Journal of Cases on Information Technology
Volume 24 • Issue 4

Suitable Site Selection of Water ATMs (Basis of Interior/Exterior Conditions) Using Graph Theory

Nayeemuddin Ahmed, University of Science and Technology, Meghalaya, India*
https://orcid.org/0000-0002-9772-8684

Atowar-Ul Islam, University of Science and Technology, Meghalaya, India

Kanak C. Bora, University of Science and Technology, Meghalaya, India

ABSTRACT

Maintenance performs a vital role in assuring safety operation, enhancing the quality and accumulating the durability of the system. In this paper, a method has been evolved to solve the different kinds of issues like new software installation, upgradation of current software, fixing of required equipment, raw water supply problem, etc. To continue the service of water ATMs we cannot start maintenance of all the water ATMs together in any particular site, so the authors require a proper network planning. The authors have developed an algorithm to select the best site for fixing of Water ATMs, so individuals can use this algorithm and find the best sites for setting up of Water ATMs such that maximum number of persons gaining the advantage of Water ATMs. In addition, the authors have planned an IoT-enabled Water ATM. The IoT-enabled technology is put in the various functions of Water ATMs, safeguarding the quality of water.

KEYWORDS

Graph Coloring, IoT, Location Weight, Minimum Vertex Cover, Problem Weight, Sensors, Vertex Cover, Water ATMS

INTRODUCTION

A Water ATM is a computerized water peddling machine that give out pure drinking water when a coin, note, card is placed into it. The key objective of this paper is to maintain the Water ATMs and choice of sites for the Water ATMs on basis of external/Internal factors of the site so that maximum number of people gains the benefits. It comes across the pure drinking water supplies at public places for citizens/visitors.

Municipality water supply is irregular in most of the cities. Slowly growing the gap between demand and supply of water. Frequent failures of government water planned create very bad condition for people depend on it. People living in hilly area and upper slopes do not have piped water supply.

DOI: 10.4018/JCIT.296720

*Corresponding Author

This article published as an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/) which permits unrestricted use, distribution, and production in any medium, provided the author of the original work and original publication source are properly credited.

Graph theory has numerous applications in Computer Science. One of the NP complete problems of Graph theory is Vertex Cover problem and Graph coloring problem.

Vertex Cover

It is a subset of vertices of undirected graph (G), so that each edge (u,v) of the G, either u or v is in vertex cover and it includes all the edges of the G.

Minimum Vertex Cover defines the least possible number of vertices that includes all the edges of the G.

Graph Coloring Problem

It is a grouping of vertices such that no two nearby vertices have the identical color. Coloring the graph with least number of colors is also of great importance as it effects how well a problem can be resolved.

Various papers of different researchers used only External factors to select the location Water ATMs. This is no any method used by any author for the site selection. These are no such works on the maintenance of Water ATMs.

In this paper, the authors considered both the internal factors as well external factors of the site selection. Example: Amount of water, Superiority of water, Remoteness of water supply source, Landscape of city and its surroundings, Altitude of source of water supply etc. also important for section of locations for placing Water ATMs. Here authors used Minimum Vertex cover method to find out the locations and algorithm is designed to find the optimal locations. In this paper authors have used Vertex Colouring technique to perform the maintenance of Water ATMs.

BACKGROUND

Zhang R. et al. (2020) discussed on chromatic polynomials of hypergraph. The idea of chromatic polynomial of a hypergraph is a usualdelay of chromatic polynomial of a graph. They have stressed on presenting some significant open problems on chromatic polynomials of hypergraph.

Sreekumar et al. (2021) analyses the semi-regular bipartite graphs, its subclass graph, SM sum graphs, SM balancing graphs all are automorphism group of a class. The relationship between the graphs is also established. By using Nauty algorithm, they find out the size of the graph.

Charbit et al. (2021) studied the edge clique cover number of graphs with independence number two, which are necessarily claw-free. They gave the first known proof of a linear bound in n for ecc(G) for such graphs, improving upon the bound of $O(n4/3\log 1/3n)$ .More precisely they proved that ecc(G) is at most the minimum of $n+\delta(G)$ and $2n-\Omega(\sqrt{n}\log n)$,where $\delta(G)$ is the minimum degree of G.

Foucaud et al. (2017) proved two conjectures for the class of line graphs. Both bounds are tight for this class, in the sense that there are infinitely many connected line graphs for which equality holds in the bounds.

Mei-Mei et al. (2020) considered the 2-good-neighbor diagnosability of some general k-regular k connected graphs G under the PMC model and the MM* model. The key result t PMC 2 (G) = tMM∗ 2 (G) = g(k − 1) − 1 with some suitable conditions is obtained, where g is the girth of G.

Tsalouchidou et al. (2020) calculated the bi-objective notion of shortest–fastest path (SFP) in temporal graphs, which studies both space and time as a linear mixture governed by a parameter.

Yegnanarayanan et al. (2015) calculated the pseudo a chromatic number of a simple graph G, denoted ψ(G), is the concentrated number of colors used in a vertex coloring of G, where the adjacent vertices may or may not obtain the identical color but any two separate pair of colors are signified by at least one edge in it. They have planned this parameter for a number of classes of graphs.

Zhang et al. (2018) offered a well-organized algorithm GRASP-CVC (Greedy Randomized Adaptive Search Procedure for Connected Vertex Cover) for CVC in general graphs.

Kuhn et al. (2013) examined the weighted vertex cover problem in graphs when a nearby bounded coloring is given. This simplifies the vertex cover problem in bounded degree graphs to a class of graphs with randomly large chromatic number.

Mohammad et al. (2008) offered a graph-coloring-based algorithm for the exam scheduling application, with the objective of accomplishing fairness, precision, and best exam time period.

Karthikeyan et al. (2017) studied one of the NP-hard problems is the “graph coloring problem”. They have shown the numerous applications of Graph coloring.

Arya et al. (2014) settled an efficient graph coloring algorithm that uses fewer numbers of colors for a graph coloring problem. The planned algorithm is applicable for all types of graph.

Ganguli et al. (2017) concentrated on College Course Timetabling where both hard and soft constraints are reflected. It aims at correctly coloring the course conflict graph and converting this coloring into conflict-free timeslots of courses.

Harish et al. (2017) proposed a new algorithm to solve the Graph Coloring Problem. Projected algorithm is based on finding vertex sets using edge cover technique. They also discussed application prospective of the algorithm.

Rajani et al. (2019) used RFID technology, the contactless technology used to recognize the person or object individually with the help of the unique code stored in it. This technology encourages cashless transaction.

Ridhi et al. (2016) discussed on certain applications of Graph coloring like Final exam timetabling, Aircraft scheduling, guarding an art gallery.

Yadav et al. (2017) installed New Delhi-based Water ATMs JanaJal, which factually means drinking water for people.

ATMs network donated expressively in execution most of the customers’ financial services in a trustworthy way (Giannakoudi, 1999).

The problem in the convectional ATMs is gradually removed. Use of Biometric Security makes the banking system more secure (Ogah et al., 2017).

Number of ATMs user increases day by day. In India also development of ATMs taking place. Now a day different types of ATMs are available. These ATMs are placed on different locations depending on different factors (Ram Raj, 2018).

OPTIMAL SITES CALCULATION

Authors have calculated the optimal locations for Water ATMs using some of the external factors and internal factors shown in the Table 1.

First authors have selected a location where the government has proposed to give Water ATMs:

- After that authors select all the (sub locations) locations from the selected site and provide site number.

Table 1. External and internal factors for selection of Water ATMs locations

External Factors	Internal Factors
1.Tourist locations 2. Railway stations 3. Bus stands Market places. 3. Park 4. Religious location, 5. People staying on rent, 6. Near Government Hospital or Medical College/Office 7.Hilly Area	1.Quantity of water 2.Quality of water 3.Distance of water supply source 4.Topography of city and its surroundings 5. Elevation of source of water supply etc. also important for section of locations for placing Water ATMs.

- Depending upon the requirement of Water ATM and significance of the site authors have given Site_weight.
- Authors detect every location and find out the Site_weight and total it.

Here authors have selected 12 sites (Fancy Bazar, India).

SG,CB,GB,SM,SN,M,DSL,NH,GD,BOB,OP,SCH(name of the sites in short form).

After finding the Site_weight and distance between the sites, two graphs have been created by the following two rules.

Rule-1: Just join the sites (nodes) one by one up to last nodes or site and for build a graph authors join last and first nodes else it will be a tree. Shown in Figure 1.

Rule-2: Join all the neighboring places (nodes) and also join the nodes which contain path from that place (maximum distance 500metres). Shown in Figure 2.

(Weight. of the edge = Site_weight of the node +Site_weight of the adjacent node
+ real distance between the nodes) (1)

Authors have found out the Minimum Vertex using the algorithm designed by them.

Choosing the least number of sites which cover the complete areas and this will give the pure drinking water to the people of those sites.

The graphs discussed in figure-2 more efficient covers more sites and within 500 m range, they have pathways to the nearest Water ATMs, if one Water ATM fail publics may move to the next next-door water ATM.

After execution of the Minimum Vertex Cover algorithm from 12 vertices we get only 5 vertices, which optimizes the sites as BOB, CB, NH, SCH, SM. i.e. by using these five sites may cover whole site.

Some of the unusual conditions for which publics may travel to the distantsites of Water ATM are as follows (shown in figure 3):

- If the Water ATM is not serviceable (Mechanical problems) in the next-door Water ATMs.

Figure 1. Site_weight calculation (Rule1)

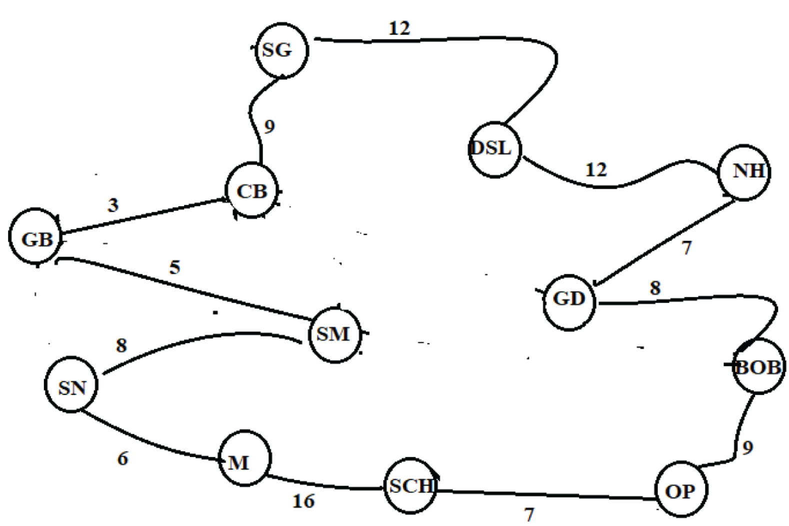


Figure 2. Site_weight calculation (Rule2)

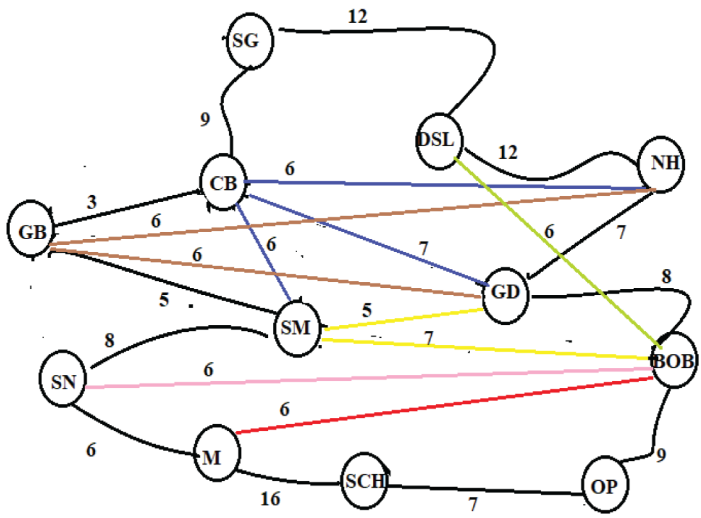
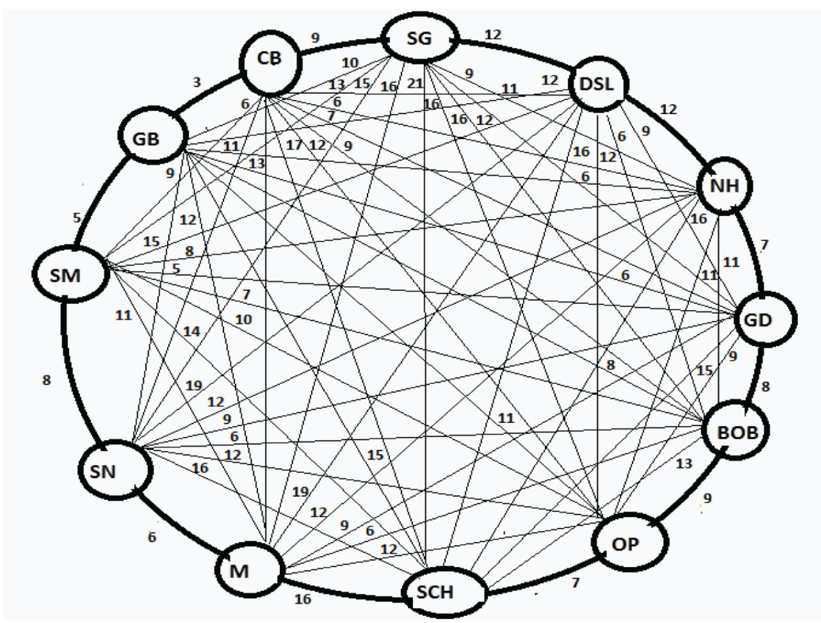


Figure 3. Joining all the sites with each other



- Due to the long Line in the next-door Water ATM.
- Due to some the Environment problems like flood etc.

Authors are using minimum vertex cover algorithm to find the minimum vertex cover and optimizes the sites using internal factors.

Authors have composed the required data from:

- Study by go to on the site.
- Gather the records from the Directorate of Geology & Mining government of Assam.

Distance from the water supply (Internal factor) source we have built the following graph shown in Figure 4 using the following formula:

Weight of the edge =Site's Problem_weight + Adjacent site's Problem_weight
+Actual distance from the water source of the location (2)

Authors have considered same 12 locations (Fancy Bazar, Assam, and India).

SG,CB,GB,SM,SN,M,DSL,NH,GD,BOB,OP,SCH(name of the locations in short form).

Water source of the locations is Brahmaputra River Front (BRF).

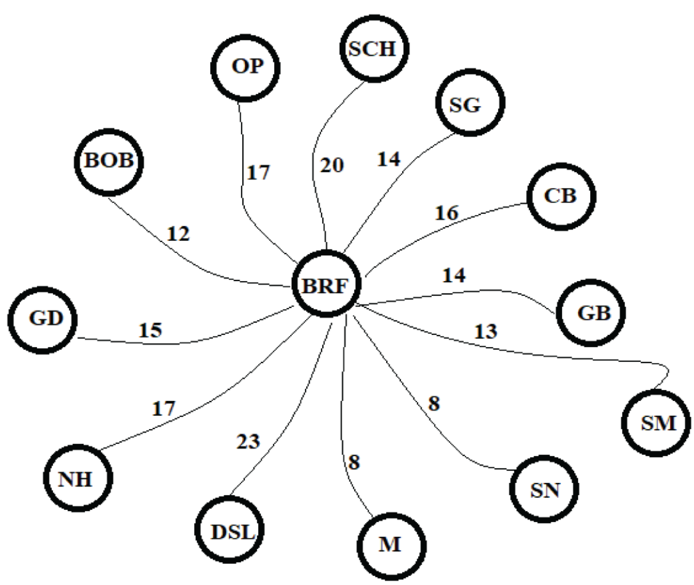
Authors have made fig. (4) a graph. Applying the minimum vertex cover algorithm in site graph get 6 locations from 12 vertices. These are - DSL, OP, GD, CB, SM and SN. Authors can apply sorting algorithm to arrange according to their serial number as follow:

CB, SM, SN, DSL, GD, OP (Output Sites)

ALGORITHM

Authors have considered Graph as input for this algorithm.
Authors want the minimum vertex as our output.
Step 1: while e ∈ E = φ do
Step 2: choice ai with highest (degree (ai)), ∀i,j = 1,2, 3 .... n
Step 3: if degree (ai)=degree (aj) then
Step 4: choice ai with max (degree (ai)) and max(weight(ai))
Step 5: else if (degree (ai) and weight(ai)) = (degree(aj) and weight(aj)) then
Step 6: choice either ai or aj

Figure 4. Investigational Graph of distance calculation



Step 7: degree (ai,aj) = degree (ai, aj) - no of joined adjacent E(ai,aj)
Step 8: weight (ai) = weight (ai,aj) – no of joined adjacent Weight(ai,aj)
Step 9: end if
Step 10: end while

DISCUSSION

To set up a fresh software, update present software, set up the essential apparatus, any other problems-like raw water source problem, repairs of pipelines, change the size of water reservoirs, power problem, plumbing, any natural problem or all routine maintenance authors cannot taken down all the water ATMs together in any particular site.

Maintenance shows an important role in assuring abilities' safety process, enlightening facilities' quality and increases the life of the system.

Authors have distributed the all the water ATMs into three sets. Authors can do the maintain work in three separate passes. So that people can collect water from rest of the any two groups of water ATMs if the update or maintain taking place in one group. Authors cannot take down all the water ATMs together in any specific close location.

From the output locations, authors calculate distance between each location to the other locations shown in Table 2.

In the figure 5 authors have connected 500merter and less and 500meter locations because people may collect water from these Water ATMs during maintenance.

INTERNET OF THINGS (IOT) ENABLE WATER ATMS

The technology that authors suggested is the Internet of Things (IoT), which necessary GSM/GPRS network as it acts as a pillar for communication between device and server. Devices communicate with their centralised server over GSM/GPRS network and confirming that every fitted unit has the accessibility of proper signal strength at the desired site. The distant monitoring device which can be attached on a commercial-scale water purification plant which pools the water related data – transactions, quality, volume, cleaning, which reduces the need for manual maintenance etc. Block Diagram of Water ATMs is shown in the figure 6.

Comparing With the Existing Literature

Most of the paper the install of Water ATMs researchers considered the importance of the location like railway station, bus stoppage tourist location etc. Secondly, they have not calculated how many

Table 2. Distance from each location to rest of the locations (Reduce the distances to 10 scales and converted nearest integer)

Serial no.	Optimal Locations	500 meters and less than 500 meters locations are shown with blue color					
		CB	SM	SN	DSL	GD	OP
2	CB	--	**4**	9	9	**5**	10
4	SM	**4**	--	6	13	**3**	8
	SN	8	6	--	17	7	10
7	DSL	9	13	17	--	7	10
9	GD	**5**	3	7	7	--	7
11	OP	10	8	10	10	6	--

Figure 5. Maintenance of Water ATMs using graph coloring

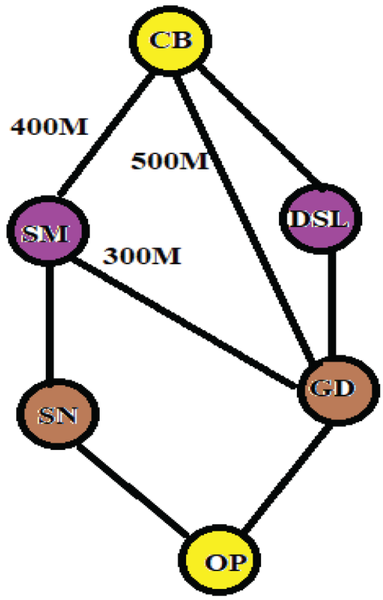
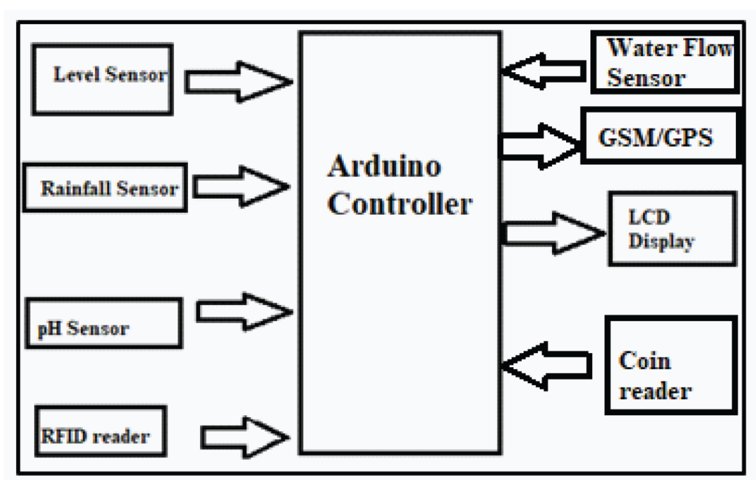


Figure 6. Block Diagram of Water ATMs



Water ATMs required availing the need of people. Thirdly there are some other internal factors also for example Quantity of water, Quality of water, Distance of water supply source etc. these factors are not mention in any other literatures. Maintenance of Water ATMs is not mention in any literature.

In this paper authors have considered both the internal and external factors for selection of location to install Water ATMs. An algorithm is designed by the authors to calculate the number of Water ATMs required in a large area. Graph coloring is used in this paper for the Water ATMs maintenance.

CONCLUSION

Authors have designed graphs with the help of algorithm that will help to select the location of Water ATMs. By using Minimum vertex cover authors calculate the minimum number of Water ATMs required fulfilling the need of that area. The maintenance of Water ATMs of a particular site can be performed in three phases without take down all the water ATMs together in any particular site. That will help the people to collect the Water from nearest other Water ATMs.

The water ATMs would be placed in optimal locations in the city so that maximum number of citizens avail the benefitsThe water ATMs would also enable citizens/visitors to access safe drinking water at various locations within Guwahati.

RECOMMENDATIONS

Authors have developed an algorithm to find out the optimal sites for Water ATMs. One can use author's algorithm and find out the optimal sites for fixing of Water ATMs such that maximum numbers of public gain the benefit of Water ATMs. Anyone can also use Authors algorithm to find out the optimal locations of Bank ATMs also however their location may different.

The technology that authors planned is the Internet of Things (IoT), which necessary GSM/GPRS network as it conducts as a support for communication between device and server.

LIMITATIONS AND CONSTRAINTS

In this paper authors have considered only one internal factor that is distance of water supply source for selection of locations for placing Water ATMs. There are also some other Internal factor like Amount of water, Quality of water, etc. which are also important for selection of locations for placing Water ATMs which will be covered in the further study.

REFERENCES

Arya, S., & Dixit, M. (2014). A Clustered Based Novel Approach of Graph Coloring. *IOSR Journal of Computer Engineering, 16*(6), 14-17.

Charbit, P., Hahn, G., Kamiński, M., Lafond, M., Lichiardopol, N., Naserasr, R., Seamone, B., & Sherkati, R. (2021). Edge clique covers in graphs with independence number two. *Journal of Graph Theory*, *97*(2), 324–339. Advance online publication. doi:10.1002/jgt.22657

Foucaud, F., & Henning, M. (2017). Location-domination in line graphs. *Discrete Mathematics*, *340*(1), 3140–3153. doi:10.1016/j.disc.2016.05.020

Ganguli, R., & Roy, S. (2017). A Study on Course Timetable Scheduling using Graph Coloring Approach. *International Journal of Computational and Applied Mathematics.*, *12*(2), 469–485.

Giannakoudi, S. (1999). Internet Banking: The Digital Voyage of Banking and Money Cyberspace. *Information & Communications Technology Law*, *8*(3), 205–243. doi:10.1080/13600834.1999.9965811

Gu, M., Hao, R., & Cheng. E. (2020). Fault diagnosability of regular graphs. *Theory and Applications of Graphs, 7*(2).

Jindal, R., & Rani, M. (2016). Graph Coloring and its Implementation. International Journal of Advance Research. *Ideas and Innovations in Technology*, *2*(5), 1–5.

Karalgikar, R., & Prasanna, H. (2019). Smart Water Vending Machine. International Journal of Research in Engineering. *Science and Management*, *2*(9), 225–228.

Karthikeyan, R., Geetha, T., Thamaraiselvan, C., & Kumar, S. (2017). Ant Colony System for Graph Coloring Problem. *International Journal of Engineering Science and Computing*, *7*(7), 14120–14125.

Kuhn, F., & Mastrolilli, M. (2013). Vertex cover in graphs with locally few colors. *Information and Computation*, *222*, 265–277. doi:10.1016/j.ic.2011.12.008

Malkawi, M., Hassan, M., & Hassan, O. (2008). A New Exam Scheduling Algorithm Using Graph Coloring. *The International Arab Journal of Information Technology*, *5*(1).

Ogah, U. S., Ahmed, A. M., & Adamu, G. M. (2017). Biometric Security Transaction in Banking System: The Automated Teller Machine (ATMs) in View. *International Journal of Science and Research, 6*(7), 1704-1708.

Patidar, H., & Chakrabarti, P. (2017). A Novel Edge Cover based Graph Coloring Algorithm. *International Journal of Advanced Computer Science and Applications*, *8*(5). Advance online publication. doi:10.14569/IJACSA.2017.080534

Ram Raj, G. (2018). Growth and Development of ATM in India. *Asian Journal of Research in Banking and Finance*, *8*(1), 64. doi:10.5958/2249-7323.2018.00007.X

Rushab, Y., Somnath, A., & Akash, S. (2017). Water ATM By Using PLC System. *International Journal of Science and Engineering*, *1*(3), 104–108.

Sreekumar, K. G., & Manilal, K. (2021). Automorphism groups of some families of bipartite graphs. *Electronic Journal of Graph Theory and Applications*, *9*(1), 65–75. doi:10.5614/ejgta.2021.9.1.6

Tsalouchidou, I., Baeza-Yates, R., Bonchi, F., Liao, K., & Sellis, T. (2020). Temporal betweenness centrality in dynamic graphs. *International Journal of Data Science and Analytics*, *9*(3), 257–272. doi:10.1007/s41060-019-00189-x

Yegnanarayanan, V., & Logeshwary, B. (2015). On Vertex Coloring of Graphs. *International Journal of Mathematical Analysis*, *9*(17), 857–868. doi:10.12988/ijma.2015.5379

Zhang, R., & Dong, F. (2020). Problems on chromatic polynomials of hyper graphs. *Electronic Journal of Graph Theory and Applications*, *8*(2), 241–246. doi:10.5614/ejgta.2020.8.2.4

Zhang, Y., Wu, J., Zhang, L., Zhao, P., Zhou, J., & Yin, M. (2018). An Efficient Heuristic Algorithm for Solving Connected Vertex Cover Problem. *Mathematical Problems in Engineering*, *2018*, 10. doi:10.1155/2018/3935804