cloud Computing”, International Journal of Advanced Research in Computer Science and Software Engineering,Volume 4, Issue 11, November 2014.

[5] Zixue Cheng, Peng Li, Junbo Wang and Song Guo, “Just-in-Time Code Offloading for Wearable Computing”, IEEE Transactions on Emerging Topics in Computing, 2015.

[6] Ning Liu, Ziqian Dong and Roberto Rojas-Cessa, “Task Scheduling and Server Provisioning for Energy-Effcient Cloud-Computing Data Centers”, IEEE 33rd International Conference on Distributed Computing Systems Workshops, IEEE 978-0-7695-5023-7/13, 2013, PP: 226-231.

[7] Sivadon Chaisiri, Bu-Sung Lee and Dusit Niyato, “Optimization of Resource Provisioning Cost in Cloud Computing”, IEEE TRANSACTIONS ON SERVICES COMPUTING, IEEE 1939-1374/12, PP: 164-177, 2012.

[8] Jignesh Lakhani and Hitesh A. Bheda, “An Approach to Optimized Resource Scheduling using Task Grouping in Cloud”, International Journal of Advanced Research in Computer Science and Software Engineering, ISSN:2277 128X, Volume 3, Issue 9, September 2013, PP: 594-599.

[9] R. Vijayalakshmi and Mrs. Soma Prathibha, “A novel approach for task scheduling in cloud”, 4th ICCCNT, IEEE-31661, July 4-6, 2013.

[10] Shivani Dubey, Vismay Jain and Shailendra Shrivastava, “An Innovative Approach for Scheduling of Tasks in Cloud Environment”, IEEE 4th ICCCNT, 2013.

[11] AV. Karthick, Dr. E. Ramaraj and R. Kannan, “An Efficient Tri Queue Job Scheduling using Dynamic Quantum Time for Cloud Environment”, International Conference on Green Computing, Communication and Conservation of Energy (ICGCE), IEEE 978-1-4673-6126-2/13, 2013.

[12] Majid Altamimi, Atef Abdrabou, Kshirasagar Naik and Amiya Nayak, “Energy Cost Models of Smart phones for Task Offloading to the Cloud”, IEEE Transaction on Emerging Topics in Computing, 2015.

[13] Paan-Ning Tan, Michael Steinbach and Vipin Kumar, Introduction to Data Mining, Pearson Education, ISBN 978-81-317-1472-0, 2013.

[14] YIN Zhonghang, TANG Yuangang, SUN Fuchun and SUN Zengqi, “Fuzzy Clustering with Novel Separable Criterion”, TSINGHUA SCIENCE AND TECHNOLOGY, ISSN 1007-0214, Volume 11, Number 1, PP: 5053, February 2006.

[15] John W. Chinneck, Practical Optimization: A Gentle Introduction, [Online] Available at: http://www.sce.carleton.ca/faculty/chinneck/po.html, 2001.

[16] Coremen, Leinserson and Rivest, Algorithms, PHI.

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