Enhancement of Supply Chain Management through Educating Key Processes with the Hub and Spoke Model Based on Multi-Adaptive Spider Monkey Optimization Algorithm

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Abstract

Supply chain performance improvement has become a critical issue for gaining a competitive edge for companies. Over the last decade of the evolution of supply chain management (SCM), a steady stream of research and articles dealing with the theory and practice of SCM have been published, but the topic of performance measurement has not received adequate consideration. However, many critical drawbacks prevent the existing performance measurement systems from making a significant contribution to the development and improvement of SCM and thus, several researches is still needed in this area. So, we present a unique multi-adaptive spider monkey optimization algorithm (MASMOA) to enhance the ability of hub and spoke model to educate the key process throughout the SCM. Initially, for the pre-processing step, we use a normalizing technique to remove unwanted noises from the raw dataset, and then we use principal component analysis (PCA) to extract the unwanted features from the pre-processed data. The information was then encrypted and fed into the hub-and-spoke model for data protection purpose. The proposed method is then used to optimize the hub and spoke model's transport process over hubs. The optimized data is then decoded using a decryption technique to transform the encrypted information into actual format. The Rivest–Shamir–Adleman (RSA) algorithm was used for the encryption and decryption operations. Finally, performance measures such as encryption and decryption execution time, security rate, and scalability level are compared to comparable techniques. Using the MATLAB environment, the results are shown.

Keywords: Supply Chain Management (SCM), Encryption, Decryption, Rivest–Shamir–Adleman (RSA), Hub and Spoke model, Multi-Adaptive Spider Monkey Optimization Algorithm (MASMOA), MATLAB tool

1. Introduction

Supply chains have led to the creation of efficient and effective public logistics networks that have had a major impact on both developed and developing nations' economic growth and social coordination. Regional hubs must be well-planned and well-designed to provide seamless supply chains that deliver high-quality and economically viable supply chain services. (Nabhani, F., Uhl, C., Kauf, F. and Shokri, A 2018) One need just look to the state of California to see that a strategically located regional logistics centre may have a significant impact on the state's economy. It was determined that the five counties around Los Angeles may benefit from a regional intermodal goods movement system that used location-allocation technique and a hub-and-spoke arrangement to better serve the state's more than one hundred transportation zones shown in figure 1. Reduced truck-miles driven and resulting reductions in traffic congestion and air pollution were only two of the benefits of this more efficient design (Rahimi, M., Asef-Vaziri, A. and Harrison, R 2008).

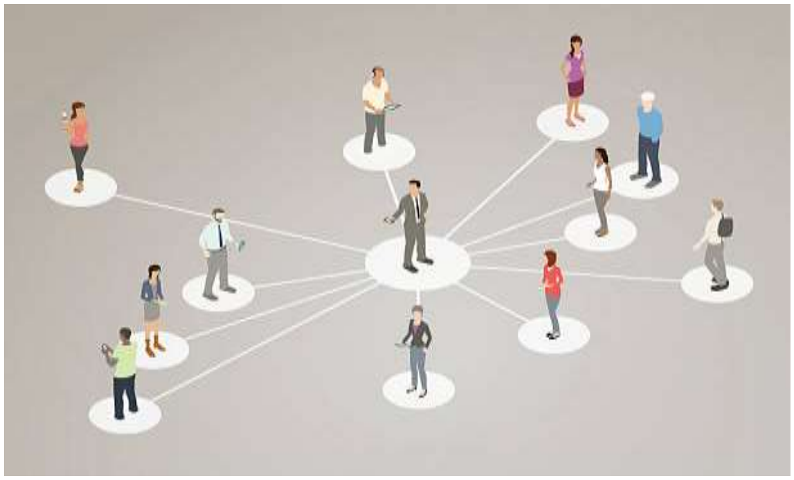

Figure 1. Hub and Spoken model arrangements

Even as China continues to grow and expand economically, it has understood the significance of constructing new and updated logistical networks. According to a 2013 plan announced by the State Council of China, 29 first-class logistics hubs and 70 second-class logistics hubs were to be built. In order to improve the availability and performance of supply chain services and reduce wasteful waste of public resources, this infrastructure development plan advocates for improved logistics network architecture. Chinese scholars and industry practitioners must work together to establish these high-performance logistics parks. Industry clusters based on a region's demands for economic growth and integration with national or global logistics networks are called regional logistics parks. Regional logistics centers of the modern era are hierarchically structured functional facilities that control the flow of freight, transportation, information, and financial resources. Depot site selection, expected demand trajectories, the net present cost of facilities building, and customer demand fulfilment needs all play a role in the efficient and successful delivery of logistics services from numerous depots employing transportation devices. There are three main components to the overall cost of a regional logistics hub: running the facilities chosen for inclusion, transferring products and materials between the facilities, and fulfilling customer demand from each of the facilities in the system. In addition, long-term logistics service infrastructure, such as logistics hubs, should be effectively exploited. There should be no rivalry between regional logistics facilities that is unnecessarily duplicative or chaotic. To meet these complicated goals, a thorough grasp of regional logistics hubs and logistics hub design theory is required. Regional logistics system planning and design issues have gotten more and more attention in academic literature during the last two decades (Li, L., Wang, B. and Cook, D.P 2014). The placement of a facility is a major issue in this field of research. An objective is to find the most cost-effective way to allocate facilities to the various locations given, with the goal of minimizing both the fixed costs of opening facilities and the variable costs of delivering goods with given demands to the facility locations (e.g., logistics service hubs, distribution centers, and/or warehouses). A wide range of methods have been used by researchers to study this particular issue category. Bender's decomposition technique has been used by some in the development of mathematical models, while others have used it to a regional intermodal commodities transportation system (Rahimi, M., Asef-Vaziri, A. and Harrison, R 2008). Everyone has contributed something unique to our knowledge of this kind of issue. There has been relatively little research done to date despite the fact that practitioners and academics alike recognize the importance of creating logistics service models that span multiple tiers and time periods in order to promote regional economic development while also meeting the demands of the global supply chain. The vast majority of published research in this field has been undertaken in wealthy nations. Developing nations' transportation infrastructures, industrial structures, and logistical demands are constantly changing, making the conclusions of such research difficult to apply. As a result of China's fast economic growth, as well as the country's robust national economic development plan that updates policy demands every five years, this is especially true. As a result, provincial and municipal governments, as well as diverse businesses, design their own five-year plans based on the revised national plan. As a result, for provincial/city governments and industry to successfully react to central government policy needs, a multi-period, multiple-echelon facility placement model must be established at the regional level. The additional detail of our research can be structured as: topic II-literature survey with problem statement; topic III-proposed work; topic IV-performance investigation; topic V-conclusion.

2. Literature Survey

An AM hub (CLSCAM) is the initial part of a closed-loop supply chain in (Son, D., Kim, S. and Jeong, B 2021). It is then built a PC approach that maximises the three sustainability indices in order to assist manufacturers in their choice to adopt AM. Two models are then constructed to assist manufacturers with their AM adoption decision. The evolutionary algorithm is used to find a solution to the PC issue with complicated product structure since it is an NP-hard problem. In a multi-echelon, multi-period, and capacitated logistics network, (Lu, H., Li, L., Zhao, X. and Cook, D 2018) proposed an integrated regional logistics centre. Based on the features of China's five-year planning programme, the integrated logistics hub analyses three stages. It is possible to locate logistics facilities at different supply chain echelons using mixed integer linear programming (MILP), the greedy heuristic approach, the particle swarm optimization algorithm, and the Hungarian method. The needs for facility expansion or closure during different time periods are determined. The hub site technique may be used to create a new blood supply chain after catastrophes (Soltani, M. and Mohammadi Zanjani, M 2021). An intercity transportation mixed-integer linear programming model based on hub location is provided after recent blood supply chain investigations are introduced separately. Since this is such a difficult issue to tackle, two novel techniques algorithm is Used To Optimize and Differential Evolution have been created. The created mathematical model and the recommended algorithms' performance are examined using real data from a case study. The results show that the new mathematical model is accurate and that the suggested methods work well in addressing the issue in real-sized dimensions. New variables and operational limitations may be included into the model to make it more realistic. To demonstrate the need for a decentralised system based on distributed data-driven application technologies such as Blockchain, (Madhwal, Y. and Panfilov, P.B 2017) used an industrial scenario in the aviation industry SCM to demonstrate the importance of a decentralised system, not only to assist in maintaining inventory of the aircraft's parts but also to monitor performance, usage, etc. Aircraft parts supply chain transparency and the possibility of black market availability may be reduced by this method. Data-driven technologies will assist SCM managers better understand the supply and demand for spare parts and how to get them from the best sources when they are integrated into SCM scenarios. (Esmizadeh, Y. and Mellat Parast, M 2021) investigate various logistics network architectures and their performance in terms of cost, quality, delivery, flexibility, and resiliency via a thorough literature study. Following a literature analysis, we utilise the findings to analyse the strengths and limitations of each logistics design for various operational strategies. Hub-and-spoke networks provide economies of scale to decrease delivery costs and routing flexibility to alleviate the consequences of interruptions; a cross-docking network offers reduced inventory cost, and an expedited delivery network delivers shorter time. (Patidar, R., Venkatesh, B., Pratap, S. and Daultani, Y 2018) Provide a route for the collection of agricultural goods by vehicle from the farm to the hub. An efficient single-period vehicle routing model is designed to ensure that a supply of items from farmers reaches the destination hub at the lowest possible cost. On an actual case situation in central India, the suggested mathematical model is solved using a genetic algorithm and a particle swarm optimization (PSO) technique. (Kayvanfar, V., Husseini, S.M., Sajadieh, M.S. and Karimi, B 2018) Supply-Demand Hub in Industrial Clusters (SDHIC), a specialised common supplier of storage and logistics operations controlled by a third-party logistics provider (3PL), is recommended to reduce the overall cost of the investigated supply chain. IC firms' activities are modelled using a two-stage stochastic programming model and accelerated Benders decomposition methods. Transparent food supply chains may be achieved by using a blockchain-based Internet of Things (IoT) architecture (Mondal, S., Wijewardena, K.P., Karuppuswami, S., Kriti, N., Kumar, D. and Chahal, P 2019). It utilises a proof of object-based authentication mechanism, which is similar to the proof-of-work technique used by the cryptocurrency Bitcoin. By combining an RFID-based physical sensor with a blockchain-based virtual one, we were able to create the whole architecture. AFSC's typical product moving dilemma is laid out in (Nasr, N., Niaki, S.T.A., Hussenzadek Kashan, A. and Seifbarghy, M 2021). As a first step, the available data is coupled with the aggregate product movement model and vehicle routing model to rebuild an existing AFSC (the ETKA Company, Iran's largest domestic fresh food supply chain). We use the clustering of farmers to optimise overall distribution costs in order to construct a mixed integer linear programming (MILP) model for the location-inventory-routing issue for perishable items in a four-tier, multi-period supply chain. Lagrangian relaxation and a genetic algorithm are used to create a "effective" "matheuristic" that is both efficient and effective (GA). Association rule mining and Internet of Things technologies were used to develop a food safety pre-warning system that monitors all detection data across the supply chain and automatically prewarns in the event of an issue. (Wang, J. and Yue, H 2017) Prior warning systems are designed to assist food industry managers identify food safety risks before they occur, and to provide information to help them make better decisions about the quality and safety of food items. First, risk is discovered using the HHM method, and then risk is appraised using both qualitative risk assessment model (Risk Filtering, Ranking and Management Framework) as well as a fuzzy logic-based risk assessment method. (Nakandala, D., Lau, H. and Zhao, L 2017) provides a hybrid model that incorporates both FL and HHM methodologies (named FL approach). Root Mean Square (RMS) analysis is used to compare the findings from the two risk assessment methods, and the total risk level of each risk is obtained. In some ways, this unique strategy takes use of the advantages of both strategies while minimising their shortcomings. Two-hub centre issue with cluster-based policy is introduced in (Yan, C., Wang, X. and Yang, K 2020) as a specific example of the well-studied topic of hub positioning (HLP). Two clusters of hub-and-spoke (H&S) networks are categorised in advance based on their cross-border geographic properties, and a fuzzy reliability optimization strategy based on the possibility measure is devised for this challenge. To begin, a mixed-integer nonlinear programming (MINLP) formulation is used to represent the issue in order to optimise the overall cross-border supply chain network dependability. (Guerrero Campanur, A., Olivares-Benitez, E., Miranda, P.A., Perez-Loaiza, R.E. and Ablanedo-Rosas, J.H 2018) In this research, a four-tier supply chain's distribution network design challenge is examined. Uncertain demand and a strategy of continual inventory review are used to simulate the situation. At the intermediate levels, there are decision factors such as the distribution of products and the movement of products between levels. These decision factors may be used to calculate the associated safety and cycle inventory levels. Using a mixed integer nonlinear programming model, we can identify the best distribution network configuration. This paper proposes a piecewise linear approximation-based linearization method for the nonlinear model. (Yang, A., Li, Y., Liu, C., Li, J., Zhang, Y. and Wang, J 2019) The original nonlinear issue is transformed into a mixed integer linear programming model by translating the goal function and nonlinear constraints into linear formulations. When comparing nonlinear and linear formulations, the suggested method was evaluated in 50 cases.

Problem statement

Supply chain performance improvement has become a critical issue for gaining a competitive edge for companies. Over the last decade of the evolution of supply chain management (SCM), a steady stream of research and articles dealing with the theory and practice of SCM have been published, but the topic of performance measurement has not received adequate consideration. However, many critical drawbacks prevent the existing performance measurement systems from making a significant contribution to the development and improvement of SCM and thus, several researches is still needed in this area.

3. Proposed Work

In this phase, we illustrate the proposed MASMOA approach. Initially, we utilize normalization approach for pre-processing stage, and then we conduct the feature extraction process by employing the PCA approach. Then the data was encrypted using the RSA and that encoded data was provided into the hub and spoke model. After that, we apply the proposed approach to optimize the process of the hub and spoke model. Then we employ decryption approach by utilizing the RSA approach for decodes the optimized data. Figure 2 depicts the Flow process of our research.

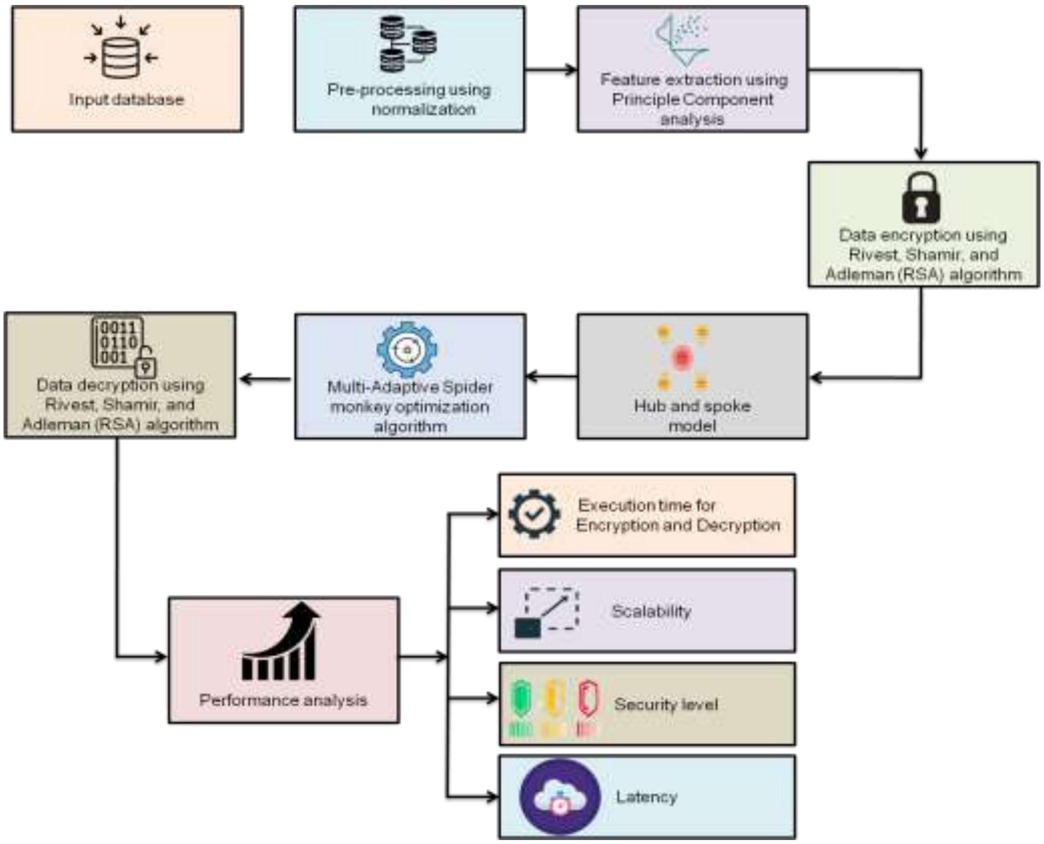

Figure 2. Flow process of proposed work

Dataset

This data contains content from freely accessible datasets using computer investigation (Chen, S., Liu, X., Yan, J., Hu, G. and Shi, Y 2021). Data collecting has two main phases. Initially, we used two datasets, Factiva as well as Nexis, to gather information regarding the current state of blockchain usage in food supply chains. For allow the researchers understand the business sector, Factiva gives comprehensive reporting of global newspapers and business news sites. Nexis has been used to obtain additional news to supplement Factiva's articles. Nexis is a big database that includes the Financial Times as well as other international news sources. Those two databases contained all current food supply chain information. Next, we examined academic resources like Science citation Index. Table 1 depicts the dataset acquisition.

TABLE 1. Dataset description

Datasets	**For database search (searched within title, abstract, and/or full text)**	**Quantity**
Factiva	'Food supply chain' and 'blockchain'	773
Nexis	'Food supply chain' and 'blockchain'	1822
Web of science	'Food supply chain' and 'blockchain'	115

Preprocessing using normalization

The data received is unfiltered and will include a fake datagram and inadequate information. It's that has been purified and normalized to delete repeated and redundant noises, along with data that is inadequate. Since the records for the university community are so large, specimen compaction techniques must be employed. Because this dataset has several features, image retrieval methods are needed to sort out the ones which aren't significant. The dataset may be normalized during the pre-processing stage. Equation (1) defines the c-count in mathematical form as,

$$C = [(M - \beta)/\tau] \tag{1}$$

Here, β express the mean of the information and τ hints the standard deviation. And C is represented as,

$$\mathrm{C} = \frac{\mathrm{M}-\bar{\mathrm{M}}}{\mathrm{Sd}} \quad (2)$$

Here $\bar{M}$ point out the mean of the specimen, and Sd points out the standard deviation of the specimens.

The random specimen looks like this:

$$C_k = \delta_0 + \delta_1 M_r + \rho_r \quad (3)$$

The defects that are depending on τ^2 are represented by r.

Ensuring that, as seen below, the defects should not depend on one another.

$$t_m \sim \sqrt{U}\frac{t}{\sqrt{t^2+u-1}} \quad (4)$$

Here, t implies the random parameter.

After that, the standard deviation is used to standardize the variable's moves. The momentary scale deviation is calculated using the formula (5).

$$\mathrm{MMS} = \frac{\mu^{\mathrm{mms}}}{\theta^{\mathrm{mms}}} \quad (5)$$

Here, momentary scale is denoted by mms.

$$\mu^{\mathrm{mms}} = \mathrm{Ex}(\mathrm{M}-\beta)\hat{}\mathrm{MMS} \quad (6)$$

Here, M stands for random variable, and Ex stands for predicted values.

$$\theta^{\mathrm{mms}} = \left(\sqrt{Ex(M-\beta)\hat{}MMS}\right)\hat{}2 \quad (7)$$

$$t_u = \frac{mms}{\bar{M}} \quad (8)$$

The coefficient of variance is denoted as t_u.

The characteristic scaling procedure will be stopped by setting all of the parameters to 0 or 1. The unison-based normalizing approach is the name for this procedure. The normalized formula would look like this:

$$M' = \frac{(t-t_{min})}{(t_{max}-t_{min})} \quad (9)$$

The info can be kept after it has been normalized, and the length and irregularity of the info could be preserved. This phase's purpose is to minimize or erase information delays. The normalized data can then be used as feed-in subsequent steps.

Feature extraction using Principal component analysis (PCA)

Extraction of features is indeed a step in the dimensional mitigation procedure that divides and reduces a wide range of original information into smaller groupings. As a result, processing would be simpler.

The main requirements for extracting PCA characteristics are as follows:

Stage-1: Compute the average of the images throughout the input (pre-processed) dataset.

Stage-2: To get the mean-shifted pictures, minus the average from the input dataset.

Stage-3: With diminished dimensional approach, estimate the eigenvectors & eigenvalues out of a covariance matrix.

Stage-4: In highest to the lowest, arrange the eigenvectors with its associated eigenvalues.

Stage-5: Just the eigenvectors with highest eigenvalues should be preserved (i.e. the principal components).

Stage-6: Through applying the preserved eigenvectors, initiate the mean-shifted pictures into the eigenspace.

PCA tries to extract the pre-processed data's characteristics by identifying a few orthogonal linear combinations of actual parameters that have the most variation. There are several Principal Components (PCs) even though there were initial parameters. For several data, the first few PCs illustrate the majority of the variation, allowing the remainder to be ignored with little data loss. PCA has been used to diminish the dimension of the enormous dataset while keeping as much data in the actual dataset as viable.

The mathematical relations to conduct a PCA on the data are as follows:

Capture the picture data: Presume $a_1, a_2, \ldots, a_K$ is depicted as $(M \times 1)$ vectors.

Determine the mean of the vector:

$$\bar{a} = \frac{1}{K}\sum_{i=1}^{K} a_i \tag{10}$$

Subtract the mean:

$$b_i = a_i - \bar{a} \tag{11}$$

Determine the co-variance matrix: $A=b_1, b_2, .., b_K$ from

$$V = \frac{1}{K}\sum_{m=1}^{K} b_m b_m^T = AA \tag{12}$$

Calculate the co-variance matrix's eigenvalues and eigenvectors

$$V = \lambda_1 > \lambda_2 > \cdots > \lambda_M \qquad \text{(Eigenvalues)} \tag{13}$$

$$V = c_1, c_2 \ldots c_m \qquad \text{(Eigenvectors)} \tag{14}$$

The pre-processed data set's principal component is the eigenvector with maximum eigenvalue. The largest eigenvalue is used to create the feature vector.

Data encryption using Rivest–Shamir–Adleman (RSA)

RSA is indeed a commonly used encryption method that is also used for electronic signatures as well as digital certificates. The RSA developed the public key method. The computation of modular exponentiation is the primary function of RSA. RSA could be inefficient in constrained situations because it is reliant on arithmetic modulo huge numbers. Additional calculation capability & duration would be needed, particularly if RSA decodes the cipher text as well as creates the signatures. RSA decryption is accelerated considerably by decreasing modulus through modular exponentiation.

The integer factorization issue is what gives RSA its safety. The RSA algorithm was simple to comprehend and deploy. The RSA method relies on a notion of a specialized form of reversible arithmetic addressing modular & exponentiation problems. RSA has been used in a variety of uses, including safety protocols. The public and private keys were expressions of two huge prime numbers, as well as the steps needed to convert cipher text into plaintext using a public key were similar in calculating the product of two prime numbers.

The RSA algorithmic steps are as follows:

- a, b, c, and d are 4 huge prime factors that could be chosen at random as well as independent of one another. Each prime numbers must have the same length.
- Calculate the $n = a\,x\,b, m = c\,x\,d,\ \varphi = (a-1)\,x\,(b-1)$ as well as $\lambda = (c1)\,x(d-1)$.
- Decide a numeral number t, $1 < t < \varphi$ in this extent G_{cd} (e, φ) =1
- Compute the secret exponent s, $1 < s < \varphi$, in this extent $t\,x\,s$ mod φ =1.
- Select an integer $g = m + 1$.
- Calculate the modular multiplicative inverse: $\mu=\lambda^{-1}$ mod m.

Public (encryption) key was (n, m, g, t).

Private (decryption) key was (s, μ, λ).

- **Encryption**

Here, F=encrypted file in which the information of the file gets converted to a string L.

Specify the random numeral c, where $c < m$.

Estimate cipher text like: $r=g^{d\wedge e mod n} \times c^m \bmod m^2$.

- **Decryption**

Find out the raw information:

Y= (((r $^{\lambda}$ mod m^2 -1)/m) x μ mod m)^s mod n.

Multi-adaptive spider monkey optimization algorithm (MASMOA)

The MASMOA algorithm is divided into six primary stages, each of which is preceded by an initialization phase. These stages depict how a spider monkey adjusts their location depending on prior experiences and neighboring behavior.

Initialization of the Population

A colony of N spider monkeys is created first. SM_i ($i = 1, 2 \ldots N$) is a D-dimensional vector that represents the initial population. MASMOA offers the best possible solution to the topic at hand. The spider monkey population is represented by SMi. The following is how SMi is set up:

$$SM_{ij} = SM_{minj} + \cup[0,1]\left(SM_{maxj} - SM_{minj}\right),$$

Here, j=1, 2... D is randomly selected within dimension, SM_i=ith food source in the swarm, $SM_{min,i}$=lower bound of SM_i, $SM_{max,i}$=upper bound of SM_i , and $\cup[0,1]$=uniformly distributed random number in the range [0, 1].

Local Leader Phase (LLP)

The Local Leader Phase is the next step. MASMOA's physical location is being modernized based on feedback from the local and global groups. Greedy selection is used by these members, who compare the fitness of a new site with their present position. As an example, consider the following equation for the ith SM in the Kth Group:

$$SM_{newij} = SM_{ij} + \cup[0,1]\left(LL_{kj} - SM_{ij}\right) + \cup[-1,1]\left(SM_{rj} - SM_{ij}\right)$$

Here, SM_{ij}=ith solution in the jth dimension, LL_{kj}=kth local group leader position, and SM_{rj}=rth solution which is selected randomly from kth group,

Global Leader Phase (GLP)

After completing the LLP, the GLP phase has just begun. The following equation is used to update the position based on the prior experience of the Global Leader and members of the local group.

$$SM_{newij} = SM_{ij} + \cup[0,1]\left(GL_{kj} - SM_{ij}\right) + \cup[-1,1]\left(SM_{rj} - SM_{ij}\right)$$

Here, GL_{kj}=global leader position.

According to the Spider Monkey's fitness, they change their location depending on probabilities (pr_i). Probability calculations may be done in a variety of ways, but they all must take fitness into consideration. Function value must be included in the fitness computation to provide an accurate picture of a function's quality.

$$pr_i = \frac{0.9 \times fitness_i}{fitness_m ax} + 0.1,$$

Global Leader Learning (GLL)

MASMOA uses greedy tactics to reposition itself as the world's most powerful organization. The best-fitting solution in the present swarm was selected as the global leader. A check is made to see whether the position of global leader has been modernized and the Global Limit Count is adjusted appropriately.

Local Leader Learning (LLL)

A greedy technique is used in this phase to reposition a local leader. The Local Leader is a well-suited option for the present swarm. It also checks to see whether the location of the local leader has been modernized, and if it has, it modifies the Local Limit Count.

Local Leader Decision (LLD)

A decision will be made concerning the Local Leader position during the LLD phase if it has not been updated to a certain level, known as the Local Leader Limit (LL_{limit}). In the event of no change, the location of LL is randomized. The following equation may be used to determine where LL should be located.

$$SM_{newij} = SM_{ij} + \bigcup[0,1]\left(GL_j - SM_{ij}\right) + \bigcup[0,1]\left(SM_{ij} - LL_{kj}\right)$$

To summarize, the SM's updated dimension is drawn to the global leader and repels the local leader as shown by the equation above.

Global Leader Decision (GLD)

As long as it hasn't been updated up to a certain point known as the Global Leader Limit (GL_{limit}), GLD will split into smaller subgroups. Use of the LLL process in this phase results in the creation of new subgroup leaders.

MASMOA's position update equation takes the average of the difference between the current location and random generated positions. For a given issue, it creates a random place in the provided range at random Convergence and dependability would both benefit from this recommended change. A better fit solution is supposed to be close enough to the best fit that they share the ideal solution.

$$Y_{ij} = X_{ij} + \phi_{ij}\left(LL_{kj} - ISM_{ij}\right) + \phi_{ij}\frac{SUM}{SN},$$

Where SUM = SUM $+X_{ij} - X_{kj}$

Here, ϕ_{ij}=uniformly generated random number in range [0, 1], SN=food source that is randomly generated the position for food source, and SUM=average of difference for current position and random generated position.

The best swarm intelligence is used to update this equation's well suited answers. MASMOA's newest feature improves the ratio of searching for and implementing the most practical solutions.

Hub and spoke model

Customers' needs and expectations are traditionally determined by product design, such as utilizing Quality Function Deployment technique, or through aggressive promotion of items such as advertising, in the supply chain management supply chain. To meet the triple bottom line goals of green marketing and sustainable supply chain management, new integration models must be developed.

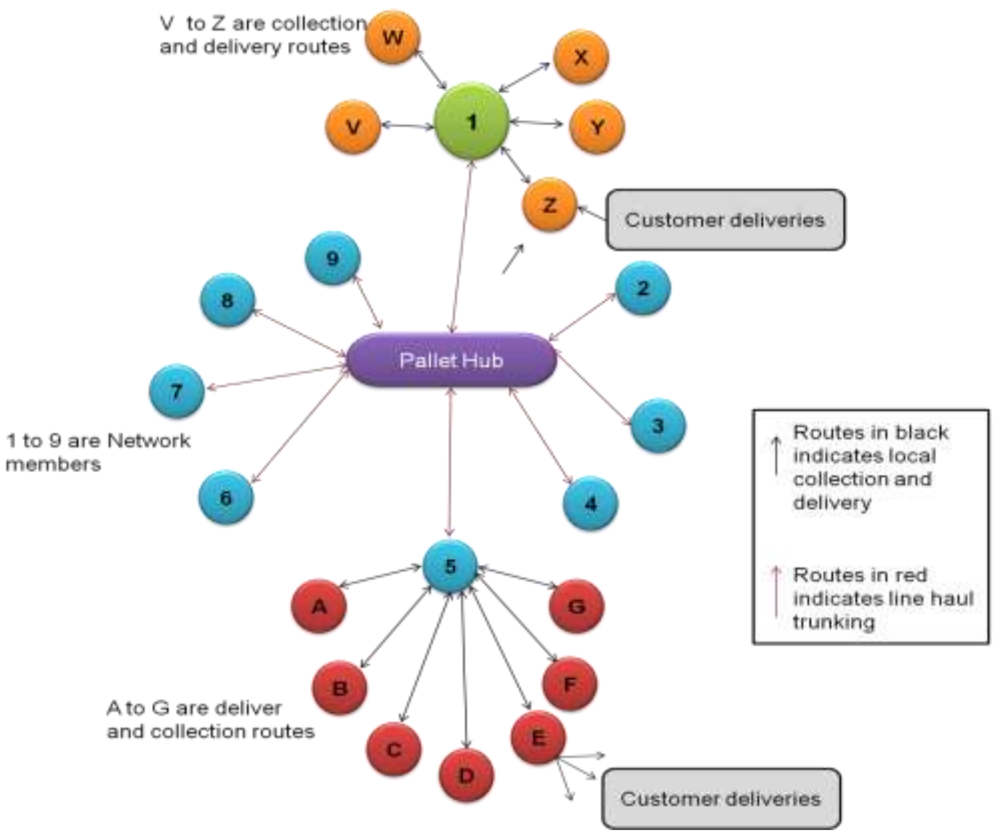

Figure 3. Hub and scope model

Distribution networks based on a hub-and-spoke model are used in a broad range of industries across the globe. There are a variety of logistics hub-and-spoke models, all of which are aimed at improving supply chain efficiency by fostering a spirit of cooperation. When it comes to teamwork, hub-and-spoke configurations are a great way to keep things well-ordered. The centralised distribution and consolidation operations supported by logistical hub-and-spoke systems often demonstrate a set of cooperation procedures (Figure 3).

The "less-than-truckload" (LTL) industry relies on hub-and-spoke networks. It is possible to combine and enhance the usage of trailers to transport cargo between cities that are spread out across a large area. So that trailer utilisation increases and operational expenses are decreased, hub and spoke networks limit the amount of underutilised direct loads.

Large unit amounts are transported to and from hubs in a hub-and-spoke arrangement in order to decrease costs and obtain economies of scale. Line haul trunks do not have to travel great distances with little loads. To varied degrees, this LTL distribution phenomena may be seen across the continent of Europe and around the globe. It is important to consider a range of elements, including the geographic area to be covered, the number of spokes, and the service level requirements, while designing a hub-and-spoke network. LTL transportation is defined as the transportation of several shipments on a single vehicle with the purpose of making multiple deliveries within a network with various users.

These carriers are often distinguished by the essential network elements (Figure 3): local pickup (V to Z), local sorting and spoke terminal collection operations, line haul, hub transshipment, destination sorting and spoke terminal delivery operations, and local delivery (A to G).

The capillary networks of hub-and-spoke systems are the spoke terminals. Hub-and-spoke efficiency may be achieved by coordinating freight movements between hubs and spokes. In theory, the hub serves as the system's beating heart, transporting goods to and from the system's furthest reaches through its line haul arteries.

Each spoke terminal is constrained, and as a result, there is a risk of congested traffic (for example, due to limited space, resources and time). In hub-and-spoke systems, spoke terminals follow the rules and coordinate with a central (hub), but choices about distribution are made at the local level by the spoke terminal and are subject to their own local control and capabilities. Years have passed in which hub and spoke networks have been primarily concerned with volume-driven delivery, in order to continue to maintain the volume-driven economic model on which they have been established and prospered. The existing hub rules for spoke terminal co-ordination have tended to be oriented on manufacturing-related freight profiles, and the policies have been designed to accommodate the delivery of enormous quantities of freight. If we take the case of pallet networks, they have traditionally transported undamaged pallets to curbside delivery points/delivery yards/unloading bays using a hub-and-spoke model. Deliveries of this kind normally take 2-5 minutes, after which a certificate of delivery is obtained and the driver is back on the road and on his way to the next drop.

New retail consumers, on the other hand, have placed strain on established hub-and-spoke rules and operating procedures. Examples include the fact that in general, these new types of deliveries necessitate sophisticated added-value requirements (for example, decanting of goods) in addition to extremely stringent customer service requirements, all of which require more time at the delivery point and are frequently in competition with core volume deliveries. For the most part, spoke terminals employ experienced drivers and supervisors who are responsible for making daily routing choices and adhering to the regulations established by the hub. These rules, on the other hand, are becoming out of date and inflexible in response to evolving network needs. As a consequence, it is necessary to modify these regulations in order to accommodate diverse freight profiles.

4. Performance Analysis

In this phase, we discuss about the investigation metrics of our proposed approach and that metrics are depicted by employing the MATLAB tool. Then those findings are related to the existing approaches to prove our approach with greatest enhancement.

Execution time is the time a system or functional unit takes to react to a given input. Figure 4 depicts the performance metric of execution time of encryption for our proposed approach and that was related to the existing approaches. Figure 5 depicts the performance metric of execution time of decryption for our proposed approach and that was related to the existing approaches. The value of execution time varies with respect to datasets. Throughout this investigation, our proposed approach carried out the processes with lower timeslot (execution time) than that of the existing approaches throughout the encryption and decryption performances.

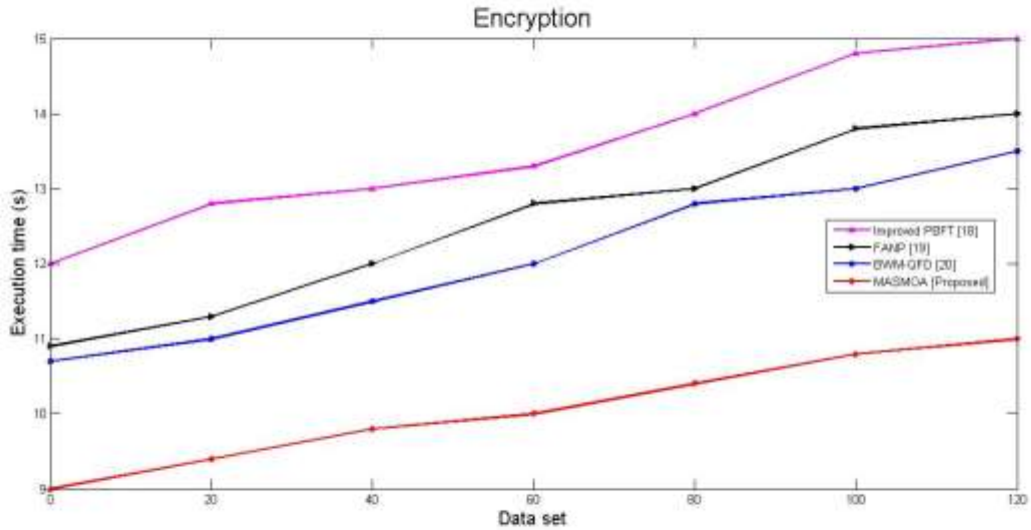

Figure 4. Comparison of Execution time for encryption with proposed and existing techniques

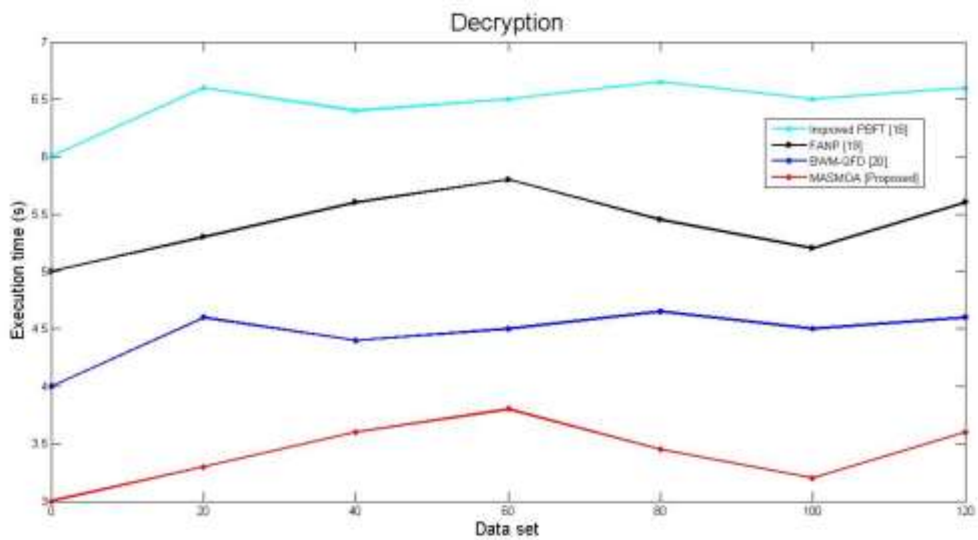

Figure 5. Comparison of Execution time for decryption with proposed and existing techniques

If the network provides the fewest number of delays throughout data exchange and cooperation involving multiple participants, the platform will be scalable. Figure 6 depicts the performance metric of scalability of our proposed approach and that was related to the existing approaches. The proportion of scalability varies with respect to datasets. Throughout this investigation, the proposed approach has the greatest rate of scalability than that of the existing approaches.

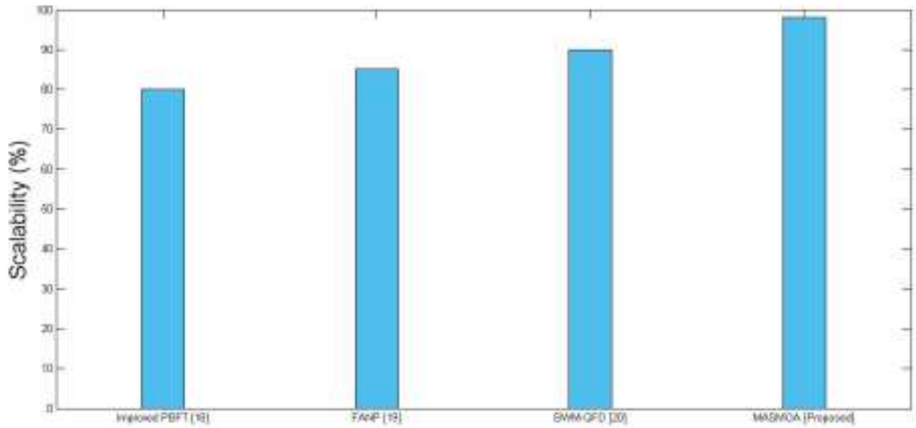

Figure 6. Comparison of scalability of proposed and existing approaches

In a private network, the company establishes its individual security procedures based on its needs. Because of its local data exchange regulation, when it is dispersed, policy has a significant impact. Various security policies might be used by a single supply chain organization to individuals in various areas. Figure 7 depicts the performance metric of security of our proposed approach and that was related to the existing approaches. The proportion of security varies with respect to datasets. Throughout this investigation, the proposed approach has the greatest rate of security level than that of the existing approaches.

Latency seems to be the timeframe among a person's activity as well as a computer database's reaction towards that interaction; it's also known as the complete circular transport time a datagram required to move in connectivity terminology. Figure 8 depicts the performance metric of latency of our proposed approach and that was related to the existing approaches. The performance of our proposed process takes just very tiny amount of duration over existing techniques throughout the datasets.

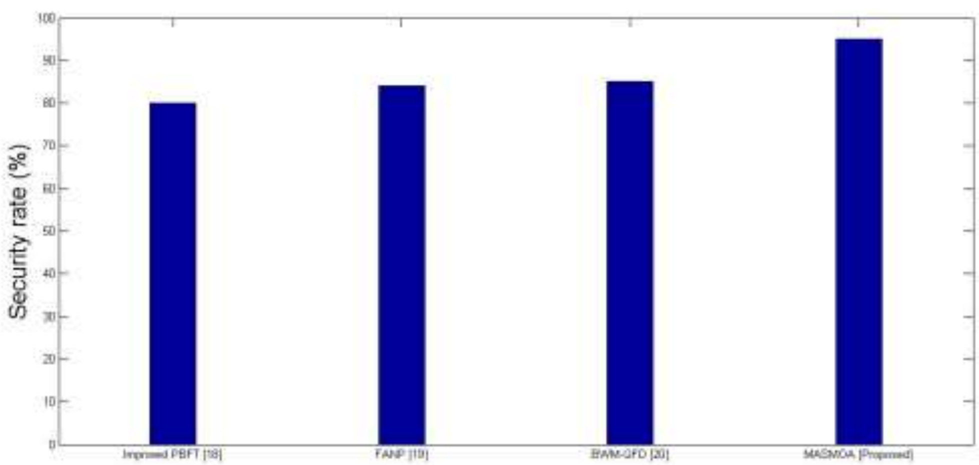

Figure 7. Comparison of security of proposed and existing approaches

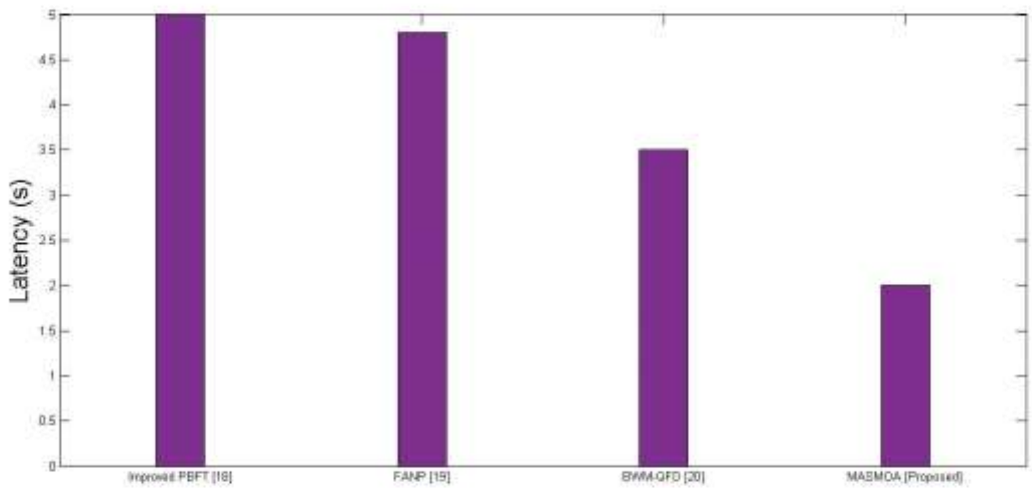

Figure 8. Comparison of latency of proposed and existing approaches

5. Conclusion

Supply chain performance enhancement is crucial for firms to obtain a competitive edge. However, many important flaws preclude present performance assessment systems from significantly contributing to SCM development and improvement, necessitating more research. Thus we present a unique MASMOA approach to overcome such concerns. Firstly, we conduct normalization technique for de-noising stage and then we execute the PCA approach for retrieve the unwanted features. Then the data was encrypted using the RSA and that encoded data was provided into the hub and spoke model. After that, we apply the proposed approach to optimize the process of the hub and spoke model. Then we employ decryption approach by utilizing the RSA approach for decodes the optimized data. Finally, the investigation metrics such as scalability, security, execution time for encryption and decryption, and also latency were analyzed and that are compared with existing approaches to prove our approach with greatest rate of enhancement.

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