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Virtual Market Using Logistics Optimization

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---ABSTRACT---

In this paper we have proposed an idea called virtual marketplace that effectively utilizes the widespread and vast cellular phone infrastructure and the recent advances in sensor technology, leading to tremendous cost and time saving. This idea takes virtual markets to a new level of evolution, with unparalleled customer convenience, speed, quality assurance and reliability. Almost every item such as books, electronic goods, milk, vegetables, televisions and food items can be traded using this virtual market. Some of the key features are: (i) Wireless communication-enabled real-time inventory and (ii) logistics optimization (iii) quality control (iv) delivery people-human employees to pick up and deliver products and (v) real time authentication of transactions. The goal of this work is to develop an eco-friendly virtual market for potential buyers/sellers (such as enabling trade with in sustainable or ecological communities), providing an efficient client-server communication through Logistics optimization.

Keywords - **virtual market, wireless communication, reliability, ecological communities, logistics optimization.**

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1. Introduction

1.1 Virtual Market Using Wireless Communication

The market will be owned and operated by a merchant who has the server and a fleet of delivery vehicles. The customers will not need to go to the market to buy and sell the goods. They can use mobile phone directly to interact with the server. In this market, every customer is also a potential seller. They can place orders, place merchandise for sale or search the virtual market using mobile phone. They will immediately get a delivery/pickup schedule notice for order/sale request. If ordered products are unavailable, they will be automatically back-ordered by the server from suppliers (from conventional markets) and a tentative availability schedule will be provided to the customer in the form of an SMS as early as possible. All demands (placed orders) cannot be met by the posted sellers on the market at any given time. So, augmentation from conventional markets is necessary. Such conventional suppliers will be located and registered with the server beforehand. The server will process daily orders and sale requests and augment them with additional required merchandise from an optional warehouse or conventional suppliers.

Some examples for existing virtual markets are ebay.com, amazon.com and namaste.com. These virtual markets facilitate trading of products by online payment. They deliver the products to the customers by courier or postal communication. For the past 10 years both buying and selling are available. In this work, the design of virtual markets is improved by integrating mobile and server communication technologies. Thus, in the proposed virtual market, customers can directly sell or buy their goods through a virtual market agent after placing orders to the market's server. Note that, by using people who both pick up and drop off goods in addition to the server one can build a virtual market that is close to real markets. Virtual market with both buying and selling using wireless communications, with a real inventory and delivery people – human employees – to pick up and deliver products – this is an expansion of a real shop.

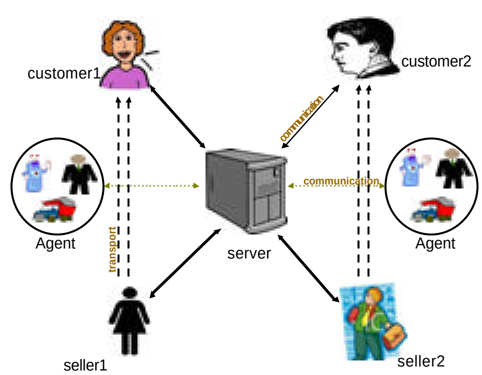

Fig1: principle behind the proposed virtual market

1.2. Logistics Optimization Of Market

When a customer places an order to the server to buy or sell products, the server communicates to one of the agents to pick up or deliver the products from either an existing inventory or from authorized conventional markets. The server has to decide which one among the pool of agents will execute a predetermined optimum set of orders, which are the warehouses or conventional markets to pick up products to be delivered, and the optimum route of travel for the chosen agent. This leads to logistics optimization [1] problems that need to be solved.

In this project, the server is designed to perform optimization of the process of delivery of the products by an agent by accounting for costs incurred in:

- Time of delivery/pick up
- Distance traveled (mileage)
- Mode of transport
- Value and nature of goods delivered/pickup

An appropriate objective function is designed with suitable constraints. The details are presented in the implementation of the logistics optimization.

2. Features

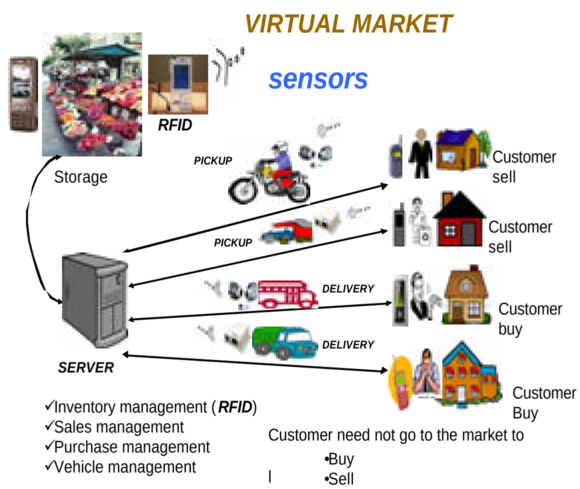

Fig2 .a sample example for description of features of virtual market

The server will process daily orders and sale requests and augment them with additional required merchandise from the warehouse. It will give instructions to the delivery person with details of pickup or drop-off of goods from warehouse and to/from each customer/seller. The optimal route of the delivery van will be planned by the server based on locations and requirements of the customers/sellers and the warehouse. The instructions given to the delivery person will incorporate the route, the sequence of house calls, quantities to be picked-up/ delivered etc. on the mobile device itself and will be updated continuously. The outstanding amount on each account may be settled on a fortnightly/monthly basis. The business owner may allow carrying over the balance (credit) for his or her preferred customers. Payment modes can be by credit card, ECH, DD,personal cheques, etc.

In this system of market, the products for sale coming to a central warehouse are minimized. As much as possible, they will be picked up from the seller and delivered to a potential buyer directly. This is favored in the optimization of the system because the objective function not only seeks to maximize profits but also minimizes costs to the environment. So, a significant amount of the inventorying has to be done on spot by the delivery person. Clearly the system heavily depends upon the honesty and integrity of the delivery person, accurate measurements of quantities and number and accurate evaluation of product quality. Therefore, the delivery van will be video-enabled to ensure that the each transaction is recorded. The delivery person will carry several wireless-enabled sensors, gauges etc. that will measure product quality and quantity and directly communicate them to the server. This minimizes subjectivity in the evaluation and measurement and gives increased confidence in the system for both the business owner and the buyers and sellers. The pricing of the merchandise will be decided by the server based on preset parameters of quality and type of the product. The buyer and seller will electronically sign/accept the price determined by the system for every transaction.

So far, a prototype for the server has been developed and prototypes of the mobile applications for the clients and the agents have been developed. A preliminary optimization procedure has also been developed for identifying the optimum mode of delivery of products by an agent subject to constraints. In order to complete a prototype of the proposed virtual market, an inventory management system needs to be developed, which is left for future work.

2.1 Server For The Virtual Market.

The prototype of the server has been developed using J2EE [2] (Enterprise Edition). The server hosts the following information (i) Customer database (ii) Product database (iii) Order database (iv) Availability of products (When an order is placed, depending on the availability and the quality of the products in the inventory, as maintained in the product database, the server will generate a reply confirming the order and predicting the time of delivery of the products.) (v) Feedback database (vi) Details of the market and its feature (vii)Help sections to assist the customers to navigate the server (viii) Graphical User Interface as a front-end to the server (ix)Interface with the customers' mobiles, delivery people's mobiles and inventory (Will be developed once the mobile applications and the inventory are developed.)

2.2 Mobile Application.

2.2.1 Mobile application for customers.

Mobile applications for the clients have been developed using J2ME [3] (mobile edition) and implemented on a mobile emulator. Through this application installed on their mobile, a customer can interact directly with the server as shown in Fig. 3, and can:

- Login to the server
- Place orders to the server

Future developments on the application should enable the customer to access and modify their profile on the server, view past transactions, and check for availability of the products.

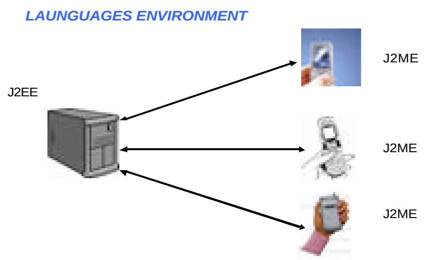

Fig3.languages environment

2.2.2 Html Parsing

In the current prototype, a mobile emulator has been used to emulate the customer's mobile phone with which he or she contacts the server. The images on the server cannot be parsed to the mobile emulator. Therefore an html parser [4] (kxml parsing) is used to parse the text from the html output to the mobile emulator.

2.2.3 Mobile Application For Delivery People

Delivery and Pickup person has with him or her: A Mobile capable of receiving instructions regarding delivery/pick up from the server. Also, the delivery person will have: (i) Scanner for customer id. (ii) Sensors for Quality checking (depending upon the product). (iii) Measuring device.

Currently, a mobile emulator has been used for the delivery person, to which instructions from the server may be sent as sms through html parsing.

3. Logistics Optimization Of The Market.

3.1. Implementation Of Logistics Optimization.

As discussed earlier the server has to make certain decisions while choosing and assigning tasks to its delivery/pick up agents:

- It has to decide, from among all the transactions to be completed, an optimum set of transactions that could be completed by a given agent
- It has to choose which agent is most appropriate for executing a set of transactions, based on the proximity of an agent and the volume of the given set of transactions
- It has to determine for the agent, where to go pick up the products to be delivered, and the sequence in which to deliver them, and so on.

These problems fall under the broad class of logistics optimization problems. For a predetermined optimum set of transactions and for a chosen agent, the optimization problem becomes:

Minimize the overall cost of transportation in a delivery/pickup market, where costs are assigned to:

- Time of delivery/pick up
- Distance traveled (mileage)
- Mode of transport
- Value and nature of goods delivered/pickup
- Percentage lost per unit of time based on the life of the product
- Size of the delivery
- Legal issues

A preliminary version of the optimization problem has been solved in the current work.

3.2. Traveling Sales Man Problem

The traveling salesman problem [5] (TSP) is one which has commanded much attention of mathematicians and computer scientists specifically because it is so easy to describe and so difficult to solve. The problem can simply be stated as: if a traveling salesman wishes to visit exactly once each of a list of m cities (where the cost of traveling from city i to city j is cij) and then return to the home city, what is the least costly route the traveling salesman can take?

3.3. Formulations:

The first step to solving instances of large TSPs must be to find a good mathematical formulation of the problem. In the case of the traveling salesman problem, the mathematical structure is a graph where each city is denoted by a point (or node) and lines are drawn connecting every two nodes (called arcs or edges). Associated with every line is a distance (or cost). When the salesman can get from every city to every other city directly, then the graph is said to be complete. A round-trip of the cities corresponds to some subset of the lines, and is called a tour or a Hamiltonian cycle in graph theory. The length of a tour is the sum of the lengths of the lines in the round-trip.

Depending upon whether or not the direction in which an edge of the graph is traversed matters, one distinguishes the asymmetric from the symmetric traveling salesman problem. To formulate the asymmetric TSP on m cities, one introduces zero-one variables and given the fact that every node of the graph must have exactly one edge pointing towards it and one pointing away from it, one obtains the classic assignment problem. These constraints alone are not enough since this formulation would allow "sub tours", that is, it would allow disjoint loops to occur. For this reason, a proper formulation of the asymmetric traveling salesman problem must remove these sub tours from consideration by the addition of "sub-tour elimination" constraints. The problem then becomes

$$X_{ij} = \begin{cases} 1 \ \textit{if the edge } i \longrightarrow j \textit{ is in the tour} \\ 0 \ \textit{otherwise} \end{cases}$$

3.4. Distance Optimization: Semi Definite Programming[6] Relaxations Of The Traveling Sales Man Problem Using (Cvx) Sdp Solver[7]

3.4.1. Formulation 1.

The Quadratic assignment problem (QAP) may be stated as the following problem:

$$\min_{x \in p_n} \operatorname{trace}(AXBX^T)$$

Where A, B are given symmetric $n \times n$ matrices and Π_n is the set of $n \times n$ permutation matrices [8]. Conditions for the permutation matrices: If "p" is a permutation matrix satisfying the condition over A, B is that A, B elements containing the elements of same values, matrices may not be the same and A, B should be symmetric matrices [9] such that $A^T = A$, $B^T = B$.

- $P = Q_B Q_A^T$ Where Q_A and Q_B are the matrices of Eigen vectors of A and B
- $B = PAP^{-1}$
- A= $Q_A \wedge Q_A^{-1}$ where $\wedge$ represents the diagonal matrix of A
- B= $Q_B \wedge Q_B^{-1}$ where $\wedge$ represents the diagonal matrix of B

Here is an example of a labeled graph and its adjacency matrix. The convention followed here is that an adjacent edge counts 1 in the matrix for an undirected graph. (X,Y coordinates are 1-6).

- The adjacency matrix of a complete graph is all 1's except for 0's on the diagonal.
- The adjacency matrix of an empty graph is all 0's.

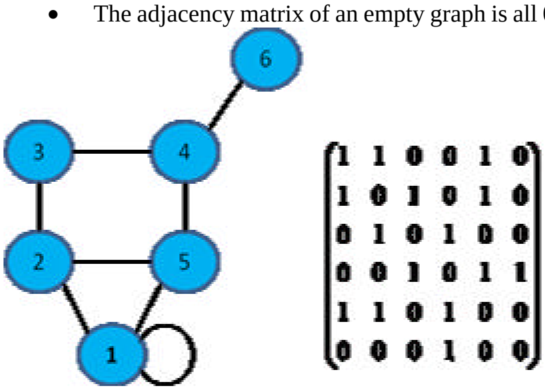

Fig4.labeled graph ,adjacency matrix

$$A=\begin{pmatrix} 0 & 2 & 3 & 4 & 1 \\ 2 & 0 & 1 & 2 & 2 \\ 3 & 1 & 0 & 5 & 3 \\ 4 & 2 & 5 & 0 & 4 \\ 1 & 2 & 3 & 4 & 5 \end{pmatrix} B=\begin{pmatrix} 0 & 4 & 3 & 2 & 1 \\ 4 & 0 & 2 & 1 & 2 \\ 3 & 2 & 0 & 5 & 3 \\ 4 & 1 & 5 & 0 & 4 \\ 1 & 2 & 3 & 4 & 5 \end{pmatrix}$$

Fig. 5 represents the relation between no of nodes that means no of customers, weighted (how much distance it will take to go from one node to another node) graph representation). X - Axis represents no of nodes and Y-axis represents weighted distance.

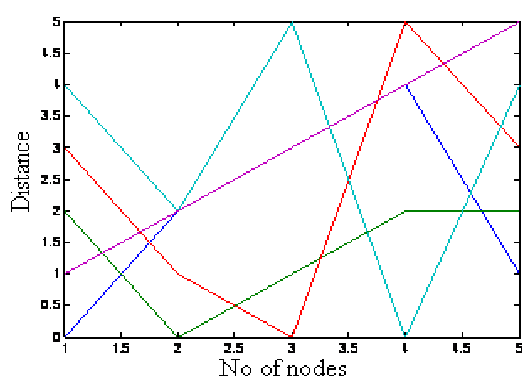

Fig5.matrix a representation

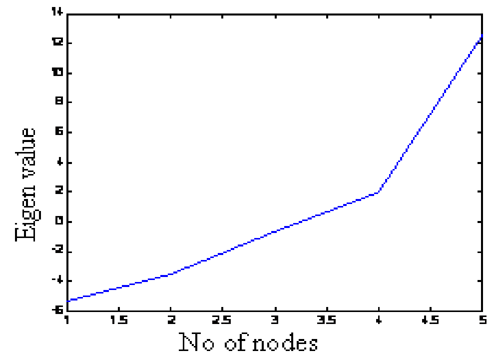

Fig6. eigen vector representation (a)

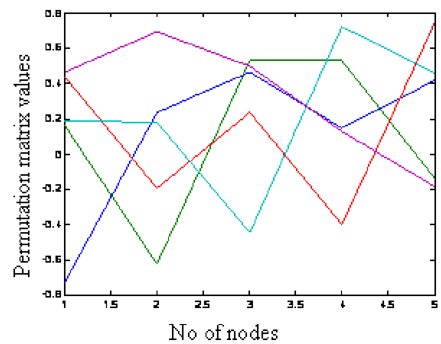

Fig7.permutation matrix representation

If we give these A, B matrices, inputs to above formulation by using convex semi definite programming solver (cvx) sdp solver in MATLAB it should give the solution to the formulation1 like this

Homogeneous problem detected; solution determined analytically.

Status: Solved

Optimal value (cvx_optval): +184.172

3.4.2. Formulation 2

It is well known that the Quadratic Assignment Problem (QAP) contains the symmetric traveling salesman problem (TSP) as a special case. To show this, we denote the complete graph on n vertices with edge lengths (weights) $D_{ij} = D_{ij} > 0 (i \neq j)$, where D is called matrix of edge lengths (weights), by $k_n(D)$.The TSP is to find a Hamiltonian circuit of minimum length in $k_n(D)$. The n vertices are often called as cities, and the Hamiltonian circuit of minimum length is the “optimal tour”.

To see that TSP is a special case of QAP, let C denote the adjacency matrix. Now the TSP problem is to obtained from the QAP formulation (1) by setting

- $A = \frac{1}{2} D$
- C=B

$$c = \begin{pmatrix} 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{pmatrix}$$

To see this, note that every Hamiltonian circuit in a complete graph has adjacency matrix XCX^T for some $X \in p_n$ .Thus we may concisely state the TSP as

$$\mathrm{TSP_{opt}} = \min_{x \in p_n} trace\left(\frac{1}{2} DXCX^T\right)$$

The solution to the above formulation by using cvx software in Matlab is:

Homogeneous problem detected; solution determined analytically.
Status: Solved
Optimal value (cvx_optval): +58.0597

3.4.3. Formulation 3

In this section we show that the optimal value of the following semi definite program provides a lower bound on the length TSP_{opt}

Where $d = \left(\frac{1}{2} n\right)$

Note that this problem involves nonnegative matrix variables $X^{(1)}, \ldots\ldots, X^{(d)}$ of order n. Here

- J is an n $\times$ n all ones matrix
- E represents all ones n vector
- I is an identity vector
- The space of n $\times$ n symmetric matrices by S_n
- The space of n $\times$ n symmetric positive semi definite matrices by S_n^+ .
- We will Also Sometimes use the notation $X \succeq \mathbf{0}$ instead of $X \in S_n^+$

$$\min_{\text{Subject to}} \frac{1}{2} trace\left(D X^{(1)} \right)$$

$$X^{(K)} \geq 0 \qquad \mathrm{K}=1,\ldots,\mathrm{d}$$

$$\sum_{k=1}^{d} X^{(k)} = J - I,$$

$$I + \sum_{k=1}^{d} \cos\left(\frac{2p\, ik}{n}\right) X^{(k)} \succeq \mathbf{0} \qquad i=1,\ldots,\mathrm{d}$$

$$X^{(k)} \in S^n \qquad \mathrm{K}=1,\ldots,\mathrm{d}$$

The solution to the above formulation is as follows by using cvx software in Matlab.
Status: Infeasible
Optimal value (cvx_optval): +Inf.

3.4.4. Formulation 4.

When applied to the QAP reformulation of TSP, this SDP relaxation takes the form:

$$\min_{\text{Subject to}} \frac{1}{2} trace(C \otimes D)Y$$

$$trace(I \otimes (J - I))Y + ((J - I) \otimes I)Y)) = 0$$

$$trace(Y) - 2ey^T = -n$$

$$\begin{pmatrix} 1 & y^T \\ y & Y \end{pmatrix} \succeq 0, Y \geq 0$$

Here $\otimes$ denotes the kronecker product [10]. It is easy to verify that this is indeed a relaxation of the formulation (2), formulation (3), by noting that

- C=B
- D=2 $\times$ A
- J is an n $\times$ n all ones matrix
- I is an identity vector
- $Y = vec(X)vec(X)^T$
- e represents all ones n vector
- $\mathbf{y} = diag(Y)$
- $X \in p_n$ Remember that p is a permutation matrix
- n is the size of the matrix

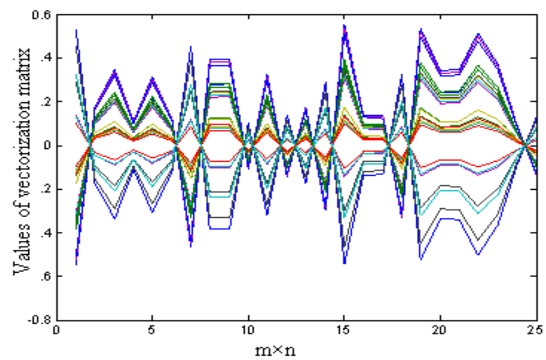

Fig8.y matrix representation using (vectorization [11]).

The solution to the above problem by using cvx software in Matlab is as follows:

Homogeneous problem detected; solution determined analytically.
Status: Solved
Optimal value (cvx_optval): +58.0597

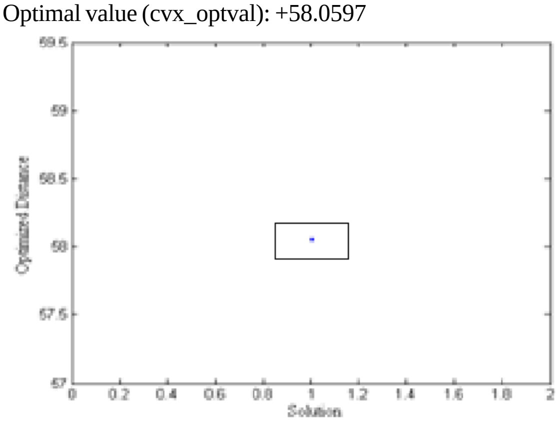

Fig9.solution to the optimization problem

Comparision(Distance Optimization)

Formulation	Nature	Status	Optimum value
1	Homogeneous . sol: Analytical	solved	+184.172
2	Homogeneous . sol: Analytical	solved	+58.0597
3	Not determined	solved	Infinitive
4	Homogeneous . sol: Analytical	solved	+59.0597

3.4.5 Time optimization

Similarly corresponding to the above formulation, in place of the distance we are going to use time as the variable and we will get the corresponding optimized time value as shown in Table.

$$A=\begin{pmatrix} 0 & 6 & 2 & 3 & 5 \\ 6 & 0 & 1 & 2 & 3 \\ 2 & 1 & 0 & 4 & 5 \\ 3 & 2 & 4 & 0 & 6 \\ 5 & 3 & 5 & 6 & 7 \end{pmatrix} \quad B=\begin{pmatrix} 0 & 3 & 6 & 2 & 5 \\ 3 & 0 & 2 & 1 & 3 \\ 6 & 2 & 0 & 4 & 5 \\ 2 & 1 & 4 & 0 & 6 \\ 5 & 3 & 5 & 6 & 7 \end{pmatrix}$$

Comparision(Time Optimization)

Formulation	**Nature**	**Status**	**Optimum value**
1	Homogeneous . sol: Analytical	solved	+349.417
2	Homogeneous . sol: Analytical	solved	+82.751
3	Not determined	solved	Infinitive
4	Homogeneous . sol: Analytical	solved	+82.751

3.4.6 Cost optimization

In this cost optimization we are going to include both distance and time as our optimization problem variables and our simple formulation becomes

$$C_{weight} = d_{weight} + t_{weight}$$

There are four special cases:

- Short distance, low wait for time
- Short distance, high wait for time
- Long distance, low wait for time
- Long distance, high wait for time

$$d_{weight} = \begin{pmatrix} 0 & 50 & 40 & 30 & 20 \\ 50 & 0 & 10 & 15 & 37 \\ 40 & 10 & 0 & 37 & 23 \\ 30 & 15 & 37 & 0 & 19 \\ 20 & 37 & 23 & 19 & 0 \end{pmatrix}$$

$$t_{weight} = \begin{pmatrix} 0 & 8 & 4 & 3 & 2 \\ 8 & 0 & 1 & 2 & 3 \\ 4 & 1 & 0 & 5 & 6 \\ 3 & 2 & 5 & 0 & 7 \\ 2 & 3 & 6 & 7 & 0 \end{pmatrix}$$

$$C_{weight} = d_{weight} + t_{weight} = \begin{pmatrix} 0 & 58 & 44 & 33 & 22 \\ 58 & 0 & 11 & 17 & 40 \\ 44 & 11 & 0 & 42 & 29 \\ 33 & 17 & 42 & 0 & 26 \\ 22 & 40 & 29 & 26 & 0 \end{pmatrix}$$

Now the matrix A and B becomes:

$$A=\begin{pmatrix} 0 & 58 & 44 & 33 & 22 \\ 58 & 0 & 11 & 17 & 40 \\ 44 & 11 & 0 & 42 & 29 \\ 33 & 17 & 42 & 0 & 26 \\ 22 & 40 & 29 & 26 & 0 \end{pmatrix}$$

And our B matrix becomes:

$$B=\begin{pmatrix} 0 & 33 & 58 & 44 & 22 \\ 33 & 0 & 17 & 11 & 40 \\ 58 & 17 & 0 & 42 & 29 \\ 44 & 11 & 42 & 0 & 26 \\ 22 & 40 & 29 & 26 & 0 \end{pmatrix}$$

The solution to the above problem is as shown in Table

Comparision (Cost Optimization)

Formulation	**Nature**	**Status**	**Optimum value**
1	Homogeneous. sol: Analytical	solved	+17189.7
2	Homogeneous. sol: Analytical	solved	+612.54
3	Not determined	solved	Infinitive
4	Homogeneous. sol: Analytical	solved	+612.54

4. Conclusion

In conclusion, a virtual market is a place where both buying and selling perform transactions with wireless communications, with a real inventory and delivery people – human-employees to pick up and deliver products, is being designed. This is to be viewed as an expansion of a real shop.

So far, most of the features of the main server for the market have been developed. In order to complete the prototype of the virtual market, the following have to be developed: features are

- Inventory management
- Server for inventory
- Sales and Purchase Management
- Vehicle Management and Tracking
- Product Quality Control using Sensors

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Veerababu Reddy received B.Tech degree from J.N.T. University and M.Tech from Amritha University.Currently he working as a Asst.professor of computer science and engineering in Vignan's Lara Institute of Technology and Science.He is involved in research of Networking, Mobile computing , Operations Research.

M.Venkata Rao received B.Tech degree in electronics and communications from Nagarjuna university, M.Tech degree from J.N.T. university, and Ph.D from University of Allahabad. He is having 15 years of teaching experience and currently working as a professor of computer science and engineering in Vignan's Lara Institute of Technology and Science .He has published /presented 15 papers inn national/international journals/conferences.He is involved in research of Parallel computing , Computer Networks and security, and Real-Time Systems.