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Industrial Engineering is concerned with the design, improvement and installation of integrated systems of men, materials and equipment. It draws upon specialised knowledge and skill in the mathematical, physical and social sciences together with the principles and methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems.

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VOL. XVI & ISSUE No. 04 April 2023

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Message from the Editor



Dear Readers,

Indian Institution of Industrial Engineering is very happy to publish this issue of the Industrial Engineering Journal.

The First Paper of this issue **"ANALYTICS DRIVEN APPROACH TO SOLVING THE TRAVELLING SALESMAN PROBLEM"** has been authored by **Shri Rahul Sahai.** In this paper, the author presents a very interesting and informative perspective of travelling salesman problem through OSRM package and Docker enterprise.

The Second Paper of this issue **"MODELING IT ROLE IN SHIPPING INDUSTRY: AN APPLICATION OF ISM "** has been authored by **Prof. Ashish Agarwal, Dr. Vipan Kumar Chand & Ms. Nishtha Agarwal.** This paper presents a supply chain modelling of shipping industry through ISM technique.

The Third Paper of this issue "**EFFECTS OF COVID-19 PANDEMIC ON INDIAN MANUFACTURING MSME: OPPORTUNITIES & CHALLENGES**" has been authored by **Sarfraz Ali Quadri & Dr. Dhananjay R. Dolas**. This paper highlights the opportunities and challenges of Covid-19 pandemic on Indian MSMEs and presents suitable recommendation.

The Fourth Paper of this issue **"INVESTIGATION OF RESOURCE SCHEDULING ISSUES IN FOG AND EDGE ENVIRONMENT"** has been authored by **Kapil Tarey & Dr. Vivek Shrivastava.** This paper investigates and highlights major concerns for scheduling resources in the environments of fog and edge computing technologies.

The Fifth Paper of this issue **"IMPROVEMENT IN PRODUCTIVITY BY PROPER UTILISATION OF AVAILABLE RESOURCES"** has been authored by **Ms. Tejal Raut & Prof. Niyati Raut.** This paper presents a lean production framework to improve the efficiency of a manual assembly line.

The Sixth Paper of this issue **"BUILDING INTUITIVE CHATBOTS FOR HUGE KNOWLEDGE BASES USING INFORMATION RETRIEVAL"** has been authored by **Umesh D & Dr. Vikas S.** In this paper, the authors present the probable use of Chatbots.

I express a deep sense of gratitude to all those who have been involved directly and indirectly in bringing out this issue in its present form. We are grateful to all the members of the Editorial Board for giving useful suggestions for improving the content of the Journal. Our thanks are due to all reviewers for sparing their valuable time to review the manuscripts of these papers. The authors who have contributed their papers to this issue deserve special thanks.

We expect to receive continued support from our esteemed readers, reviewers, and authors.

Prof. (Dr.) Kuldip Singh Sangwan,
Editor-in-Chief

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INDUSTRIAL ENGINEERING JOURNAL

ANALYTICS DRIVEN APPROACH TO SOLVING THE TRAVELLING SALESMAN PROBLEM

Rahul Sahai

ABOUT THE TRAVELLING SALESMAN PROBLEM

- The travelling salesman problem (also called the travelling salesperson problem or TSP) asks the following question: "Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city exactly once and returns to the origin city?" It is an NP-hard problem in combinatorial optimization, important in theoretical computer science and operations research.
- The travelling purchaser problem and the vehicle routing problem are both generalizations of TSP.
- In the theory of computational complexity, the decision version of the TSP (where given a length L, the task is to decide whether the graph has a tour of at most L) belongs to the class of NP-complete problems. Thus, it is possible that the worst-case running time for any algorithm for the TSP increases superpolynomially (but no more than exponentially) with the number of cities.
- The problem was first formulated in 1930 and is one of the most intensively studied problems in optimization. It is used as a benchmark for many optimization methods. Even though the problem is computationally difficult, many heuristics and exact algorithms are known, so that some instances with tens of thousands of cities can be solved completely and even problems with millions of cities can be approximated within a small fraction of 1%.

ABOUT THE TRAVELLING SALESMAN PROBLEM

The TSP has several applications even in its purest formulation, such as planning, logistics, and the manufacture of microchips. Slightly modified, it appears as a sub-problem in many areas, such as DNA sequencing. In these applications, the concept city represents, for example, customers, soldering points, or DNA fragments, and the concept distance represents travelling times or cost, or a similarity measure between DNA fragments.

The TSP also appears in astronomy, as astronomers observing many sources will want to minimize the time spent moving the telescope between the sources; in such problems, the TSP can be embedded inside an optimal control problem. In many applications, additional constraints such as limited resources or time windows may be imposed.

INTRODUCTION TO OPEN STREET MAPS

- Open Street Map (OSM) is a free, open geographic database updated and maintained by a community of volunteers via open collaboration. Contributors collect data from surveys, trace from aerial imagery and also import from other freely licensed geodata sources.
- Open Street Map is freely licensed under the Open Database License and as a result commonly used to make electronic maps, inform turn-by-turn navigation, assist in humanitarian aid and data visualisation. OpenStreetMap uses its own topology to store geographical features which can then be exported into other GIS file formats.
- The Open Street Map website itself is an online map, geodata search engine and editor.

LEVERAGING ROUTING MACHINES

In contrast to most routing servers, OSRM does not use an “A” variant to compute the shortest path, but instead uses contraction hierarchies or multilevel Dijkstra's. This results in very fast query times, usually below 1 millisecond for data sets like Europe, making OSRM a good candidate for responsive, web-based routing applications and websites.

- Very fast routing
- Highly portable
- Simple data format makes it easy to import custom data sets instead of OpenStreetMap data or import traffic data
- Flexible routing profiles (e.g., for different modes of transportation)
- Respects turn restrictions, including time-based conditional restrictions
- Respects turn lanes
- Localized turn-by-turn instructions powered by OSRM Text Instructions

Besides chronological routing, OSRM also provides additional functionality, such as map matching, traveling salesman problem solving, and generating vector tiles that contain routing metadata.



Open Street Map

OSRM PACKAGE FOR R MAKES IT CONVENIENT TO SEND ROUTE REQUESTS TO OSRM SERVER

The public server is fine for testing but not for sending too many requests in a short time. It will give errors and not work. Therefore it is suggested to get your own OSRM instance.

The easiest solution is to run it with Docker. This requires 2 preparatory steps:

Install Docker CE https://docs.docker.com/install/
Get the osrm-backend running https://hub.docker.com/r/osrm/osrm-backend/
The first step of installing Docker might take 30 minutes if you follow the steps in the installation tutorial. The second step, to run the Docker container on your machine, is also pretty straightforward if you follow the Quick Start section in the Docker Hub link provided above.

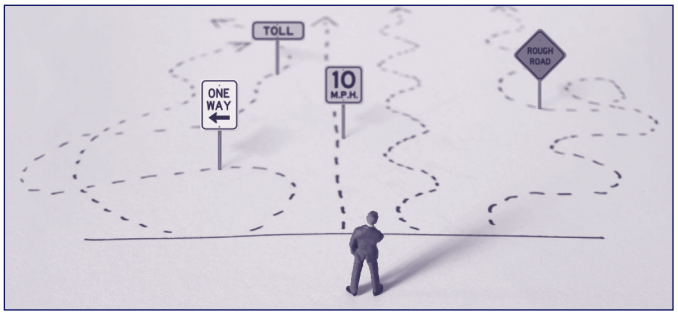
The OpenStreetMap data required to compute paths can be downloaded from http://download.geofabrik.de. For this project we want the latest data (*.osm.pbf) of Switzerland, which can be downloaded here.

```
install.packages("osrm")
library(osrm)
## Data: (c) OpenStreetMap contributors, ODbL 1.0 - http://www.openstreetmap.org/copyright
## Routing: OSRM - http://project-osrm.org/
By default the OSRM package uses a public demo server.
getOption("osrm.server")
## [1] "http://router.project-osrm.org/"
```

Start by installing the OSRM package

CALCULATING HOW FAR ARE YOU FROM YOUR CUSTOMERS?

- Optimizing your physical touch points is an important aspect of customer support (depending on the type of support we are talking about)
- Areas to ponder over:
  - Enhance response times
  - Reduce costs of touch points that are redundant
  - Better manage warranty support
  - … and more…

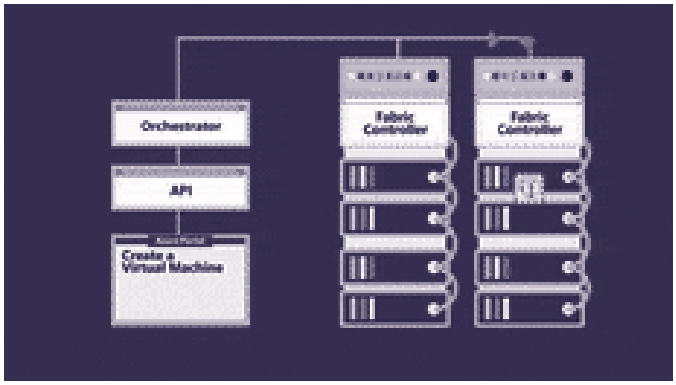


LET'S COVER SOMETHING DIFFERENT TODAY…

- Virtual Machines & Containers
- Enable Hyper-V
- Docker Installation
- Running the OSRM Backend
- The Code
- Output

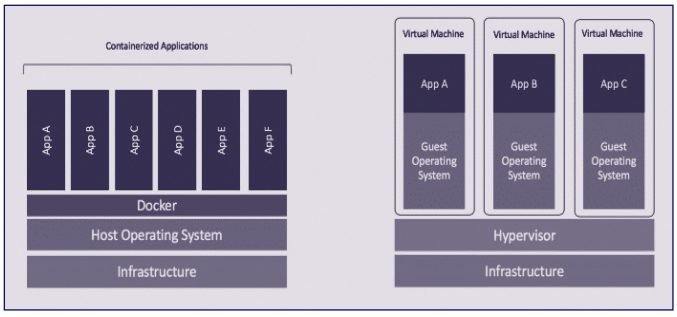


VIRTUAL MACHINES



Virtual Machine (VM) is an emulation of a computer system. Virtual machines are based on computer architectures and provide functionality of a physical computer. Their implementations may involve specialized hardware, software, or a combination.

Containers Are More Agile than VMs

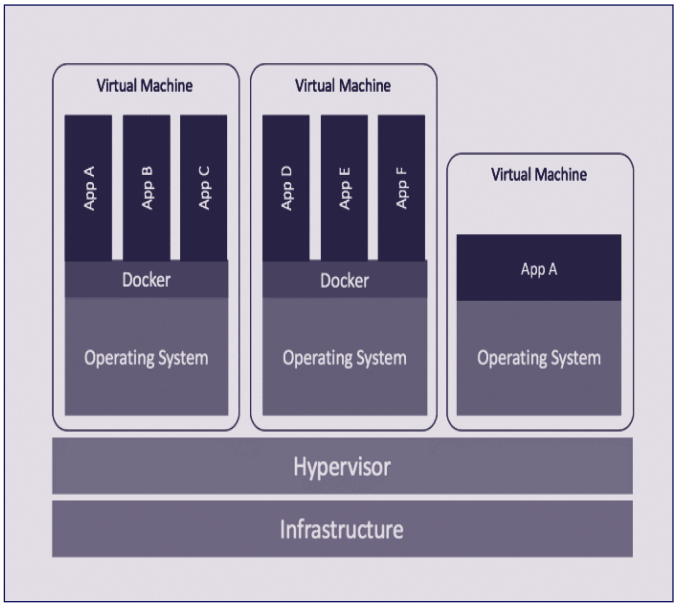


Containers give both developers and operators more agility. Containers deploy quickly, deliver immutable infrastructure and solve the age-old "works on my machine" problem. They also replace the traditional patching process, allowing organizations to respond to issues faster and making applications easier to maintain.

CONTAINERIZED APPLICATIONS GREATLY REDUCE THE NUMBER OF VMS NEEDED

Most enterprise organizations have a mature virtualization environment which includes tooling around backups, monitoring, and automation, and people and processes that have been built around it. By running Docker Enterprise on virtualized infrastructure, organizations can easily integrate containers into their existing practices and get the benefits of points 1 and 2 above.

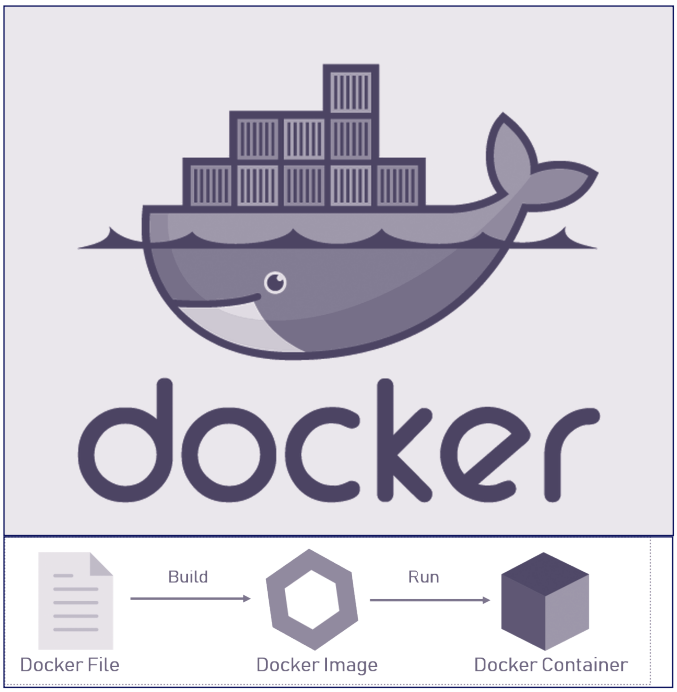
Containerized applications share common operating system and software libraries which greatly improves CPU utilization within a VM. This means an organization can reduce the overall number of virtual machines needed to operate their environment and increase the number of applications that can run on a server.



… AND THE WINNER IS DOCKER

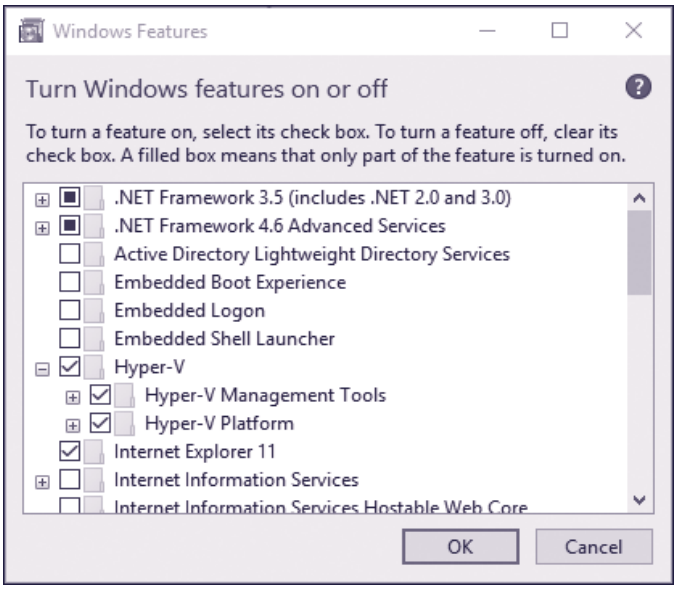
In the end, Docker containers can run inside a virtual machine or on bare metal – the choice is up to you. Just like every other decision in the data center, the path you want to go down should align to your business priorities. Containers work well with virtual machines, but they can also run without them.

- Docker can help facilitate savings by dramatically reducing infrastructure resources.
- Docker containers ensure consistency across multiple development and release cycles, standardizing your environment
- Docker enables you to build a container image and use that same image across every step of the deployment process. A huge benefit of this is the ability to separate non-dependent steps and run them in parallel.
- Eliminate the "it works on my machine" problem once and for all. One of the benefits that the entire team will appreciate is parity.

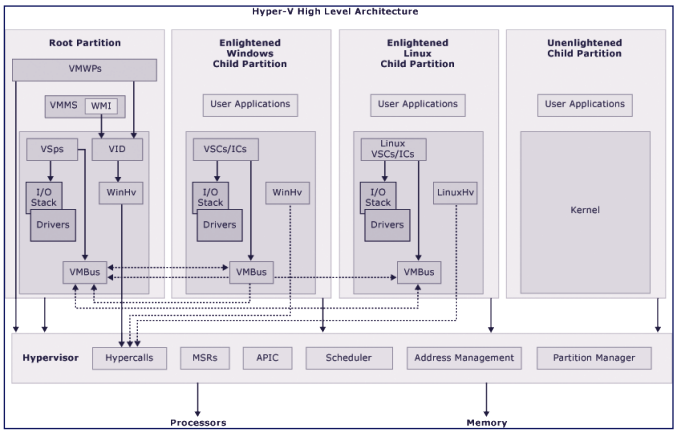


GETTING STARTED- ENABLE HYPER-V

- Hyper-V lets you run multiple operating systems as virtual machines on Windows
- Hyper-V specifically provides hardware virtualization. That means each virtual machine runs on virtual hardware. Hyper-V lets you create virtual hard drives, virtual switches, and several other virtual devices all of which can be added to virtual machines.
- Experiment with other operating systems. Hyper-V makes it very easy to create and remove different operating systems
- Hyper-V is available on 64-bit versions of Windows 10 Pro, Enterprise, and Education. It is not available on the Home edition
- Most computers run Hyper-V, however each virtual machine runs a separate operating system. You can generally run one or more virtual machines on a computer with 4GB of RAM



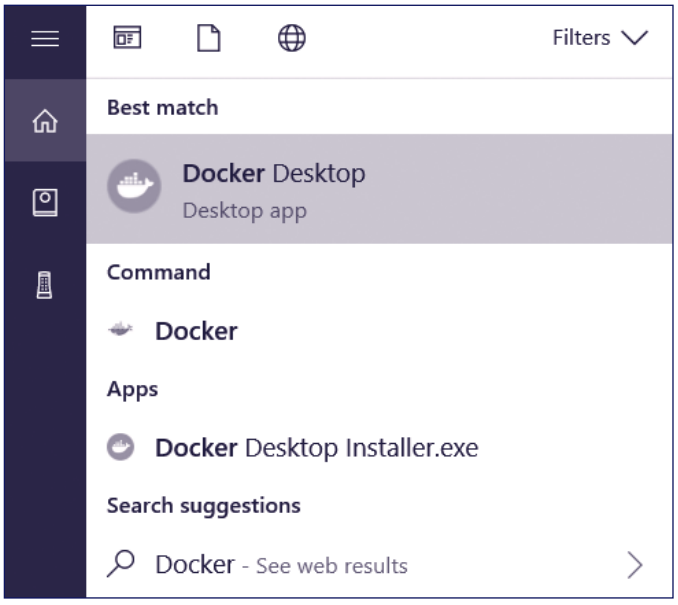
Hyper V- Architecture



DOCKER INSTALLATION

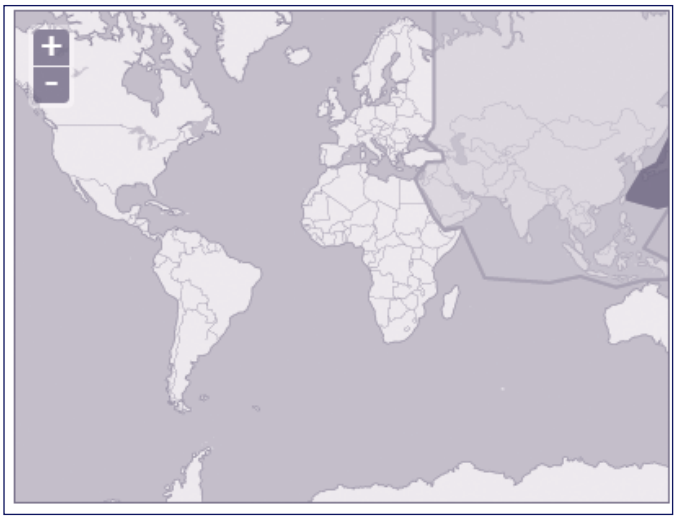
https://docs.docker.com/docker-for-windows/install/

- Double-click Docker Desktop Installer.exe to run the installer.
- If you haven't already downloaded the installer (Docker Desktop Installer.exe), you can get it from Docker Hub. It typically downloads to your Downloads folder, or you can run it from the recent downloads bar at the bottom of your web browser.
- When prompted, ensure the Enable Hyper-V Windows Features option is selected on the Configuration page.
- Follow the instructions on the installation wizard to authorize the installer and proceed with the install. When the installation is successful, click Close to complete the installation process.
- If your admin account is different to your user account, you must add the user to the docker-users group. Run Computer Management as an administrator and navigate to Local Users and Groups > Groups > docker-users. Right-click to add the user to the group. Log out and log back in for the changes to take effect.



Download OpenStreetMap data for region

Sub Region	Quick Links		
	.osm.pbf	.shp.zip	.osm.bz2
Afghanistan	[.osm.pbf] (40.6 MB)	[.shp.zip]	[.osm.bz2]
Armenia	[.osm.pbf] (28.2 MB)	[.shp.zip]	[.osm.bz2]
Azerbaijan	[.osm.pbf] (23.9 MB)	[.shp.zip]	[.osm.bz2]
Bangladesh	[.osm.pbf] (226 MB)	[.shp.zip]	[.osm.bz2]
Bhutan	[.osm.pbf] (7.4 MB)	[.shp.zip]	[.osm.bz2]
Cambodia	[.osm.pbf] (25.2 MB)	[.shp.zip]	[.osm.bz2]
China	[.osm.pbf] (640 MB)	[.shp.zip]	[.osm.bz2]
GCC States	[.osm.pbf] (108 MB)	[.shp.zip]	[.osm.bz2]
India	[.osm.pbf] (826 MB)	[.shp.zip]	[.osm.bz2]
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Japan	[.osm.pbf] (1.5 GB)	✖	[.osm.bz2]
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Malaysia, Singapore, and Brunei	[.osm.pbf] (157 MB)	[.shp.zip]	[.osm.bz2]
Maldives	[.osm.pbf] (3.1 MB)	[.shp.zip]	[.osm.bz2]
Mongolia	[.osm.pbf] (31.3 MB)	[.shp.zip]	[.osm.bz2]
Myanmar (a.k.a. Burma)	[.osm.pbf] (123 MB)	[.shp.zip]	[.osm.bz2]



http://download.geofabrik.de/asia.html

KICKSTART THE CONTAINER FROM DOCKER

PS C:\Users***Path***> docker run -t -v "${PWD}:/data" osrm/osrm-backend osrm-extract -p /opt/car.lua /data/india-latest.osm.pbf

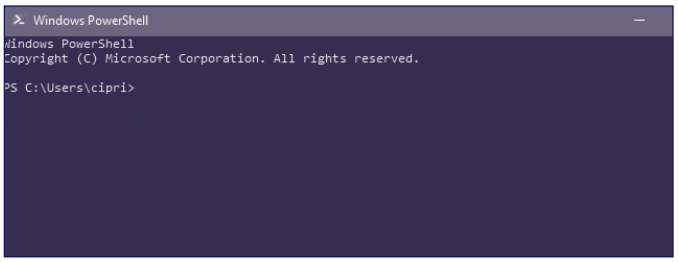
PS C:\Users ***Path*** > docker run -t -v "${PWD}:/data" osrm/osrm-backend osrm-partition /data/india-latest.osrm

PS C:\Users***Path*** > docker run -t -v "${PWD}:/data" osrm/osrm-backend osrm-customize /data/india-latest.osrm

PS C:\Users ***Path*** > docker run -t -i -p 5000:5000 -v "${PWD}:/data" osrm/osrm-backend osrm-routed --algorithm mld --max-table-size 65535 /data/india-latest.osrm

↑

Don't forget to increase table size



Load your files: Customers locations and your touch points

```
library(osrm)
getOption("osrm.server")
options(osrm.server = "http://localhost:5000/")
getOption("osrm.server")
library(tidyverse)
library(readxl)

dealer <- read_excel("201101 dealerTP.xlsx")
view(dealer)
customers <- read_excel("201101 customers.xlsx")
```

Containerized server instance from your own machine

REQUESTING TRAVEL TIMES

```
basicmap %>%
  addCircleMarkers(data = customers, lng = customers$Longitude, lat = customers$Latitude, color = "orange", radius = 3,
                   group = "customers") %>%
  addLayersControl(overlayGroups = c("Touch", "customers"))

#requesting for travel times using osrm table- input data frames with the columns id/lon/lat

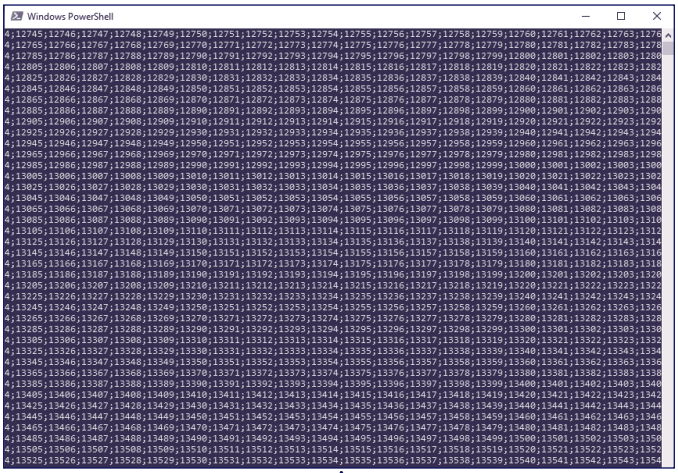
n_cust=nrow(customers)
customers_df <- customers %>%
  dplyr::select(4, 3) %>%
  mutate(id=1:n_cust) %>%
  as.data.frame()
customers_df <- customers_df %>%
  select(id, everything())

n_touch=nrow(dealer)
dealer_df <- dealer %>%
  dplyr::select(8, 7) %>%
  mutate(id=1:n_touch) %>%
  as.data.frame()
dealer_df <- dealer_df %>%
  select(id, everything())


t0 <- Sys.time()
distancetable <- osrmTable(src = dealer_df, dst = customers_df)
Sys.time() - t0
distancetable %>% summary()

#Next, we extract the minimal driving times and add it to a map
mindistances <- bind_cols(distancetable$sources, mintime = apply(distancetable$durations, 1, min)) %>%
  as_tibble() %>%
  mutate(mintime_str = as.character(mintime))

binpal <- colorBin("Blacks", domain = 0:max(mindistances["mintime"]))
basicmap %>%
  addCircleMarkers(data = mindistances, lng = customers$Longitude , lat = customers$Latitude, radius = 4,
                   color = ~binpal(mintime), popup = ~mintime_str,
                   group = "Driving times") %>%
  addLayersControl(overlayGroups = c("Touch", "Driving times"))
```



You will see the Powershell send data to the OSRM Table (through the container instance you have created earlier)

FEW FINAL TOUCHES…

```
# request OSRM server
t0 <- Sys.time()

distancetable <- osrmTable(src = customers_df, dst = dealer_df)

rrt <- as.numeric(Sys.time(), units = "secs") %>% round(3)

mindistances_i <- bind_cols(distancetable$sources, mintime = apply(distancetable$durations, 1, min)) %>%
  as_tibble() %>%
  mutate(mintime_str = as.character(mintime))

mindistances <- bind_rows(mindistances, mindistances_i)

print(str_c("run: , request response time: ", rrt, "secs"))

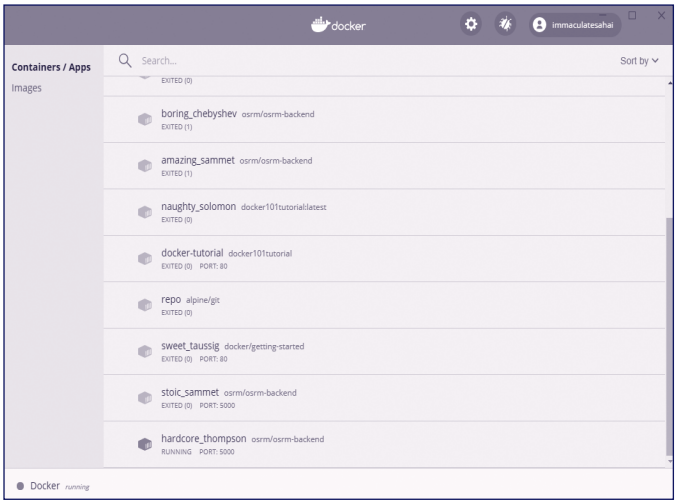
# we also add the coordinates of the dealers themselves with a mintime of 0.
mindistances <- bind_rows(mindistances,
                          dealer_df %>%
                            dplyr::select(Longitude, Latitude) %>%
                            mutate(mintime = 0, mintime_str = "0"))

  mindistances <- mindistances %>%
  distinct()

nrow(mindistances)

#Let's see it our map
binpal <- colorBin("blacks", domain = 0:max(mindistances["mintime"]))

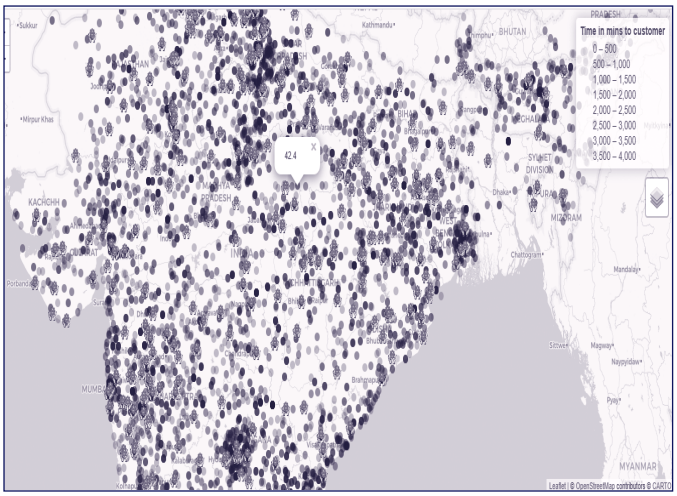
basicmap %>%
  addCircleMarkers(data = mindistances, lng = customers$Longitude, lat = customers$Latitude, radius = 5,
                   color = ~binpal(mintime), popup = ~mintime_str,
                   group = "Driving times",
                   opacity = 0.2) %>%
  addLegend(data = mindistances, pal = binpal, values = ~mintime, group = "Driving times",
            title = "Time in mins to customer") %>%
  addLayersControl(overlayGroups = c("Touch", "Driving times"))
```



Docker containers

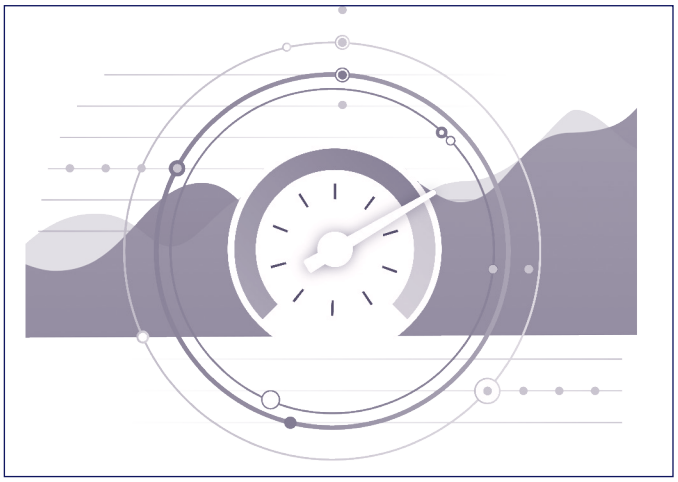
BRINGING IT TOGETHER ON THE MAP…

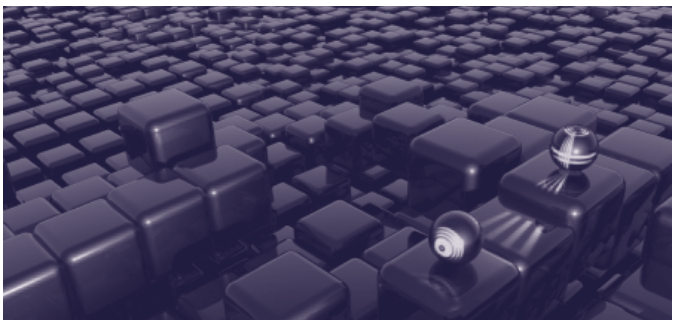
Minimum Travel times from closest optimized locations for customer support



Blue- Your locations
Black- Customer Locations
Bubble- minimum time taken to travel from closest location

THIS WORKS GREAT FOR LARGE SCALE ROUTING OPTIMIZATIONS!





http://project-osrm.org/docs/v5.23.0/api/#

AUTHOR

Shri Rahul Sahai, President IIIE NC, Chief Executive Officer, Kirloskar Oil Engines Limited, Laxmanrao Kirloskar Road, Khadki, Pune – 411 003 (MS) India
Website: www.kirloskaroilengines.com

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MODELING IT ROLE IN SHIPPING INDUSTRY: AN APPLICATION OF ISM

Prof. Ashish Agarwal
Dr. Vipan Kumar Chand
Ms. Nishtha Agarwal

Abstract

Purpose: *Supply chain management (SCM) in Maritime sector helps shipping companies in integrating their logistics and maritime cargo operation by collaborating with other maritime entities to meet the unpredictable demand of the end user at the importing countries. Use of IT is the fundamental characteristic of a Maritime Supply Chain (MSC) needed for survival in turbulent and volatile Maritime competition, which is a requirement for the transparency in business. Getting the right cargo, at the right time for the consignee is not only the utmost priority for competitive success, but also the key to survival. Maritime fraternity's satisfaction and understanding of maritime sector are critical in the use of IT in management of supply chain both cargo and passengers. This study is an attempt to develop a structural model of variables for modeling role of IT in Shipping Industry using ISM.* ***Approach:*** *From the maritime literature review and opinion of the experts from maritime fraternity, various variables for role of IT in shipping industry have been identified. After brain storming to the top management expert of Ships (Captains and Chief Engineers), certain variables were identified. Based on the driving power and dependence of variables, classifications of these were achieved. Questionnaires were E-mailed to forty ships to rank these variables and as per responses received. These variables in the management of use of IT in maritime supply chain have been analyzed using Interpretive Structural Modeling (ISM).* ***Findings:*** *Eleven variables have been identified from the maritime literature and subsequent discussion with onboard maritime experts. Based upon the expert's opinions, the model so developed is a hypothetical. Clear understanding of interaction among these variables will help maritime sector to prioritize and manage these variables more efficiently and effectively to draw advantage in use of IT in Maritime sector.* ***Originality:*** *Through this, researcher contributes to identify the variables to implement IT in maritime sector and prioritize them. The structural model developed will help to understand interdependence of the variables in maritime sector.*

Key words: Maritime sector, Business sensitivity, Interactive, Reachability, Interaction, MICMAC

1. INTRODUCTION

An integrated Maritime supply chain engineered to cope with uncertainly can satisfy customer demand at the consignee end, while non- integrated logistics and cargo distribution leads to poor relationships with maritime fraternity and end user at discharge port at importing country. This may be the recipes of business failure at Maritime sector. In the era of time-based competition, supply chain must have the ability to meet the demand of customers at importing country in shorter delivery times and also during the peaks and troughs of the demand. To have this ability, MSC must be responsive to the needs of importing country, which requires speed and high level of maneuverability in management of vessels in Ports and sea- passage. This is greatly enhanced by the use of IT in the maritime sector. This environmental force reduces uncertainly of higher risk in the supply chain management. Turbulent and volatile markets are becoming the norm as life cycles shorten and global economic and competitive forces create additional uncertainty. The risk attached to lengthy and slow-moving logistics "pipelines" has become unsustainable, forcing organizations to look again at how their supply chains are structured and managed. (Christopher Martin, 2000). The choice of supply chain strategy should be based upon a careful analysis of the demand/supply characteristics of the various product/markets served by a shipping company through maritime sector. It presents the basis for taxonomy of appropriate supply chain strategies. (Martin Christopher et al., 2006). Sustainability and the search for solutions that are both efficient and ecologically sound (eco-efficient) have become topics of great interest. However, companies seeking to develop supply chain solutions that are eco-efficient are often hampered by their ability to control the wider supply chain and they may need to draw upon external support from logistics service providers. Efficient use of IT in Maritime Business enhances the capabilities that embrace organization structure, information system and, in particular, mindset. Proper use of IT in MSC means using maritime knowledge and virtual corporation to exploit profitable opportunities in a volatile marketplace at consignee as well as shippers end. ISM is a methodology for identifying and summarizing relationships among specific elements, which define an issue or problem and provides a means by which order can be imposed on the complexity of such element (Mandal, A., and Deshmukh, S. G., 1994). The emphasis is on adaptability to changes in the business addressing market and customer needs proactively. Changes in the business environment due to varying needs of the customers lead to uncertainty in the decision parameters. (Agarwal, A. et al., 2006). The model brings out the inter-relationships of the variable and their levels. These variables have also been categorized depending on their driving power and dependence. The insight from model would help supply chain managers in strategic planning for improving supply chain with proper use of IT.

2. LITERATURE REVIEW

Customer service is a strategic weapon in the attraction and retention of customers, and has become one of the most significant factors in the success of manufacturers and service providers (Zeithaml, 1988; Gale, 1994; Woodruff, 1997; Parasuraman, 1998). Studies on Maritime sector and connecting supply chain during ocean passage as old as when human start fathoming the oceans for their supremacy.

3. METHODOLOGY

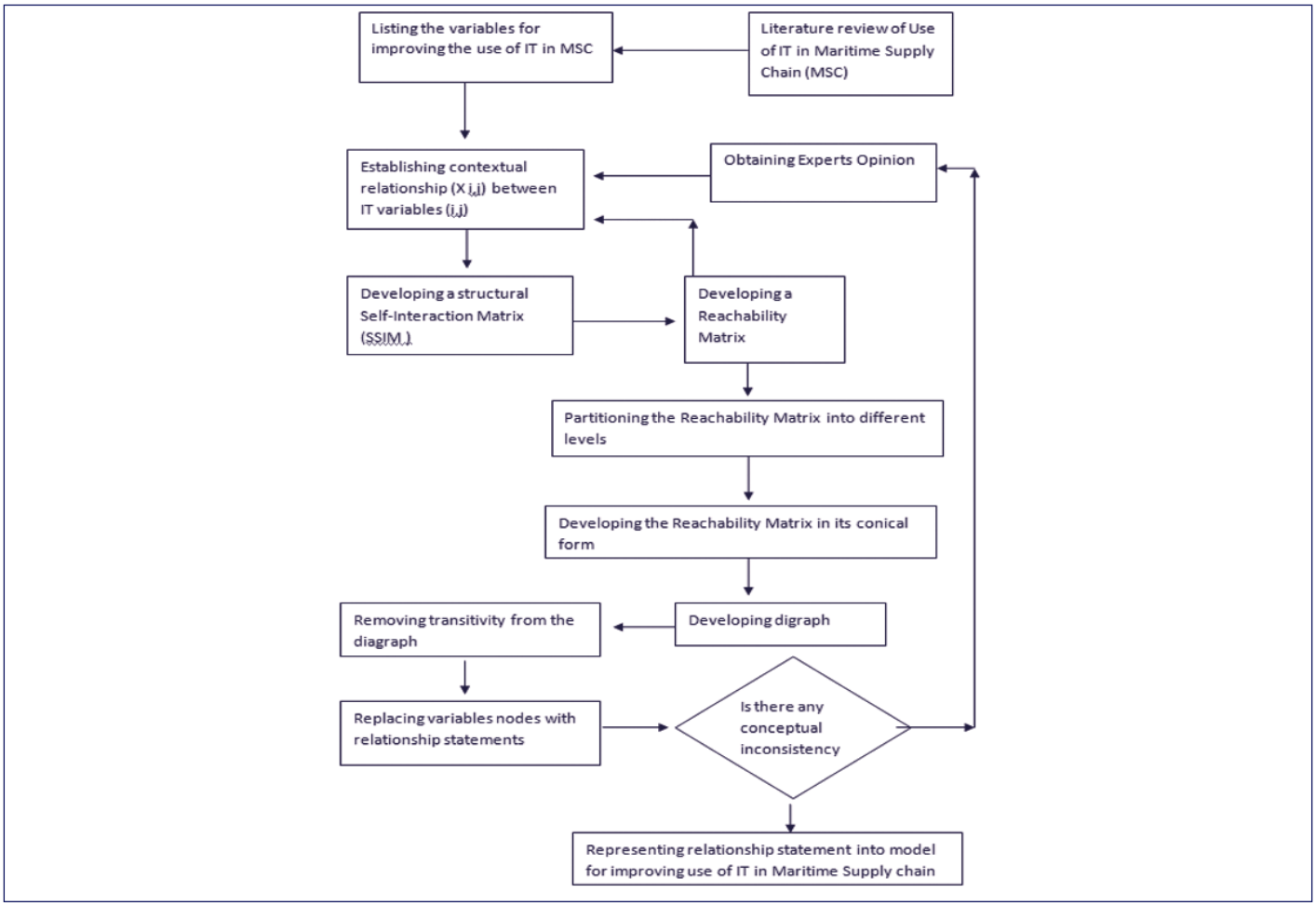
ISM is an interactive learning process. A set of different and directly related element are structured into a comprehensive systemic model. The model so formed portrays the structure of complex issue or problem, a system or a field of study, in a carefully designed pattern implying graphics as well as words. . (Sage A.P. 1977). Interpretive Structural Modeling is a methodology for identifying and summarizing relationships among specific elements, which define an issue or problem. It provides a means by which order can be imposed on the complexity of such elements. (Singh M. D., et al., 2003). ISM is well established methodology for identifying and summarizes the mutual relationships among the specific items which define a problem or an issue. (Sharma et al., 2012). ISM methodology helps to impose order and direction on the complexity of relationships among element of a system.

The objective of MICMAC analysis is to analyze the driving power and dependence power of variables (Saxena et al., 1990; Mandal and Deshmukh, 1994)

The various steps (Figure 1) involved in the ISM technique are:

1. Variables which can be objectives, Actions, individuals in use of IT are being listed first, then establish a contextual relationship between variables with respect to which pair of variables will be examined.
2. After this develop a Structural Self Interaction Matrix (SSIM) of variables, which indicates pair-wise relationship between variables of the system.
3. Once the development of SSIM is complete, then develop a Reachability matrix from the SSIM, and check the matrix for transitivity, then partition the Reachability matrix into different levels is to be done.
4. Then develop the Reachability in its conical form, i.e. with most zero (0) variables in the upper diagonal half of the Matrix and most unitary (1) variables in the lower half.
5. Based on the above, draw a directed graph (digraph), and remove transitive links.
6. Convert the resultant digraph into an ISM, by replacing variable nodes with statements.
7. For checking any conceptual inconsistency, review the ISM model and carry out the necessary modifications.

Fig. 1: Flow Diagrams for ISM



4. IDENTIFICATION OF ELEMENTS

Based on literature review and Marine expert's opinion, the following variables have been identified:

1. Business Sensitiveness (BS)
2. Sea-passage Connectivity (SC)
3. Data Accuracy (DA)
4. Latest Equipments Introduction (LEI)
5. Centralized and Collaborating Planning (CCP)
6. Use of IT Tools (UIT)
7. Service Level Improvement (SLI)
8. Cost Minimization (COM)
9. Customer Satisfaction (CUS)
10. Quality Improvement (QI)
11. Trust Development (TD)

5. QUESTIONNAIRE – BASED SURVEY

The questionnaire consists of eleven variables related to MSC agility. These variables are identified on the basis of a personal visit and discussion with experts in shipping company having more than five years of experience in MSC area. Questionnaire was E-mailed to management level (Captain, Chief Officer, Chief Engineers and 2nd Engineers) staff of the 40 ships. Out of 160 questionnaires sent, 42 responsive were received, resulting 26% response rate. Out of 42 responses it is found that of 37 numbers are usable. The purpose of the questionnaire-based survey was to identify the impact of IT on SC in Maritime sector from user at maritime sector at seaway point of view. Later, the correlation matrix for the variables obtained from the questionnaire results, is used together with.

6. ANALYSIS

6.1 Structural Self-Interaction Matrix (SSIM): Variables of modeling IT in shipping Industry using ISM, discussed in earlier section, are maritime business sensitiveness (element 1), data accuracy (element 2), Latest equipment introduction (element 3), centralized and collaborative planning (element 4), use of IT tools (element 5), service level improvement (element 6), cost minimization (element 7), customer satisfaction (9), quality improvement (10) and trust development (11). For analyzing variables of modeling IT in shipping industry using ISM, a contextual relationship of "leads to" type is chosen. This means that one variable led to another variable. Keeping in mind the contextual relationships for each variable, the assistance of a relation between any two sub-variables (i and j) and the associated direction of the relation are questioned.

Four symbols are used for the type of the relation that exists between the two sub-variables under consideration:

V- Variable i will help to achieve variable j;

A-Variable j will help to achieve variable i;

X-Variables i and j will help achieve each other, and

O-Variables j and i are unrelated.

The supply chain, under study, is in fast moving consumer goods business and consists of IT expert, ship mangers dealing with HR and stores, and Captain of ship's (on leave). Five experts from different ship and ashore, were consulted in identifying the variables and nature of contextual relationships among variables. The expert was having more than ten years of experience in the area of Maritime supply chain management. These experts were consulted in camera and they were asked to provide a consensus score for each pair wise comparison. Though ISM methodology suggests use of expert's opinion alone (based on various management technique such as nominal group technique etc.) in developing the contextual relationship, the correlation coefficients obtained from the questionnaire have also been used to facilitate the experts in identifying the nature of these relationships.

The following statements explain the use of symbols, V, A, X and O in SSIM.

1) According to expert's opinion Business sensitiveness (element 1) and quality improvement (element 10) are unrelated; therefore, O is assigned to the cell in the SSIM at the intersection of row of Business sensitiveness (element 1) and column of quality improvement (element 10). The experts feel that Business sensitiveness hardly help in achieving quality improvement. Similarly, quality improvement does not help to enhance market sensitiveness of a supply chain.
2) Business sensitiveness (element 1) helps to achieve customer satisfaction (element 9); hence V is assigned to the cell at the intersection of Business sensitiveness (element 1) row and customer satisfaction and (element 9) column.
3) Connectivity performance (element 2) will be achieved by Business sensitiveness (element 1) and Business sensitiveness will be achieved by connectivity performance; hence A is assigned in the cell at the intersection of Business sensitiveness row and connectivity performance column.
4) Centralized and collaborative planning (element 5) helps in service level improvement (element 7), and service level integration initiates centralized and collaborative planning; therefore, relationship X is assigned in at intersection of centralized and collaboration and planning and service level improvement.

Based on these contextual relationships, the SSIM is developed as shown in Table 1.

Table 1: Structural Self Interaction Matrix (SSIM)

Elements	11	10	9	8	7	6	5	4	3	2
1	A	O	V	O	O	A	A	V	A	V
2	A	O	V	O	V	A	A	O	A	
3	A	V	O	O	O	A	O	O		
4	A	O	V	O	O	A	A			
5	V	O	O	V	O	V				
6	V	O	O	O	O					
7	O	O	V	O						
8	O	O	X							
9	O	A								
10	O									
11										

6.2 Reachability Matrix: The SSIM format is transformed into a Reachability matrix format by transforming the information in each entry of the SSIM into 1s and 0s in the Reachability matrix.

Four situations related to this model are as follows:

1. If the (i, j) entry in the SSIM is V, then the (i, j) entry in the Reachability matrix becomes 1 and the (j,i) entry becomes 0.
2. If the (i, j) entry in the SSIM is A, then the (i, j) entry in the matrix becomes 0 and the (j,i) entry becomes 1.
3. If the (i, j) entry in the SSIM is X, then the (i, j) entry in the matrix becomes 1 and the (j, i) entry also becomes 1.
4. If the (j,i) entry in the SSIM is O, then the (i,j) entry in the matrix becomes 0 and the (j,i) entry becomes 0.

Initial Reachability matrix for the variables is prepared and shown in table 2.

Table 2: Reachability Matrix

Elements	1	2	3	4	5	6	7	8	9	10	11
1	1	1	0	1	0	0	0	0	1	0	0
2	0	1	0	0	0	0	1	0	1	0	0
3	1	1	1	0	0	0	0	0	0	1	0
4	0	0	0	1	0	0	0	0	1	0	0
5	1	1	0	1	1	1	0	1	0	0	1
6	1	1	1	1	0	1	0	0	0	0	1
7	0	0	0	0	0	0	1	0	1	0	0
8	0	0	0	0	0	0	0	1	1	0	0
9	0	0	0	0	0	0	0	1	1	0	0
10	0	0	0	0	0	0	0	0	1	1	0
11	1	1	1	1	0	0	0	0	0	0	1

There was no gap found in the opinion collecting during development of structural self-instructional matrix. The final Reachability matrix is same as table 3.

6.3 Partitioning the Reachability Matrix: The matrix is partitioned by assessing the Reachability and antecedent sets for each variable. The Reachability set consists of the element itself and other elements, which it may help to achieve, whereas the antecedent set consists of the element and other elements, which may help achieving it. Then the intersection of these sets is derived for all the elements. The elements for which the Reachability and intersection sets are same are the top-level elements in the ISM hierarchy. The top-level element of the hierarchy would not help to achieve any other element above their own level in the hierarchy. Once top-level element are identifies, it is separated out from the rest of the elements. Then, the same process is repeated to find the next level of elements. These identified levels help in building the digraph and final model. In the present, the variables along with their Reachability set, antecedent set, intersection set and the levels are shown in Table 3, and completes as follows.

Table 3: Levels of Maritime sector variables

Element (Pi)	Reachability Set: R(Pi)	Antecedent Set: A (Pi)	Intersection R(Pi) A(Pi)	Level
1	1,2,4,9	1,3,5,6,11	1	IV
2	2,7,9	1,2,3,5,6,11	2	III
3	1,2,3,10	3,6,11	3	V
4	4,9	1,,4,5,6,11	4	II
5	1,2,4,5,6,8,11	5	5	VIII
6	1,2,3,4,6,11	5,6	5	VII
7	7,9	2,7	7	II
8	8,9	1,8,9	8,9	I
9	8,9	1,2,4,7,8,9,10	8,9	I
10	9,10	3,10	10	II
11	1,2,3,4,11	5,11	11	VI

In Table 3, Element 8 (cost minimization) and Element 9 (customer satisfaction), are put at level I. These elements will be positioned at the top of ISM in the digraph. Elements 4 (Latest equipment introduction), Element 7 (service level improvement) and Element 10 (quality level improvement) are at level II. Element 2 (Connectivity performance) comes at level III. Element 1 (Business sensitivity) is at level IV. Element 3 (Data accuracy) is at level V. Element 11(Trust development) comes to level VI. Element 6(Use of IT tools) comes at VII. Final iteration brings out level VIII elements as centralized and collaborative planning (Element 5).

6.4 Developing Conical Matrix: A conical matrix is developed by clustering elements at the same level, across rows and columns of the final Reachability matrix, as shown in Table 4

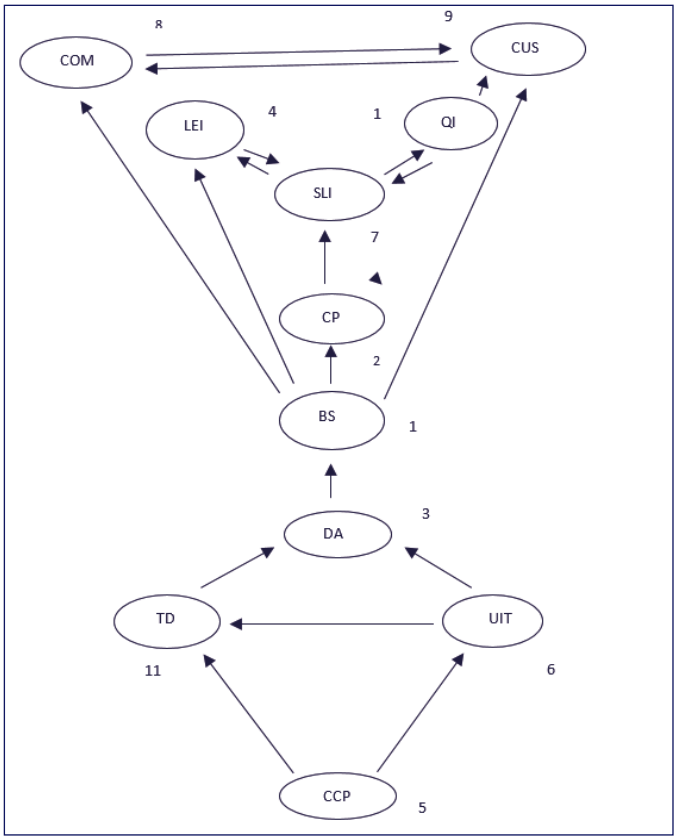
Table 4: Conical Form of Reachability Matrix

Elements	8	9	4	7	10	2	1	3	11	6	5
8	1	1	0	0	0	0	0	0	0	0	0
9	1	1	0	0	0	0	0	0	0	0	0
4	0	1	1	0	0	0	0	0	0	0	0
7	0	1	0	1	0	0	0	0	0	0	0
10	0	1	0	0	1	0	0	0	0	0	0
2	0	1	0	1	0	1	0	0	0	0	0
1	0	1	1	0	0	1	1	0	0	0	0
3	0	0	0	0	1	1	1	1	0	0	0
11	0	0	1	0	0	1	1	1	1	0	0
6	0	0	1	0	0	1	1	1	1	1	0
5	1	0	1	0	0	1	1	1	1	1	1

6.5 Development of Digraph: Based on the conical form of reliability matrix, the initial digraph including transitive links is obtained. After removing indirect links, the final digraph is obtained, as shown in Figure 2. From Figure 2, it is observed that centralize and collaborative planning (element 5), use of IT tools (element 6) and Trust development

improvement (element 11) play significant role in modeling IT in the Maritime supply chain in shipping industry under consideration and they form the base of ISM hierarchy. Cost minimization (element 8), customer satisfaction (element 9), and Latest equipment introduction (element 4) are variable which appear at the top of digraph. Effective centralized and collaborative planning (element 5) and use of IT tools (element 6) provides an environment which helps in increasing connectivity performance (element 2) and thus improves the quality improvement in service (element 10). This leads to developing trust (element 11) among maritime trading partners. This helps in achieving efficient data accuracy (element 3) and better business sensitiveness (element 1). Effective service level improvement (element 7) is achieved due to better data accuracy (element 3) and Business sensitiveness (element 1). Connectivity performance (element 2) for supply chain under consideration enhance as a result of effective service level improvement (element 7). Latest Equipment introduction (element 4) helps management to concentrate on better use of IT Tools (element 6) for cost minimization (element 8) which result in better connectivity performance (element 2). Connectivity performance (element 2) provides better service level (element 7), which result into improve level in customer satisfaction (element 9). Service level improvement (element 7) minimize impact of waste including time; therefore, expert feel that improvement in quality level (element 10) can be achieved with effective service level improvement (element 7). Improvement in customer satisfaction level (element 9) is also achieved with better quality level (element 10).

Figure 2: ISM-Based Model of Variables of IT for Improving Supply Chain after Removing Indirect Links.



7. MICMAC ANALYSIS

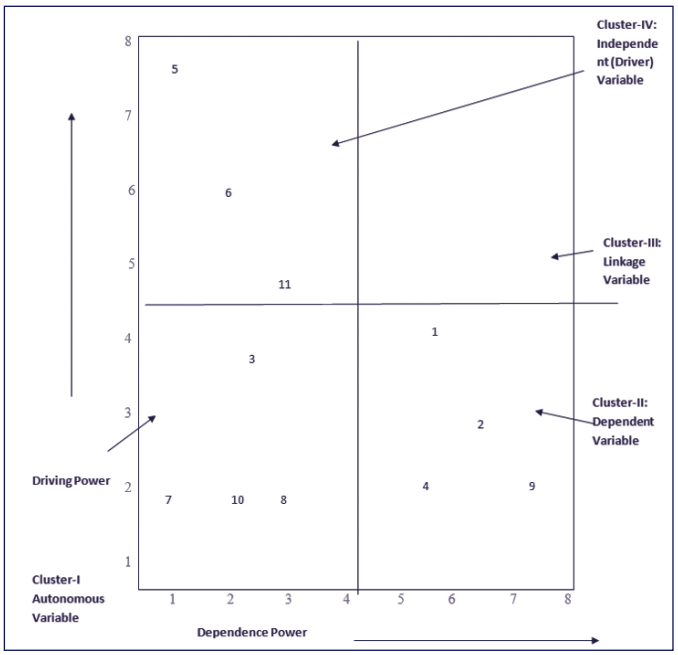
The objective of MICMAC analysis is to analyze the driving power and dependence power of variables (Saxena et. al., 1990; Mandal and Deshmukh, 1994; Sharma et.al., 2012). The variables in maritime supply chain are classified into four clusters. First cluster includes "autonomous variables" that have weak driver power and weak dependence. These variables are relatively disconnected from the system, with which they have only few links, which may be strong. Second cluster consists of the dependent variables that have weak driving power but strong dependence. Third cluster has the linkage variables that have strong driving power and also strong dependence. These variables are unstable. Any action on these variables will have an effect on others and also a feedback effect on themselves. Forth cluster includes independent variables having strong driving power but weak dependence. It is observed that a variable with the very strong driving power, called as the key variables, falls into the category of independent or linkage variables. In Table 5, an entry of "I" along the column and rows indicates the dependence and driving power, respectively.

Table 5: Conical Form of Reachability Matrix

Elements	8	9	4	7	10	2	1	3	11	6	5	Driving Power	Ranks
8	1	1	0	0	0	0	0	0	0	0	0	**2**	**VI**
9	1	1	0	0	0	0	0	0	0	0	0	**2**	**VI**
4	0	1	1	0	0	0	0	0	0	0	0	**2**	**VI**
7	0	1	0	1	0	0	0	0	0	0	0	**2**	**VI**
10	0	1	0	0	1	0	0	0	0	0	0	**2**	**VI**
2	0	1	0	1	0	1	0	0	0	0	0	**3**	**V**
1	0	1	1	0	0	1	1	0	0	0	0	**4**	**IV**
3	0	0	0	0	1	1	1	1	0	0	0	**4**	**IV**
11	0	0	1	0	0	1	1	1	1	0	0	**5**	**III**
6	0	0	1	0	0	1	1	1	1	1	0	**6**	**II**
5	1	0	1	0	0	1	1	1	1	1	1	**8**	**I**
Dependence	**3**	**7**	**5**	**1**	**2**	**6**	**5**	**4**	**3**	**2**	**1**		
Ranks	**V**	**I**	**III**	**VII**	**VI**	**II**	**III**	**IV**	**V**	**VI**	**VII**		

The variables are categorized into ranks according to their driving power and dependence rank. For example, element 4 has third rank in dependence and sixth in driving power; while element 2 has second rank in dependence and fifth rank in driving power. All the 11 elements are grouped under four clusters as shown in figure 7.1. Centralized and collaborative planning (5), use of IT tools (6) and Trust Development (11) comes under cluster IV and, therefore, categorized as independent drivers. Nil element is there in cluster III which strong driving power and strong dependence. Data accuracy (3), Service level improvement (7) , Cost minimization (8) and Quality improvement (10) are autonomous variables and are kept under cluster I. Business Sensitiveness (1) , Connectivity performance (2) , Latest equipment introduction (4) and customer satisfaction (9) are kept under the cluster of dependent variables. (cluster II).

Figure 3: Cluster of Variables for improving IT in Supply Chain



8. DISCUSSION

One of the major objectives of this study is to analyze the driving and dependence power of the variables that significantly affect the improvement of use of IT in Maritime sector. The result of the survey indicates that use of IT brings strong customer satisfaction, quality of improvement in service, cost minimization, connectivity performance, latest instrument introduction and finally business sensitivity. The top-level variables emerging in ISM have weak driving power, but strong dependence on other variable for use of IT. It has been observed that use of IT leads to quality improvement, cost minimization, service level improvement and finally brings transparency in trading partners in shipping sector. These attributes depend on other variables like information enrichment, vessel tracking and collaboration across the supply chain. In ISM, the bottom level variables like Centralized and Collaboration Planning and use of I T tools are considered to have strong drivers to improve the role of IT in supply chain. These variables help to achieve improvement in variables business sensitiveness, data accuracy and trust development. Service level improvement, cost minimization and quality improvement are the middle level variables. Performance of these variables can only be improved when improvement of bottom level variables is achieved. Improvement in middle level variables helps to achieve top-level variables. Improvement in top level variables helps in enhance use of IT in maritime sector. Therefore, management should focus its attention to build up a strong network of maritime partners through better use of IT equipment on ships, centralized and collaborative planning and service level improvement. They should develop strategies to achieve better quality, higher service level, improved customers satisfaction, enhancing connectivity performance, and latest Equipment introduction to have integrated and responsive supply chain in Maritime sector. Similar interdependent action plan could emerge out of combinations of these variables. For example, data accuracy (element 3), business sensitivity (element 1) and service level improvement (7) are variables having medium driving power and medium dependence. These variables need consistent attention of the management in enhancing the use of IT in supply chain Management should always keep a watch on the level of these variables. Slight variation in the level of these variables may strongly affect the role of IT in maritime sector.

Variables like use of IT tools (6), centralized and collaborative planning (element 5), service level improvement (element 7) and trust development (11) have strong driving power. These variables have capability to condition the whole supply chain and can be called independent drivers of effective improvement for the supply chain in Maritime sector.

9. CONCLUSION

The level of variables is important in understanding the characteristics of variables to improve use of IT in maritime sector. Cost minimization, customer satisfaction and quality improvement are the key performance related variables in maritime sector and, thus, therefore these appear at the top of the hierarchy. The trading partners in maritime sector using maritime supply chain should share information and assist each other's in their strategic planning to achieve the desired business goal. Data accuracy would be affected by other variables such as use of IT tools, centralized and collaborative planning, service level improvement and development of trust. However, it acts as a driver for importer market sensitive supply chain and thus quickly respond to the market demand. Strategy to develop Trust among maritime partners helps to improve business sensitiveness which supports the use of better IT tools. Ability to introduce latest IT Equipments in maritime supply chain is governed by the capability to visualize and manage the uncertainty in getting update information. Uncertainty in maritime activity could be better managed if supply chain has centralized and collaborative planning. This needs to be overall supported by effective use of IT Equipments in the supply chain. Trust development among maritime partners help to generate reliable data at each stage of the supply chain. All three variables namely, use of IT tools, centralized and collaborating planning and service level improvement are the major drivers, hence they appear the top priority for the use of IT in maritime sector. Service level improvement again can be termed as the most important variable for improving the role of use of IT. It is driven by the business sensitiveness and helps in making fast turnaround of vessels. This improved turnaround of the vessel enhances consignee satisfaction. Increased consignee satisfaction will help to improve market share at his end by reducing lead time, wastes at various leg of journey and providing better quality of service. Quality improvement is captured in the present model by considering the customers satisfaction level, which is also necessary to gain market shares. Supply chain integration variables like use of IT tools, centralized and collaborative planning and process integration have relatively low dependence and thus appears at the bottom level of hierarchy in ISM. This implies that use

of IT tools, centralized and collaborative planning and service level play significant role and work as the driver of the supply chain integration.

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AUTHORS

Prof. Ashish Agarwal, Director, Mechanical Engineering, School of Engineering and Technology, IGNOU, 93, Maidan Garhi Road, Maidan Garhi, New Delhi – 110 068, India
Email: ashisha@ignou.ac.in

Dr .Vipan Kumar Chand, Master Mariner & Nautical Faculty, United Marine Academy, Sector 11, CBD Belapur, Navi Mumbai – 400 614, (MS), India

Ms. Nishtha Agarwal, Research Scholar, PhD, Indian Institute of Foreign Trade, B-21, Qutab Institutional Area, New Delhi -110 016, India

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EFFECTS OF COVID-19 PANDEMIC ON INDIAN MANUFACTURING MSME: OPPORTUNITIES & CHALLENGES

Sarfraz Ali Quadri
Dr. Dhananjay R. Dolas

Abstract

In the recent past the world came to an unimaginable halt due to a contagious invisible virus that affected not just one but all countries and global trades, it made us aware of our negligence towards our resources. The worst impact of this pandemic is visible on the industrial sector which was brought to almost cessation; especially many Indian MSMEs are on the brink of obliteration due to huge financial losses. Industries all over the world are facing a lot of challenges to achieve better productivity and customer satisfaction due to increasing necessity and demand for more reliable products at minimal cost. This is not only applied to pharmaceuticals or transportation industries but to all sectors such as Manufacturing, energy, logistics, automotive, textiles, food processing and agriculture. The COVID-19 calamity has had a substantial impact on the Indian economy and triggered unprecedented policy responses across the sectors. With evident effects on the manufacturing industry manifested until the mid of 2021, So this paper aims to address the key impacts of Covid-19 on Indian economy as a whole and specifically challenges faced by manufacturing industries. The paper also highlights few notable recommendations for sustainable development in the Indian manufacturing industries.

Keyword: Manufacturing, Indian Industries, MSME, Covid-19, Pandemic etc.

INTRODUCTION

The pandemic has lead to a disastrous loss of life globally and presented an unparalleled test to community health, foods & work life. The financial and social disorder caused by the covid-19 is shattering: millions of individuals are at risk of declining into extreme poverty, whilst the number of malnourished people, currently estimated at nearly 690 million, could increase by up to 132 million soon.

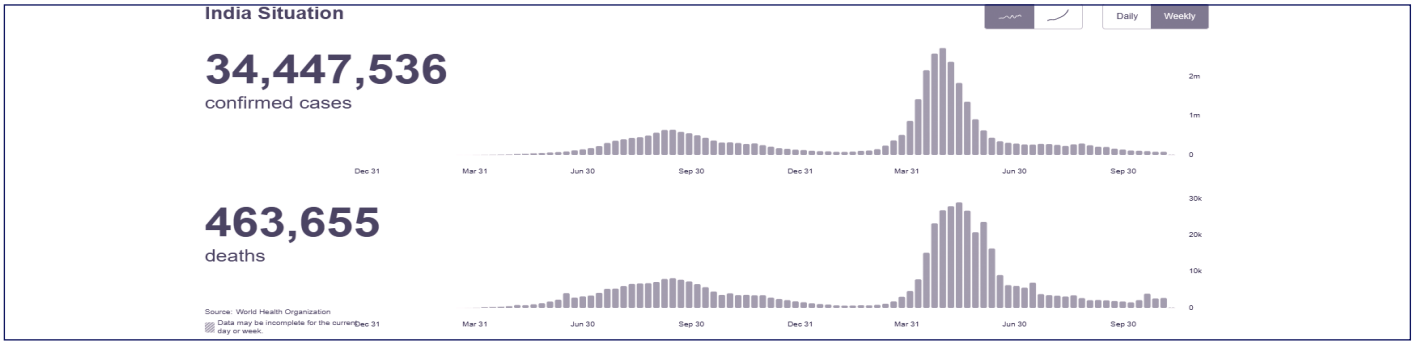
Countless enterprises face an existential risk. Nearly half of the world's 3.3 billion global employees are at risk of losing their livelihoods. Informal financial system workers are predominantly vulnerable because the majority lack social safeguard and access to quality healthcare and have lost access to productive resources. Without the means to earn an income during lockdowns, several are unable to feed their families. For many, no earnings means no food, or, at best, less food and less nutritious food.

The pandemic has been disturbing the entire food chains and has laid bare its vulnerability. Border closures and trade restrictions have been preventing farmers from access to markets for buying inputs and selling their goods, and restricted agricultural workforce from harvesting crops, thus upsetting domestic and international food supply chains and reducing access to healthy, safe and diverse diets. The pandemic has costs jobs and placed millions of livelihoods at risk. As bread earners lose jobs, get ill and die, the food security and nourishment of millions of women and children are under threat, with those in third world countries, particularly the most marginalized populations, which include small-scale farmers, producers, tribal and indigenous peoples, being hardest hit. [1]

The pandemic, which originated in the city of Wuhan, China, has rapidly reached to various countries, with many cases having been reported globally. India, with a population of more than 1.34 billion, the second largest population in the world, faced severe complexity in controlling the spread of severe acute respiratory syndrome corona virus and its associated effects amongst its population. [2]

In India, from 3 January 2020 to 4:30pm CET, 15 November 2021, there have been 34,447,536 confirmed cases of COVID-19 with 463,655 deaths, reported to WHO. As of 8 November 2021, a total of 1,095,926,470 vaccine doses have been administered.[3]

Figure 1. COVID-19 Situation in India [3]



Multiple strategies were highly essential to handle the outbreaks; these include computational modeling, statistical tools, and quantitative analysis to manage the spread as well as the swift development of a new treatment. The Ministry of Health and Family Welfare of India raised alertness about the outbreak and has taken necessary actions to control the spread of COVID-19. The central and state governments are still taking several measures and formulating several wartime protocols to achieve this goal. Moreover, the Indian government implemented a 55-days lockdown throughout the country that started on March 25th, 2020, to reduce the transmission of the virus. This outbreak is inextricably related to the economy of the nation, as it has radically impeded industrial sectors because people worldwide are currently cautious about engaging in business in the affected regions. [2]

IMPACT OF COVID-19 PANDEMIC ON INDIA AND ITS ECONOMY

The ambush of the pandemic has ripped through the Indian economy. This is certain that the scale of the financial damage caused by the COVID-19 will be far bigger than that caused by the 2008 global financial crisis and also the substantial uncertainty of the duration of crisis prevails. The pandemic constitutes a unique challenge with very severe socio-economic consequences. It is significant to mention, that Indian economy had already experienced considerable slowdown over the last fiscal year, during which the economy grew at a six-year low rate of 4.7%. Pandemic has impacted both demand and supply side elements of the economy, and crashed hopes for recovery in recent years.[4]

Table 1. GDP of the Globe [4]

Top 10 Countries by GDP	2017	2018	2019
U.S.	2.4	2.9	2.3
CHINA	6.9	6.7	6.1
JAPAN	2.2	0.3	0.7
GERMANY	2.8	1.5	0.6
U.K.	1.9	1.3	1.4
FRANCE	2.4	1.7	1.3
INDIA	6.5	6.7	5.3
ITALY	1.7	0.7	0.3
BRAZIL	1.3	1.3	1.1
CANADA	3.2	2.0	1.6

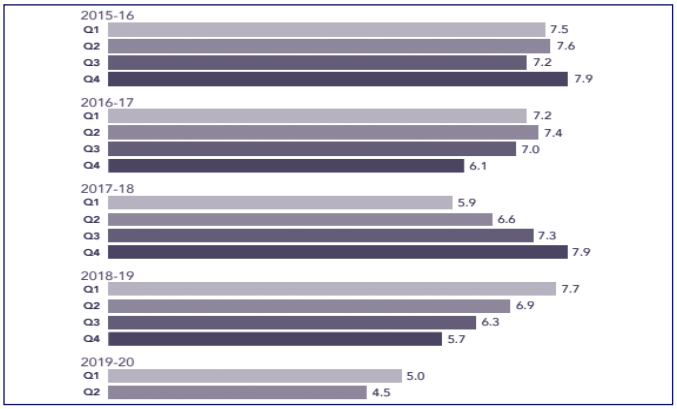
The data reveals that first world nations like US, Germany, UK, France etc. showed maximum slowdown as compared to both India and China. The Purchasing Managers Index (PMI) data indicates the prevailing direction of economic trends in the manufacturing and service sectors of any nation. The PMI data for various countries also depict a grim story as shown in Table 2. The hostile Chinese economy was severely affected by COVID-19 with PMI at 40 in the month of February, 2020, as against India which maintained a fairly good run-rate till February, 2020.

Table 2. PMI Data of various Countries [4]

ASIA & PACIFIC	AUSTRALIA	52.0	51.6	50.9	50.3	50.0	49.9	49.2	49.6	50.2
	CHINA	49.4	49.9	50.4	51.4	51.7	51.8	51.5	51.1	40.3
	JAPAN	49.3	49.4	49.3	48.9	48.4	48.9	48.4	48.8	47.8
	KOREA	47.5	47.3	49.0	48.0	48.4	49.4	50.1	49.8	48.7
	INDIA	52.1	52.5	51.4	51.4	50.6	51.2	52.7	55.3	54.5
	INDONESIA	50.6	49.6	49.0	49.1	47.7	48.2	49.5	49.3	51.9
	MALAYSIA	47.8	47.6	47.4	47.9	49.3	49.5	50.0	48.8	48.5
	SINGAPORE	49.6	49.8	49.9	49.5	49.6	49.8	50.1	50.3	48.7
	VIETNAM	52.5	52.6	51.4	50.5	50.0	51.0	50.8	50.6	49.0

India's growth rate year 2000 onwards has been, by and large, stable and resilient across broad based sectors: agriculture, industry and services. The growth is also linked to increased productivity both labour as well as total factor productivity. The diversified trade basket and trading partners have given India a cushion, which insulates from slowdown at any particular part of world. One of the major highlights of India's GDP growth has been the continuous tilt towards services away from agriculture. The GDP growth of India during the period 2015 to 2020 is depicted in Fig. below:

Figure 2. GDP Growth of India (2015-2020)



Source: Quarterly estimates of gross domestic product for the third quarter (Q3) of 2019-20, Ministry of Statistics and Programme Implementation (MoSPI), 28 February 2020, accessed on 24 March 2020.

COVID-19 with global shutdown and quarantine has severely affected the supply side of economy without collateral damage to the demand side. However, mankind history is replete with several instances of not only recovering but also coming back strongly from several pandemics including two world wars. We shall overcome COVID-19 also. In order to calculate impact on demand, correlations between demand, lockdown and spread were taken into account. Impact of COVID-19 on supply and demand in various sub sectors of economy also has been analysed and presented in the table as annexed.

Table 3. Impact on Covid-19 on Different Sectors in India [4]

Sectors	% of GDP	Employment (2018-2019)	COVID-19 IMPACT in 2020-2021
Apparel/Textiles	2	45 Million	Med-High
Auto	7-8	40 Million	High
Aviation and Tourism	11.4	43 Million	High
Building and Construction	~10		High
Retail	10	10% of total workforce	Med-High
Education and Skilling	3		Medium
Financial Sector (Incl. Insurance)	9		Medium
Food and Agriculture	15	43% of total workforce	Medium
MSME	30	11.4 crore (99% Micro)	High

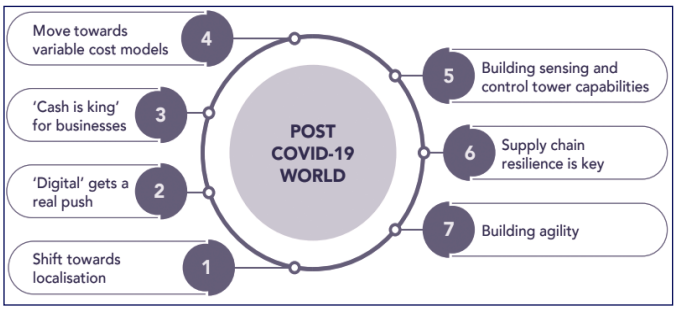
It is inferred from the table that supply side in the sectors of Mining, Manufacturing, construction, food , entertainment and recreation have been badly impacted whereas in sectors like agriculture, textile, electrical equipment, education and healthcare services, the demand is not so affected. Some sectors which are crucial to the national economy like: Healthcare, Agriculture and Food Processing, Manufacturing & Machinery, ICT and Electronics etc. have been studied in greater details in next section. However, the broad approach in each sector is mentioned below:

- **Healthcare:** This sector has components that show increase in demand while limitations are projected on supply side. This calls for technology boosts using ICT and new-age technologies to make this sector a positive earner for India.
- **Agriculture and Allied Sectors:** The production is not as impacted as most other sectors, while the demand exists. This is a sector that can help India in covering losses posed by other sectors, if the right kind of technology support is provided. Technology adoption is also required to strengthen Public Distribution System, to reduce post-harvest losses and mechanization for agriculture operation.
- **Manufacturing:** Some categories of this sector are severely impacted, while not so much in other categories. The difference in impact across categories within the sector poses an interesting challenge where there may be need of shift of roles for a number of stakeholders in the sector.
- **ICT& Electronics:** Some of the categories within the sector are showing a boost for the economy, thus creating a need of technological interventions in this sector for helping other sectors.

SUGGESTIONS & SOME KEY RECOMMENDATIONS FOR INDIAN SCENARIO

The current COVID-19 pandemic is Global but the solutions to the challenges have to be Local. It is crucial that we urgently rethink, refocus our priorities and plan fundamental changes in the way we do business and support economy. Self-reliance will be the new mantra.

Figure 3 Perspective for Post COVID Re-Development



KEY RECOMMENDATIONS FOR INDIAN MANUFACTURING INDUSTRIES

The Manufacturing sector is of strategic importance to the Indian economy and forms the backbone of the Indian Economy. China occupies a lion's share in manufacturing sector with around 20 % of global production. India has significant dependence on imports in the machines and electronics (~18%), fuels (~16%), capital goods (~11%) sectors. These include machines for infrastructure development as well as for supporting manufacturing industries, automotive and textile industries etc. The country also needs to develop competency in emerging areas such as battery and photovoltaic cell manufacturing. The resultant regressive globalization and supply chain disruptions,post COVID-19, has given India an opportunity to position itself as an alternate global manufacturing hub. Some target segments are:

- Critical Equipment / Machinery which are being imported from China.
- Raw Material sourcing from China or Eastern Europe in areas of renewable energy
- Cutting, Drilling CNC and Robotic machinery used for Component manufacturing in Indian Railways & Infrastructure sector.

Some important recommendations based of key sectors are highlighted below;

➢ **Manufacturing Sector**

- Enhanced production of competitive capital goods (CG): ensuring parity of import duties with domestic duties, providing incentives etc
- Creating Integrated Industrial Infrastructure Facilities popularly known as Machine Tool Parks (for High end Machines)
- Create a 'Start-up Centre' with support from the Department of Heavy Industries and Institute of Research & Collaborations with European Industry • Manufacturing hub in transformers, IGBT, Control Panels, inverters for motors, drives and power sources, cutting , drilling equipment, robotics

➢ **Automobiles Sector**

- For electric mobility, utilization of domestic reserve of rare earth : processing of rare earth materials, development of rare earth permanent magnets and development of permanent magnet motors
- Development of alternative technologies for lithium ion batterysuch as Sodium ion battery, aluminium air battery,Super-capacitor,etc.
- Automation and Digitalization in vehicle and component design to leverage IoT capabilities in gear, steering, braking system etc. (MSME In collaboration with big industries)

➢ **Textiles Sector**

- High-speed looms Design development
- Make more factories FFI compliant w.r.t international standards and giving support through special schemes such as Textile Up-gradation Fund (TUF)
- Thrust areas of Technical textiles (e.g. Agro-tech, Pro-tech, Medi-tech and Mobil-tech).
- Specialized coating and lamination for the fabrics:add value to the fabrics by imparting special fabric surface properties like fire retardant, anti-microbial, easy-care etc.
- Design and Availability of local Jacquard for designing
- Development of Good eco-friendly dyes/ mordents.
- Machine development for producing 3D fabrics, nonwovens, ink jet printing and plasma processing & finishing

➢ **Solar Energy Sector**

- Focus on solar PV cell manufacturing, starting from semiconductor fabrication
- Solar projects/ parks on engineering, procurement, and construction (EPC) basis of modules, cells and ancillary equipment like back-sheets, glass, inverters, transformers and cables so as to cater to entire ecosystem of renewable energy

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AUTHORS

Mr. Sarfraz Ali Quadri, Research Scholar, Jawaharlal Nehru Engineering College, MGM University, MGM Campus, N-6, Cidco, Aurangabad – 431 003, (MS)

Dr. Dhananjay R. Dolas, Associate Professor, Jawaharlal Nehru Engineering College, MGM University, MGM Campus, N-6, Cidco, Aurangabad – 431 003, (MS)

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INVESTIGATION OF RESOURCE SCHEDULING ISSUES IN FOG AND EDGE ENVIRONMENT

Kapil Tarey
Dr. Vivek Shrivastava

Abstract:

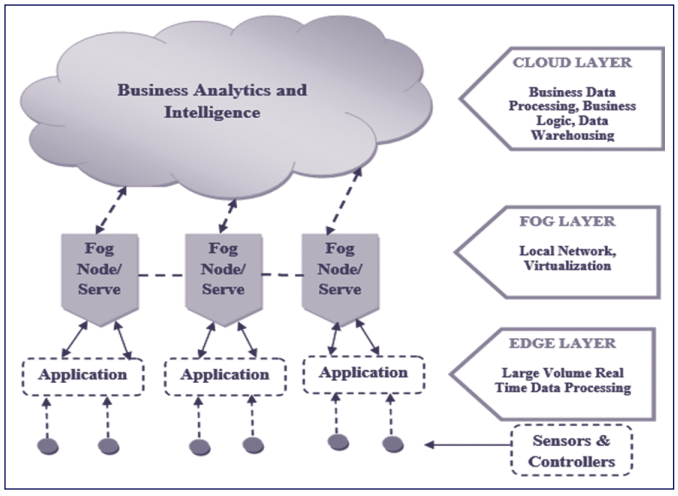
Fog and edge technology are comprehensive cloud concepts comprised of devices that form a distributed network. The primary advantage of cloud frameworks is that they permit information gathering from various locations throughout the network. Data from such an omnipresent network is accessible from anywhere in the world. These paradigms offer massive volumes of data collection and processing locally. Cloud-based edge and fog infrastructures usually involve resource management, allocating resources, workflow balance, provisioning, scheduling, and Quality-of-Service (QoS) to enhance performance. As edge and fog paradigms are typically resource-constrained and more flexible than cloud, resource scheduling is a significant issue. This study investigates and highlights major concerns for scheduling resources in fog and edge environments.

Keywords: Resource scheduling, Edge Computing, Fog Computing, Scheduling issues

1. INTRODUCTION

Cloud data centers offer access to resources for most applications over the Internet. Generally, data generated by consumer devices like smartphones, wearables, and sensors is sent to geographically separated clouds for processing and storage. This data may be impractical as it could increase communication latency due to the network being used by thousands of machines [1]. Increased communication delays may negatively impact applications, lowering their efficacy and QoS. Resolving these problems may require shifting to a new computing paradigm that places computing resources nearer to user sensors and devices for data processing [2], [3]. Communication latency would be reduced by reducing the amount of data transported to the cloud. The edge/fog computing model is the current trend in research. These models decentralize computing resources in data centers. As shown in Figure 1, this distribution is more convenient for end users, actuators, sensors, and transducers. Micro data centers provide a simple, safe option for deploying this infrastructure, as they may use existing public and private networks. Edge computing is a computer technology concept that uses network edge resources [4], [5]. Fog computing technologies utilize edge and cloud computing resources. [6], [7]. Numerous studies in the literature describe various approaches for managing fog and edge computing resources. Literature also reveals that edge resources have little computational capabilities than cloud resources situated at data centers. They also have small power consumption in operations, low cooling costs, and limited space. Increased resource processing at the data centers can result in task performance delays in a system. The most significant challenge in fog and edge computing is resource scheduling with the constraints mentioned earlier.

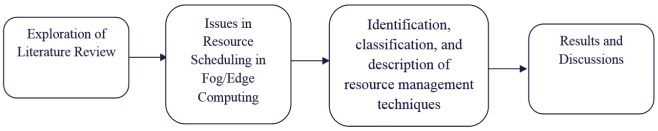
Fig. 1. Association of Fog/Edge computing with the cloud and network edge resources



2. METHODOLOGY

This study is organized into several steps. The first stage is investigative and focuses on the literature and challenges associated with fog and edge computing resource management. The second stage involves identifying, classifying, and describing resource management techniques. The research methodology is shown in figure 2.

Fig. 2. Research Methodology of the paper



3. BACKGROUND AND RELATED WORK

This section begins by reviewing the existing literature and some notable contributions in resource scheduling in edge, fog, and cloud computing.

3.1 Resource Scheduling issues in Fog Computing

Sriraghavendra et al. [1] presented a multi-layer fog computing algorithm DoSP that offered fog and cloud node services. This work devised a method for utilizing low-cost fog resources while ensuring response time fulfills a time constraint.

Pfandzelter [2] described the huge low-Earth-orbit (LEO) satellite communication networks that facilitate worldwide broadband Internet access. Existing studies on resource allocation on a 2D torus can be extended to this challenge by using the particular architecture of LEO satellite networks, as the authors have demonstrated. The suggested LEO satellite communication system simulation revealed that QoS is orbital parameter-dependent. The recommended method can consider these impacts, whereas the existing strategy cannot.

Lakhan [3] explored the issue of resource allocation in software-defined networks (SDN) to facilitate fog networks. Many severe limitations, such as mobility, deadlines, and resource capacity, must be met throughout application execution. The study presented a novel container-based architecture with multiple fog nodes. According to the performance review, the proposed model and schemes outperformed previous research by 30%. (energy and execution time).

According to Talaat in [4,] data in health, transport systems, automated driving, smart agriculture, and other fields must be evaluated and handled in real-time. The Author developed prediction and resource provision EPRAM. Resource provisioning is complicated since it necessitates using several resources and fog nodes. EPRAM used a real-time resource allocation and prediction system to try to accomplish successful resource utilization in a fog environment.

Cai et al. [5] presented two algorithms CaGTS and DaTR, for developing failure-resilient DAG task scheduling. The CaGTS prepares the DAG job scheduling problem, whereas the DaTR method addresses the edge server failure event. Using Python simulation, the performance of the proposed methods is assessed. Simulation indicated that CaGTS reduces average completion time by at least 10.47% compared to standards, while DaTR outperforms in preventing task scheduling interruptions caused by server failure occurrences.

Li et al. [6] established a vehicular fog-edge computing model as a multi-stage Stackelberg game to address these difficulties. Based on the Stackelberg game, the authors found pricing systems that maximize the benefits for all participants. The usefulness of this incentive mechanism was proved by simulation results, which revealed the patterns of users' energy usage and offloading preferences with varying factors.

Choi et al. [7] explain that cloud-based cloud data centers (CDCs) have uncertain response times due to variable latencies between service requestors (Internet of Things devices and end devices) and Data centers. This cloud computing limitation is particularly significant when delivering IoT services with strict timing requirements. The authors determined the optimal placement of services within the time interval. The proposed solution is scalable because fog/edge network resources are sufficient.

Caminero et al. [8] proposed a network-aware scheduling approach that seeks to identify the optimal fog component for the execution of the program with a strict deadline. This scheduling technique was created on a scheduler-designed Kubernetes and evaluated to previously published approaches. The comparison demonstrates that this algorithm can complete all tasks within time constraints.

Yamuna et al. [9] offered a task-scheduling technique for resource prioritization. Based on attributes such as blood pressure, heart rate, and temperature, the requests are extremely delay-sensitive, moderately delay-sensitive, and low delay-sensitive. Establishing a threshold value optimizes the execution time to deliver services with minimal latency. Compared to alternative scheduling strategies, overall performance increases by 40.1%.

Baburao [10] suggested a dynamic resource scheduling method EDRAM that utilizes PSO to minimize task wait time and latency. This method helped allocate resources by removing long-inactive, unused, and slow services from memory.

Ren et al. [11] created a framework for collaborative task offload and task scheduling to balance computing and caching resources in diverse edge networks. The data-driven simulation confirmed that the proposed strategy minimizes overall consumption, maximizes the long-term advantages of edge resource distribution, and increases task completion success rate.

Sarma et al.[12] proposed an efficient fuzzy clustering-based load balancing and resource scheduling solution for fog computing. This research suggests an upgraded fuzzy C-means (FFCM) algorithm with crow search optimization (CSO) for resource scheduling in fog computing. The extensibility decision technique is employed for load balancing.

Wadhwa et al.[13] created an innovative scheduling technique for the resource grading system in the fog computing scenario. Using the expectation maximization (EM) algorithm, this method monitors the intensity level of existing jobs. It estimates the current condition of available resources. On the iFogSim simulator, the algorithm's performance is evaluated and compared against SJF, FCFS, and MPSO. The outcomes demonstrated that it effectively reduces execution time, network utilization, and energy consumption.

Alqahtani et al.[14] exploited Passive Optical Network to establish federated (i.e., cooperative) computational units by connecting several scattered fog units. They suggested linear programming model MILP to optimize the placement of virtual machines among the federated fog to reduce total power consumption. Compared to other methods, the results revealed a 52% reduction in energy use for VM allocation.

3.2 Resource Scheduling issues in Edge Computing

Diamanti et al. [15] highlighted the network's various levels of available computer capability. They created a reward system to transfer the choice of selfish users from the edge to the top fog computing layer, taking their latency tolerance into account. The game aims to reduce the network's end-to-end energy consumption and increase resource usage efficiency.

The following scenario and framework for resource allocation are evaluated through modeling and simulation in terms of their performance and efficiency under various situations.

Lei [16] presented an approach for resource scheduling and computation offloading for IoT in an edge-of-the-network computing environment. They modeled a system for computation offloading and resource management. The paradigm consists of Macrocell Base Station (MBS) having Mobile Edge Computing (MEC) workstations and Smallcell Base Station (SBS) that may be utilized as a relay for dynamic resource management and control. The MATLAB-based experimental findings demonstrated that the suggested prospective game formula could evolve to Nash equilibrium.

Kuang et al.[17] developed the Mobile edge computing (MEC) architecture. They explore the coordinated mechanism and resource deployment in mobile edge computing as a single problem. The numerical results indicated that the proposed approach exceeds MEC, local and full cloud concerning execution delay.

Li et al. [18] established a vehicular fog-edge computing model as a multi-stage Stackelberg game to address these difficulties. Based on the Stackelberg game, the authors found pricing systems that maximize the benefits for all participants. The usefulness of this incentive mechanism was proved by simulation results, which revealed the patterns of users' energy usage and offloading preferences with varying factors.

Vijayasekaran et al.[19] introduced a method for processing data in edge devices and transmitting it to the cloud to minimize latency and improve system efficiency. It is accomplished by hybrid data aggregation and resource scheduling based on deep learning. The performance of the suggested integration strategy is assessed regarding latency, efficiency, and computing time. The recommended solution provided low latency and increased efficiency compared to conventional clustering methodologies and cloud IoT systems.

3.3 Resource Scheduling issues in Fog-Edge-Cloud Computing

Ijaz et al.[20] examined workflow scheduling in fog-cloud systems for energy-efficient task scheduling within acceptable application finishing timeframes. The authors presented an energy Makespan Multi-Objective Optimization (EM-MOO) scheduling method. They modeled a multi-objective optimization issue, computed a compromise among conflicting goals while allocating fog and cloud resources, and assigned latency-sensitive jobs to fog resources and computationally demanding tasks (with low latency needs) to cloud resources. The results demonstrated that this strategy lowered energy consumption by fifty percent compared to previous approaches.

Chen et al.[21] propose a two-component communication resource-aware cooperation with computation resources (CRACCR) system. Under spectral multiplexing computation analysis, the system concatenates communication resources under the allocation of calculation resources. Experiments demonstrated that energy efficiency is improved.

Aburukba et al.[22] suggested a scheduling technique that utilizes three-tiered fog computing to fulfill the most significant requests within their deadline constraints. This paper presents an optimization model that uses mixed integer computation to reduce missed deadlines. The performance of the suggested GA was assessed and compared to round-robin and priority scheduling, demonstrating a 20%–55% improvement in missed deadlines compared to the other strategies.

Focusing on fog-cloud design with software-defined networks, Cao et al. [23] build a unique 5G IoV architecture. In addition, following careful consideration of the IoV's service requirements, a prototype with a multi-objective optimization algorithm is developed. The experiment demonstrated that the suggested algorithm outperforms other cutting-edge algorithms.

The enhanced particle swarm optimization (EPSO) technique was developed by Narayana et al.[24] to optimize the work scheduling problem in cloud-fog situations. This work tries to maximize resource productivity and reduce the time required to execute tasks. The iFogSim simulator is employed in experiments. Comparing the performance of this method to that of other approaches revealed that the performance of the proposed technique is comparable to that of different strategies.

Bashir et al. [25] suggested a solution for the dynamic allocation of cloud, fog nodes, and user resources. First, it establishes the rankings of fog nodes utilizing TOPSIS to determine which fog node is most suited for the user's requests. Logical regression simultaneously estimates the load of specific fog nodes and sends the result back to the broker. The simulation results demonstrated proposed system enhances performance and achieves 98.25% accuracy.

Huang et al. [26] introduced a particle swarm optimization (PSO) approach using a Lyapunov framework (LPSO). This system has balanced the computational energy usage of the IoT nodes and the fog node computing energy usage. This allowed the activities to be accomplished with minimal energy use. The PSO approach performs substantially better than the original PSO method and the greedy technique.

Dubey et al. [27] devised a system for establishing coalition games based on resource allocation in fog-based IoT networks. The authors incorporated a physical layer security-based distribution of resources to raise the required data flow with a higher rate of secrecy in IoT networks based on fog. The numerical result demonstrated that the given strategy is effective in terms of enhanced data rate and secrecy.

Tripathy et al. [28] proposed an algorithm for offloading jobs in mist oriented cloud environment to reduce the overall time and fast response. The fuzzy logic algorithms concept uses attributes, resource deployment, and assortment. Simulated results suggested that it improved the provision period for time-critical tasks compared to previous approaches.

4. COMPARISON OF THE EXISTING SCHEDULING TECHNIQUES IN FOG AND EDGE

Table 1 summarizes the scheduling algorithms' fundamental concepts, advantages, limits, and simulation tools. This table

allows researchers to evaluate algorithms based on the method employed to address a specific category of the scheduling problem, the benefits of using the proposed algorithm, and the issues it confronts. Thus, researchers can select and build the most appropriate algorithms.

Author & Paper No.	Algorithm Designed	Fundamental Idea	Testing Tool	Environment	Key Benefit	Limitation
Sriraghavendra et al. [1]	Deadline-oriented Service Placement (DoSP)	Utilization of minimal-cost fog resources.	iFogSim	Fog	Guaranteeing the response time meets specified time restrictions.	Not concerned about transmission costs.
Pfandzelter [2]	LEO satellite communication system	Improvement in communication QoS by LEO satellite.	Linpack with java	Fog	Reduced communication delay.	Algorithm Ignores the computation time in the cloud.
Lakhan [3]	Novel container-based architecture with multiple fog nodes	Mobility, deadlines and resource capacity is available throughout application execution.	iFogSim	Fog	Lower Energy and fast execution.	Not appropriate for large-scale use.
Talaat [4]	Prediction and Resource Allocation Methodology (EPRAM)	Real-time resource allocation and prediction system.	iFogSim	Fog	Accomplished successful resource utilization in a fog environment	It takes high scheduling time for task execution.
Cai et al. [5]	Two algorithms CaGTS and DaTR	CaGTS prepares the DAG job scheduling problem, whereas the DaTR addresses the edge server failure event.	Unknown simulators	Fog	reduces average completion time by 10.47% and prevents task scheduling interruptions caused by server failure occurrences.	Single workflow for scheduling.
Li [6]	Vehicular fog-edge computing model	Multi-stage Stackelberg game	C++	Fog	Pricing systems that maximize the benefits for all participants	Ignored network usage
Choi et al. [7]	Optimal placement of services within the time interval.	Efficient scheduling algorithm to distribute tasks among remote clouds with the order of services	iFogSim	fog/edge	scalable	High workload execution time.
Caminero et al. [8]	Network-aware scheduling approach.	To identify the optimal fog component for the execution of the program with a strict deadline.	Kubernetes Schedular	Fog/Edge	This algorithm can complete all tasks within their respective time constraints	Only limited datasets were tested.
Yamuna et al. [9]	offered a task-scheduling technique for resource prioritization.	Establishing a threshold value optimizes the execution time to deliver services with minimal latency.	iFogSim	Fog	Overall performance increased by 40.1%.	Because of the simplistic architecture, latency is high.
Baburao et al.[10]	Dynamic resource allocation model (EDRAM)	Utilizes PSO for minimizing task wait time and latency.	CloudSim	Fog-Cloud	Allocates resources by removing long-inactive, unused, and slow services from memory.	Cloud computation time is not considered.
Ren et al. [11]	Framework for collaborative task offload and scheduling for resources in diverse edge networks.	This strategy minimizes overall consumption, maximizes the long-term edge resource allocation	C++	Edge	Increased task completion success rate.	Task execution takes a long time to schedule.
Sarma et al.[12]	Load balancing and scheduling based on fuzzy clustering for fog computing.	Upgraded fuzzy C-means (FFCM) algorithm with crow search optimization (CSO) for resource scheduling in fog	MATLAB	Fog	The extensibility decision technique is employed for load balancing.	This does not apply to task clustering and fog nod clustering.
Wadhwa et al.[13]	Resource grading in the fog computing	The algorithm monitors the intensity level of existing jobs.	iFogSim	Fog	Effectively reduces execution time, network utilization, and energy consumption.	High-time issue.

Alqahtani et al.[14]	Passive Optical Network to establish federated (i.e., cooperative) computational units by connecting several scattered fog units.	Linear programming model to optimize the placement of virtual machines among the federated fog.	iFogSim	Fog	Reduction in energy use for VM allocation. .	Slow service processing time due to inefficiency.
Diamanti et al. [15]	Reward system to transfer the choice of selfish users from the edge to the top fog computing layer, taking their latency tolerance into account.	The game aims to reduce the network's end-to-end energy consumption and increase resource usage efficiency.	Using Java	Edge	Reduces the network's end-to-end energy consumption	Reduced scalability.
Lei [16]	The paradigm consists of Macrocell Base Station (MBS) having Mobile Edge Computing (MEC) workstations and Smallcell Base Station (SBS) that may be utilized as a relay for dynamic resource management and control.	Dynamic resource management and control.	MATLAB	Edge	The prospective game formula could evolve to Nash equilibrium.	Complex to implement.
Li et al. [18]	Vehicular fog-edge computing model as a multi-stage Stackelberg game	Pricing systems that maximize the benefits for all participants.	Unknown	Edge	Patterns of users' energy usage and offloading preferences with varying factors.	High execution time.
Chen et al.[21]	Two-component communication resource-aware cooperation with computation resources (CRACCR).	The system concatenates communication resources under the allocation of calculation resources.	CloudAnalyst	Edge	Energy efficiency is improved.	Many objective functions might be included to enhance resource utilization and decrease latency.
Bashir et al. [25]	Dynamic allocation of cloud, fog nodes, and user resources.	Establishes the rankings of fog nodes utilizing TOPSIS to determine which fog node is most suited for the user's requests.	CloudSim	Edge	Enhances performance and achieves 98.25% accuracy.	Workload execution time is lengthy.
Dubey et al. [27]	System for establishing coalition games based on resource allocation in fog-based IoT networks.	A physical layer security-based distribution of resources to raise the required data flow with a higher rate of secrecy in IoT networks based on fog.	CloudSim	fog-based IoT networks	Effective in terms of enhanced data rate and secrecy.	Limited scalability

5. CONCLUSION

This study reviews and evaluates the most relevant recent fog computing scheduling techniques. A brief introduction to the various resource management issues is discussed for cloud, fog, and edge developers. Several performances and measurements for cloud, fog, and edge computing are also covered extensively, which could be valuable for future research. Several remaining issues are also emphasized to give researchers a whole idea of future directions in the performance review of scheduling and provisioning strategies.

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AUTHORS

Kapil Tarey, International Institute of Professional Studies, (IIPS), DAVV, IIndore), Takshila Campus, Khandwa Road, Indore – 452 001, (MP)

Dr. Vivek Shrivastava, Lecturer, International Institute of Professional Studies, (IIPS), DAVV, (Indore), Takshila Campus, Khandwa Road, Indore – 452 001, (MP)

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IMPROVEMENT IN PRODUCTIVITY BY PROPER UTILISATION OF AVAILABLE RESOURCES

Tejal Raut
Prof. Niyati Raut

Abstract

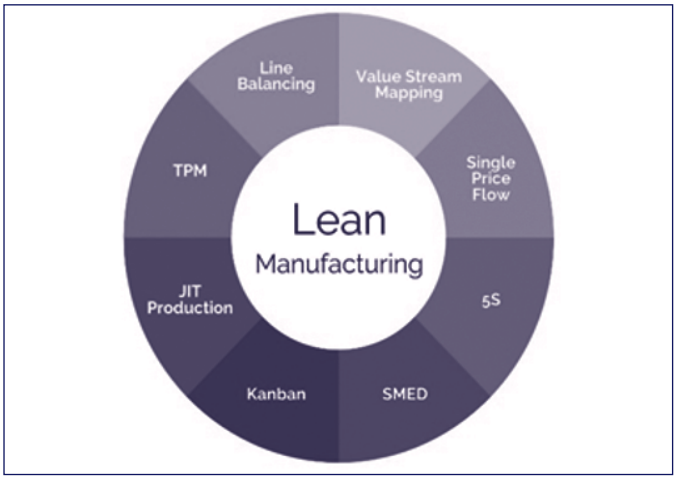
This project aims to improve the efficiency of a manual assembly line by employing operations analysis within the framework of Lean production. A methodology for increasing the productivity of any production process is proposed. The methodology includes the selection of a product or product family to be investigated, followed by an analysis of the current process. After documenting the present process, all assembly activities must be timed using time study techniques. Operations analysis facilitates the reduction of non-productive jobs and yields a collection of standardised work elements as well as a set of standard operating procedures. Assembly line balance and the associated operations analysis contribute to the construction or reconfiguration of an assembly system, which is the most important stage in enhancing the overall performance of an assembly line. In accordance with this methodology, two manual assembly line configurations (single stage parallel line and five-step serial line) are created for a case study. The results demonstrate that by switching to a single-stage assembly line arrangement, operator productivity is increased by removal of non-value-added tasks to the current assembly approach. Minimization of the number of workstations and maximization of the production rate are the most common goals. This report presents the reviews of different works in the area of assembly line balancing and tries to find out latest developments and trends available in industries in order to minimize the total equipment cost and number of workstations.

Keywords- Assembly line balancing, Productivity, Productivity, Lean Production, Non-Value Added.

INTRODUCTION

Assembly lines are one of the most common production methods. Utilizing the available resources, the productivity of a production system is the quantity of work that can be completed per unit of time [1]. Assembly line productivity is defined as the efficiency with which a manufacturing system utilizes its resources to achieve production goals at optimal costs. Conventional productivity measurements, such as throughput and utilization rate, provide a major assessment of an assembly line's success. These two indicators are insufficient to fully characterize the behaviour of a production system. In addition to throughput and utilization rate, the performance of a production system is characterized by a variety of other metrics, including assembly line capacity, production lead time, the number of value-added (VA) and non-value-added (NVA) activities, work-in-process, material handling, operator motion distances, line configuration, and others. By optimizing all these elements, a production line achieves optimum performance. In order to establish productive and competitive manufacturing processes, adaptability and suppleness are crucial. With manual assembly techniques, this level of adaptability can be easily attained for products needing light manufacture and assembly [2]. Manual assembly lines are the most prevalent and conventional type of assembly line, and they continue to be an attractive and adequate method of production for products that require fewer manufacturing steps and straightforward assembly processes. Global competition is compelling businesses to reduce production costs while simultaneously improving quality and shortening production lead times. With the adoption of Lean Manufacturing, which systematically and continually detects and removes waste at all levels of a production system, it is possible to effectively execute several improvement possibilities that dramatically increase assembly line productivity. Lean manufacturing is a methodology that focuses on minimizing waste within manufacturing systems while simultaneously maximizing productivity. Waste is seen as anything that customers do not believe adds value and are not willing to pay for. Some of the benefits of lean manufacturing can include reduced lead times, reduced operating costs and improved product quality. Lean manufacturing, also known as lean production, or lean, is a practice that organizations from numerous fields can enable. Some well-known companies that use lean include Toyota, Intel, John Deere, and Nike.

Fig. 1.1 Lean manufacturing



Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process. The processes that have this common theme, controlled material removal, are today

collectively known as subtractive manufacturing, in distinction from processes of controlled material addition, which are known as additive manufacturing. Machining is a part of the manufacture of many metal products, but it can also be used on materials such as wood, plastic, ceramic, and composites. A room, building, or company where machining is done is called a machine shop. Much of modern-day machining is carried out by computer numerical control (CNC), in which computers are used to control the movement and operation of the mills, lathes, and other cutting machines.

LITERATURE REVIEW

Esra Can and Adalet Öner et. al, (2021), In this project, an assembly line was analysed. At the end of the literature review and researches, some methods were determined to solve the assembly line balancing problem. The RPW method and the mathematical modelling methods were used. These methods were compared and it was found that the results like each other. As a result of these studies, after line balancing balance efficiency is improved.

Lakhdar Belkharroubi, Khadidja Yahyaoui et. al, (2021), In this paper, the mixed model assembly line balancing problem type 2 is addressed, and the objective is to find the best assignment of tasks among workstations to minimize the cycle time. A Greedy randomized adaptive search procedure based Ranked positional weight heuristic is proposed in order to seed the initial population of the genetic algorithm, and a numerical example that represents a mixed model assembly line that assembles two different products is used to test the proposed hybridization.

Qidong Yin, Xiaochuan Luo, Julien Hohenstein et. al, (2021), this study verifies the effectiveness of using the column generation method to solve the TALBz problems. A B&P algorithm is presented to deal with the TALBz problem for the first time. The published models cannot be directly applied to implement a column generation procedure. Thus, Dantzig–Wolfe decomposition of the original model is conducted. Models of the master problem and subproblems are reformulated. The proposed branching strategy is demonstrated to be effective in obtaining an integer solution.

Iqbal Hussain Zaidi, Muhammad Ali Khan et. al, (2021), This paper is the presentation of review of literature on the topic of lean manufacturing which is the famous waste reducing technique for the manufacturing, process, and service industries. It was indicated from the literature review nowadays lean manufacturing if being implemented at the large scale in manufacturing industries and at the same time, the bakeries are also reported to be user of lean manufacturing. From this slowly and gradually the small, medium, and large businesses are compelled to simplify their process for the survival in this diversified market. Since, it is the popular waste eliminating technique thus it was used for the elimination of non-value-added activities.

Bhuvana Ramkumar & Varshitha Harish et. al, (2021), The new developments in the global economy have demanded a paradigm change from profit maximization to customer satisfaction in the manufacturing sector. One such processoriented approach for achieving sustainability in competitive markets is LM techniques. Our research provides a precedent that creates an opportunity to propose a repository of information to encourage LM-related studies. The bibliometric analysis was performed on the data using the open-source R code and visualized using VOS viewer. Mostly increasing growth pattern of the LM subject is found based on previous publications.

Neena Sinha, Misha Matharu et. al, (2019), Systematic review of literature indicates that the most dominant theme found in literature is lean adoption, followed by lean and its relation to performance. Lean is also emerging as an important dimension in organizational theory literature but there is a need for further consolidation. Compatibility of lean with sustainability and green practices is also reflected in the contemporary literature. The superiority of lean as process improvement methodology led to conformance by the manufacturers globally to the paradigm. The present business environment with its rapid changes in market, rise in its economic, technical, and socio-psychological complexities has paved way for acceptance of lean as an operating strategy in a pervasive manner.

Richa Rashmi Sarmah and Debashish Gogoi et. al, (2019), From the study of the assembly line, it can be summarized that, through logical planning and proper distribution of total job between the work stations a balanced assembly line can be obtained. In order to, achieve that, certain factors like the number of work stations, cycle time, takt time, total cost imposed and productivity must be given special attention. Therefore, we must arrange the work stations in such an optimal way that higher productivity can be achieved for an organization at a comparatively low cost.

Muhammad Waseem Bari, Meng Fanchen and Muhammad Awais Baloch et. al, (2016), This study examines the direct and indirect effect of TQM on soft job satisfaction practices in the context of the Pakistani banking sector. The relational psychological contract mediates the relationship between gentle TQM practices and job satisfaction. A questionnaire was designed and distributed to 400 employees of different management levels. The helpful response rate was 74%. The data were analyzed using the SEM-PLS technique. The main findings were as follows: (1) Three gentle TQM practices (teamwork, rewards and recognition, and education and training) had a significant direct and indirect effect on job satisfaction. Organizational culture (OC) does not have a direct effect on job satisfaction; however, PRC participates significantly in the indirect effect of CO on job satisfaction.

Mohd Ghazali Maarof and Fatimah Mahmud et. al, (2016), This paper reviews some selected factors that contribute to the successful implementation of Kaizen and its challenges among small and medium-sized businesses. Factors such as good communication between senior management and their employees, a clear corporate strategy, the presence of a Kaizen champion staff in the organization, good knowledge management, and employee empowerment were found to contribute to the successful implementation of Kaizen. The review also found that resistance to change, lack of employee

motivation, lack of understanding of companies' strategic path, and difficulties in managing continuous improvement formed some of the challenges in implementing Kaizen. It seems that there are 18 some similarities between small and medium-sized companies and large companies in terms of the factors that contribute to the implementation of Kaizen. Therefore, this document can provide some ideas on the factors that contribute to the successful implementation of Kaizen and their challenges.

Gulin Idil Sonmezturk Bolatana, Sitki Gozlub, Lutfihak Alpkanc and Selim Zaimd et. al, (2016), The aim of this research was to define the critical factors of technology transfer performance and to measure its impact on quality performance and total quality management. In this study, a questionnaire form was designed and later conducted face to face with manufacturing managers or quality managers of manufacturing companies in Turkey. Two hundred organizations of the 1000 largest enterprises according to the classification of the Istanbul Chamber of Industry were assessed. A model was developed to study the relationships between technology transfer performance, quality performance and total quality management based on theoretical considerations. Technology transfer performance had a positive and strong impact on total quality management, but it did not have a significant impact on quality performance. A positive and solid relationship has been established between total quality management and quality performance. The relationship between technology transfer performance and quality performance has become significant with the mediating role of total quality management.

Ignatio Madanhirea and Charles Mbohwab et. al, (2016), This research focused on the study of statistical process control, i.e., the TQM tool in manufacturing systems, with the general objective of updating them to improve quality and profitability. This is an attempt to fill the gaps in the literature on the implementation of TQM. With a focus on early detection and prevention of problems, TQM has proven to have a clear advantage over quality methods such as final product inspection. It was necessary to check the meters and machines and determine the need for maintenance or overhaul, as faulty machines could not produce good quality products. Operators had to be trained, new documents produced and actions agreed for the future. A system should be in place to review progress and monitor results with as much priority as financial results.

Mohd Ghazali Maarof and Fatimah Mahmud et. al, (2016), The This paper reviews some selected factors that contribute to the successful implementation of Kaizen and its challenges among small and medium-sized businesses. Factors such as good communication between senior management and their employees, a clear corporate strategy, the presence of a Kaizen champion staff in the organization, good knowledge management, and employee empowerment were found to contribute to the successful implementation of Kaizen. The review also found that resistance to change, lack of employee motivation, lack of understanding of companies' strategic path, and difficulties in managing continuous improvement formed some of the challenges in implementing Kaizen. It seems that there are 18 some similarities between small and medium-sized companies and large companies in terms of the factors that contribute to the implementation of Kaizen. Therefore, this document can provide some ideas on the factors that contribute to the successful implementation of Kaizen and their challenges.

G.R.Esmaeilian, F.Ghanbarian et. al, (2015), In this paper, we study and modeled the PMMALB/D problem with two objectives: reducing the number of workstations required and reducing the cost of labor. Moreover, a computational test, which was done using the prominent dataset in this field, was evaluated.

Jayant, Mohd. Azhar and Priya Singh et. al, (2015), The main objective of this document was to provide an updated and structured overview of the recent review of the literature related to interpretive structural modeling and its implementation to model variables of supply chain management and other related fields. The ISM literature is examined in three ways. First, phase of study of the concept of ISM and examination of ISM as a modeling technique. In the second phase, application of it to model supply chain management. Third, phase of the ISM technique by researchers in their modeling work in different fields. All this description of the literature provides a good basis and a clear guide for researchers on the ISM methodology. Using the ISM methodology, the researcher and industry manager can develop the model from variables from different domains, which improves the performance of those domains.

Filiz Eryılmaza and Mehmet Eymen Eryılmaza et. al, (2015), The middle-income trap based on per capita income and measuring per capita income in dollars and primarily against purchasing power parity indicates the vicious circle in which a country enters at a certain level of income. Thus, countries caught in the middle-income trap remain in this cycle for long periods of time and have not been able to reach the next income level, the high-income group. Several ways out of this trap for countries have been proposed in the literature highlighting the importance of incentives and support that the state could provide to the private sector. The objective of this study was to discuss the possible changes that the incentives provided by the State based on R&D innovations could initiate in particular in the competitive strategies of large companies and to present two proposals based on this discussion on all aspects such as as Value Stream Mapping (VSM), Cellular Manufacturing (CM), U-line System, Line Balancing, Inventory Control, One Minute Die Swap (SMED), Pull System, Kanban, Production Leveling, etc. a lean roadmap for the organization to implement the lean manufacturing system. Analyzes of the scoping survey results have been summarized in this article to illustrate the sequence of implementing lean elements in a volatile business environment and the findings of this review have been synthesized to develop a unified theory for the implementation. lean elements.

Akhil Kumar et. al, (2014), This paper shows that one the major difficulties companies encounter in attempting to apply lean is not knowledge of tools and techniques, perhaps lack of comprehensive and suitable lean knowledge related to

probable problems within the companies by the managers, direction, gap and a lack of recognition of lean culture in whole of the organization and planning cause the fails within the implementations. Additionally, some managers try to enhance the implementation by some of the lean tools and mostly try to only implement the "continuous improvement" and explicitly forget another basic lean principle, "respect for people". The managers should know that lean thinking won't derive during a short time, and they should prepare the context of implementations before every decision making. Lack of Planning, Lack of top management commitment, Lack of Methodology, Unwillingness to learn and see and Human Aspects are the main barriers or problems which can be faced while implementing the Lean Manufacturing. These have already been discussed in the previous section.

Dr. Nitin Upadhye, Devendra Singh Awana and Sandeep Mathur et. al, (2014), This study had attempted to find the catalysts from the literature review and expert opinions from the corrugated packaging industries and developed the matrix of relationships to see the driving power and dependence between them. In this study, a modeling was carried out in order to know the interrelationships between the catalysts using interpretive structural modeling and the multiplication of the cross-impact matrix applied to the classification, i.e., MICMAC analysis for the performance of the Indian corrugated packaging industries.

Dr. Meenakshi Tyagi et. al, (2014), Small and medium-sized enterprises have played an important role in the growth process of the Indian economy since independence, despite stiff competition from the large sector and lackluster support from the government. The essence of the argument that comes to mind was that although they play a crucial role in contributing enormously to job creation in the country, SMEs are not well equipped and work in the traditional way to do so. facing the challenges of global competition. Due to globalization, the competition was very stiff and the big players have a strong hold on the market because they are prosperous in every area be it money, management, machines or methods. They must work with TQM components to meet the challenges in today's competitive global 24 environment. The objective of this document was to declare the urgency of TQM to improve the productivity and quality level of SMEs by showing the result of companies that have successfully implemented TQM. This study was able to present the importance of the TQM approach and provides a positive direction for future work.

Raj Kumar et. al, (2014), He focused on improving quality and productivity significantly to improve the competitiveness of an organization. Organizational leadership plays a vital role in affecting the efficiency and productivity of a particular organization and the management of employees and workers involved. But the quality of business leadership was another problem in implementing TQM in these companies. This document has tried to find out what are the factors that hinder the implementation of the total quality management of small and medium-sized companies for a continuous process of business development. Data had been collected from 100 units of small and medium-sized enterprises located in rural or urban areas. For data reduction, the factorial analysis technique was used. After data collection, the model was developed.

Suresh Prasad and S.K. Sharma et. al, (2014), Operations management has long been focused on waste reduction, so modern management programs like Lean Manufacturing represent today's best practices in operation management. Even without explicitly targeting environmental results, lean efforts can yield sufficient environmental benefits. However, because environmental wastes and pollution are not the main focal points, this achievement may not be maximized in the normal scheme of lean. Thus, it is concluded that the two strategies (lean and green) can be integrated and offered simultaneously in the operation management to reduce both waste and pollution.

PROBLEM STATEMENT

Assembly line balancing (ALB) problems mainly deal with proper allocation of tasks to the workstations in a balanced manner without violating the precedence relationship and optimizing a given objective function. This problem mainly occurs in a continuous production line and is classified as one of the hard optimization problems. Since the installation of assembly line is a long-term decision and highly cost intensive, there is a proper need of designing the assembly line and balancing the workload at the workstations. The assembly line balancing problem (ALBP) consists of assigning tasks to an ordered sequence of stations such that the precedence relations among the tasks are satisfied and some performance measure is optimized.

OBJECTIVES

- To minimize the number of work stations for a given cycle time.
- To minimize the cycle time for a given number of workstations, to reduce the cost & to maximise the profit.
- To improve the productivity of the process with less nos of non-value-added activities.
- Proper utilization of the space & to avoid the unnecessary movements.

METHODOLOGY

Step 1: - A reliable stopwatch to perform time study.

Step2: - A data collection sheet to record work elements and corresponding times.

Step 3: - The obvious problems are taken care of first. There is no reason to spend time describing and timing work elements that are obviously unnecessary or redundant.

Step 4: - The time study analyst should familiarize with the assembly operations before documenting the elemental times. Also, there should be plenty of communication between assembly operator and the time study analyst. The operator participation must be encouraged and their ideas must be captured.

Step 5: - Start the study capturing all work elements first (VA and NVA) – once all work elements have been captured, and then proceed to time them one by one. Trying to do both simultaneously can be overwhelming and confusing.

EXPERIMENTAL PROCEDURE:

The Time Sheet data in Table 5.1 shows the no. of work element steps enlisted in the study. The below table distinguishes the type of activity & their respective avg. time taken for the respective activity & the standard time for it. The activities are distinguished in five ways, set-up tasks, actual processing tasks, administrative system tools, non-value added, value-added. The following table 5.1 shows the distribution of Value added, non-value added, set-up tasks, administrative tasks, actual processing tasks & their respective Std. time & average time from the selected study.

Table 5.1 Work Element Sheet with Time Data

Sq. No.	Work Element	Type of Activity					Time	
		S	P	A	VA	NVA	Avg.	SD
1	Take Master Box	ü						
2	Take Mixer Body	ü						
3	Attach the rotating switch from inside & screw it.	ü						
4	Fit the indicator	ü						
5	Take accessories		ü				0.82	0.21
6	Fit small rubber on top of the body		ü				3.10	1.91
7	Check the test lamp					ü	2.80	1.06
8	Check the motor wiring by the intensity of bulb to assure the 1st, 2nd & 3rd speed.		ü				7.82	1.89
9	Attach the motor to the body		ü				1.42	0.61
10	Drill the center of the top					ü	1.91	0.50
11	Add washer on top					ü	1.93	0.74
12	Fix the motor by means of screw & washer		ü				3.89	1.55
13	Take rubber base at bottom		ü				3.56	1.88
14	Do oiling on the rubber base				ü		1.87	0.55
15	Fit them in the respective hole		ü				2.44	0.82
16	Take overload circuit breaker		ü				1.05	0.50
17	Fix the circuit breaker at the body base					ü	0.80	0.32
18	Take the knob in the rotary switch					ü	0.57	0.16
19	Check the test lamp for speed					ü	0.69	0.24
20	Connect a 3-inch wire in point O of rotary switch.		ü				2.36	1.05
21	Check again the speed		ü				1.78	0.65
22	Check for point 1,2,3					ü	0.76	0.34
23	Attach rotary switch O to speed point 1 of motor		ü				5.49	2.53

24	Attach 1st speed of the motor point connect to the point 1 of rotary switch					ü	1.43	0.75
25	Attach 2nd point of speed of motor point to the end point of the rotary switch					ü	1.00	0.82
26	Take the mains lead					ü	1.29	0.69
27	Cut the wire points		ü				2.01	0.51
28	L side of the mains lead & one side of the indicator will connect to the pole point P of the rotary switch		ü				1.69	0.45
29	Joint the points by the soldering process		ü				14.53	44.56
30	Join the tip of the wire on the second point of the indicator		ü				1.70	0.69
31	connect side of indicator & side of the mains lead will connect to circuit breaker		ü				2.21	1.52
32	Join the wires by soldering					ü	0.71	0.39
33	Neutral side of the motor will connect to another side of the circuit breaker				ü		1.40	0.66
34	Join the wires by soldering					ü	0.76	0.30
35	Neutral side of the motor will connect to another side of the circuit breaker				ü		2.12	0.98
36	Earthing wire of the mains lead will connect to the body of the mixer motor		ü				2.96	1.54
37	Make a gap for mains lead		ü				1.87	0.86
38	Bottom side of the body attached to the upper section body of the screws		ü				0.98	0.59
39	Check the mixer operation by the electricity source		ü				2.41	0.73
40	Fix the coupler on the top section of the coupler		ü				3.10	1.32
41	Again, check the operation & rotation of the coupler		ü				7.09	1.53
42	Attach the mixer jar to the mixer body					ü	0.77	0.40
43	Check the working of the mixer by attaching the jar		ü				0.78	0.21
44	Wound the wire		ü				4.02	1.88
45	Place it in the wrapper		ü				6.72	3.44
46	Place the package in box		ü				1.36	0.43
47	Tape master box	ü						
48	Move to storage	ü						
Total							107.99	seconds

Table 5.2 The relation between cumulative annual usage and cumulative value of items

Work Element Sequence No.	Work Element	Time Samples												Avg. Time	Std. Dev.	Standard Error
		1	2	3	4	5	6	7	8	9	10	11	12			
5	Take accessories															
6	Fit small rubber on top of the body															
7	Check the test lamp															
8`	Check the motor wiring by the intensity of bulb to assure the 1st, 2nd & 3rd speed.															
9	Attach the motor to the body	1.33	1.18	0.68	0.87	1.00	0.87	0.87	0.85	0.89	1.01	0.83	1.17	0.96	0.18	0.05
10	Drill the center of the top	4.24	3.30	3.10	2.68	5.90	2.72	4.62	4.58	4.09	3.97	4.31	2.71	3.85	0.94	0.27
11	Add washer on top	1.13	0.65	0.52	0.63	0.86	0.72	0.62	0.61	0.92	1.30	1.22	0.75	0.83	0.25	0.07
12	Fix the motor by means of screw & washer	1.22	0.67	1.15	0.52	0.74	0.72	0.72	0.94	1.12	1.50	0.69	0.81	0.90	0.28	0.08
13	Take rubber base at bottom	3.78	1.66	1.83	1.68	1.42	1.26	1.36	1.64	1.74	1.25	1.71	1.08	1.70	0.67	0.19
14	Do oiling on the rubber base	2.49	3.31	1.64	1.59	2.40	2.45	2.26	2.40	2.36	1.12	3.73	2.12	2.32	0.68	0.20
15	Fit them in the respective hole	0.95	0.68	0.41	0.70	0.33	1.77	1.38	0.57	0.56	0.56	0.39	0.63	0.74	0.41	0.12
16	Take overload circuit breaker	1.00	0.91	0.59	0.57	1.13	0.68	1.63	0.31	0.43	0.70	0.66	0.64	0.77	0.34	0.10
17	Fix the circuit breaker at the body base	1.12	1.16	1.14	2.09	0.93	0.79	1.43	1.28	1.13	1.24	1.16	1.30	1.23	0.3	0.09
18	Take the knob in the rotary switch	1.08	0.68	1.07	1.09	1.30	1.07	0.76	0.90	1.37	1.02	0.88	0.97	1.02	0.19	0.05
19	Check the test lamp for speed	1.70	1.30	0.73	1.17	0.30	0.86	0.76	0.82	0.80	0.74	0.73	0.74	0.89	0.34	0.10
20	Connect a 3-inch wire in point O of rotary switch.	3.54	3.62	3.88	6.89	2.92	4.19	3.21	3.43	3.47	3.87	3.69	3.72	3.87	0.96	0.28
21	Check again the speed	3.91	7.51	4.53	5.14	4.06	5.39	4.11	3.20	5.10	3.27	3.02	3.57	4.40	1.21	0.35
22	Check for point 1,2,3	2.27	1.37	1.43	1.45	2.26	1.53	1.80	1.63	1.72	1.54	1.97	2.16	1.76	0.32	0.09
23	Attach rswitch O to speed point 1 of motor	0.84	1.48	1.19	2.12	3.23	1.14	1.60	1.56	1.92	1.07	1.17	1.76	1.59	0.61	0.18
24	Attach 1st speed of the motor point connect to the point 1 of rotary switch	1.91	1.83	1.16	1.23	0.98	1.02	1.24	1.14	0.97	0.85	0.91	1.43	1.22	0.33	0.09
25	Attach 2nd point of speed of motor point to the end point of the rotary switch	1.04	0.57	0.83	0.94	1.11	1.06	1.12	1.18	0.89	0.90	0.85	0.96	0.95	0.16	0.05
26	Take the mains lead	0.61	0.65	0.30	0.73	0.80	0.59	0.44	0.64	0.76	0.56	0.65	0.74	0.62	0.14	0.04
27	Cut the wire points	2.42	2.11	1.94	1.98	2.89	3.51	2.96	3.11	3.01	2.62	3.00	2.30	2.65	0.48	0.14
28	L side of the mains lead & one side of the indicator will connect to the pole point P of the rotary switch	1.08	1.27	0.94	1.08	0.70	0.88	1.56	1.91	1.09	1.06	1.80	0.89	1.19	0.36	0.10
29	Joint the points by the soldering process	3.51	2.21	2.06	2.48	2.36	2.89	1.39	3.01	2.01	3.11	2.00	3.32	2.53	0.61	0.18
30	Join the tip of the wire on the second point of the indicator	0.88	0.59	0.72	0.50	0.66	0.62	0.79	0.81	0.67	0.87	1.00	0.73	0.74	0.13	0.04
31	connect side of indicator & side of the mains lead will connect to circuit breaker	2.38	1.81	0.71	0.81	0.80	0.87	0.68	0.81	1.13	0.65	1.18	0.91	1.06	0.5	0.14
32	Join the wires by soldering	2.63	1.78	2.50	1.52	1.55	1.66	2.28	2.69	1.89	0.88	2.34	2.16	1.99	0.52	0.15
33	Neutral side of the motor will connect to another side of the circuit breaker	1.90	1.99	1.47	1.28	1.64	1.56	1.81	1.56	1.86	1.37	2.24	1.50	1.68	0.27	0.08
34	Join the wires by soldering	4.92	4.42	5.12	4.42	2.46	3.64	5.95	4.37	3.20	4.07	3.82	3.74	4.18	0.88	0.25
35	Neutral side of the motor will connect to another side of the circuit breaker	1.56	2.00	2.56	1.06	1.67	1.75	2.10	2.75	4.70	2.13	2.21	2.16	2.22	0.86	0.25
36	Earthing wire of the mains lead will connect to the body of the mixer motor	5.25	4.32	4.50	4.14	3.90	6.86	4.62	4.08	4.19	3.19	4.31	4.78	4.51	0.85	0.25
37	Make a gap for mains lead	1.56	1.18	1.39	1.62	1.62	1.36	1.41	2.35	1.18	1.23	1.31	1.56	1.48	0.3	0.09
38	Bottom side of the body attached to the upper section body of the screws															
39	Check the mixer operation by the electricity source															
	Total Time (Per one individual package)													53.87 seconds		

The mean station times follow a Normal Distribution and the loading and unloading times are estimated to have Triangular Distribution. The distribution is found from the available data for station times. The actual data is not available for loading and unloading times. Hence, it estimated that these times lie between 3 seconds and 5 seconds. MINITAB Statistical Tool is used to draw both the distributions. By using the estimated data, we can conclude the loading and unloading time distribution in Minitab software. Fig. 5.2 shows the loading and unloading time distribution.

Table 5.3 Time Study Data Sheet with Station Times

Sr. No.	Cycle Time inSeconds	Avg. Station Time in Seconds	Std. Dev.
Stn 1	10.77	11.31	1.52
Stn 2		11.16	1.72
Stn 3		10.97	1.12
Stn 4		8.04	0.96
Stn 5		12.39	1.6

Figure 5.1 Station Time Distribution

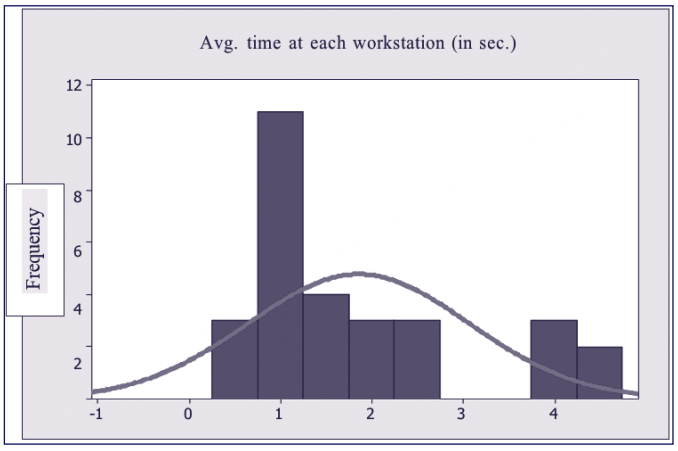
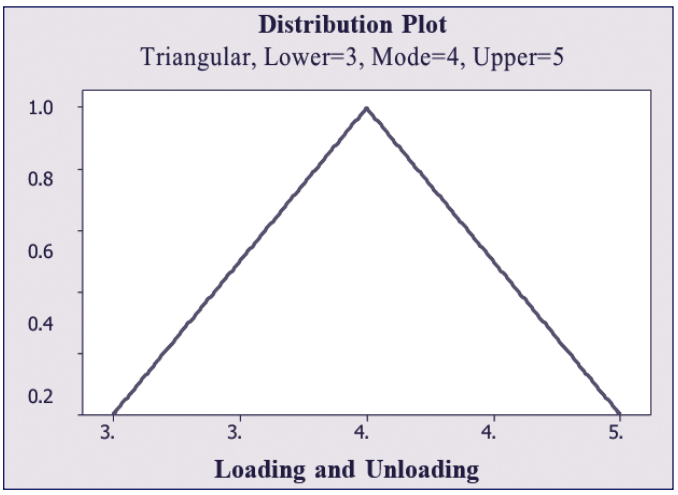
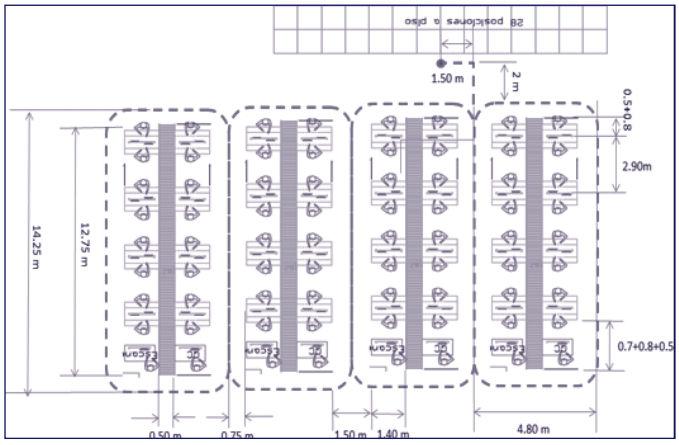


Figure 5.2 Loading and Unloading Time Distribution



The dimensions and the layout used for simulation of Single Stage Parallel Line configuration is given below in figure 5.3 as shown.

Figure 5.3 Assembly Layout with Dimension



The figure 5.4 shows the detailed assembly layout with dimensions & the pattern of assembly table and the sitting pattern of workers. Red dotted line shows the path movement of the material handling.

Figure 5.4 Material Handling Cart Routing Logic

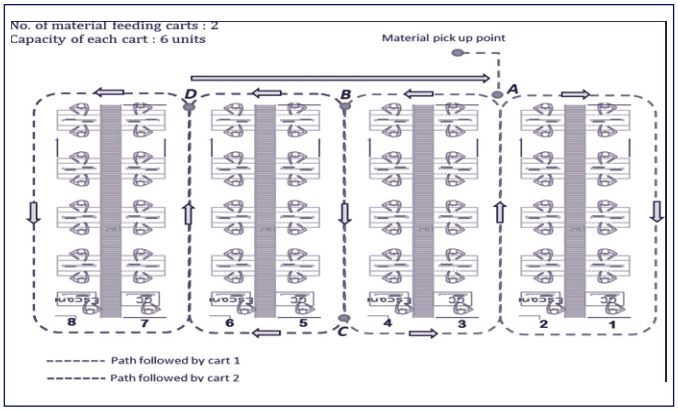


Figure 5.4 shows Cart movement logic in material handling, both the carts 1 & 2 pick-up boxes at the pick-up point and go to A. Path followed by cart 1 & 2 are shown by red and blue dotted line respectively. Firstly, at position A, Cart 1 checks for the total number of boxes across buffers in line 1 and line 4. It then proceeds to the fill the line with a smaller number of boxes as per requirement. Cart 2 directly proceeds to point B. Now at point B, firstly Cart 2 checks for the total number of boxes across buffers in line 5 and line 8. It then proceeds to the fill the line with a smaller number of boxes. At C, Cart 1 proceeds to fill lines 2 and 3. If empty, goes to the pickup point. If cart 2 is empty, it proceeds along line 3 to the pickup point, else goes to fill lines 6 and 7. At D, If cart 2 is empty it directly goes to pick up point to load boxes, else goes to fill line 8. Then, the finished master boxes are moved to bar-coding manually by operators. Now the figure 5.5 shows the improved assembly layout material handling, where bar coding area is connected to the assembly area as to reduce the travelling of material after assembly to barcode area. It will save the material handling time.

Figure 5.5 Five-Stage Serial Line Configuration

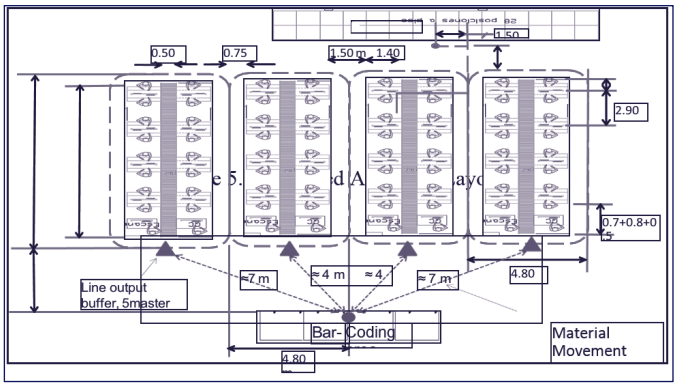
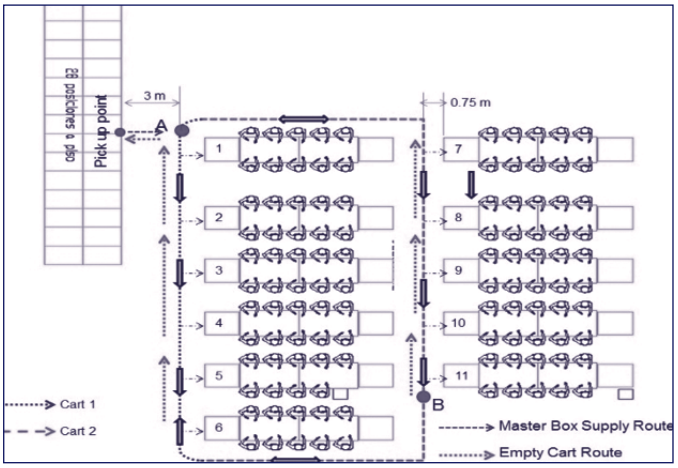
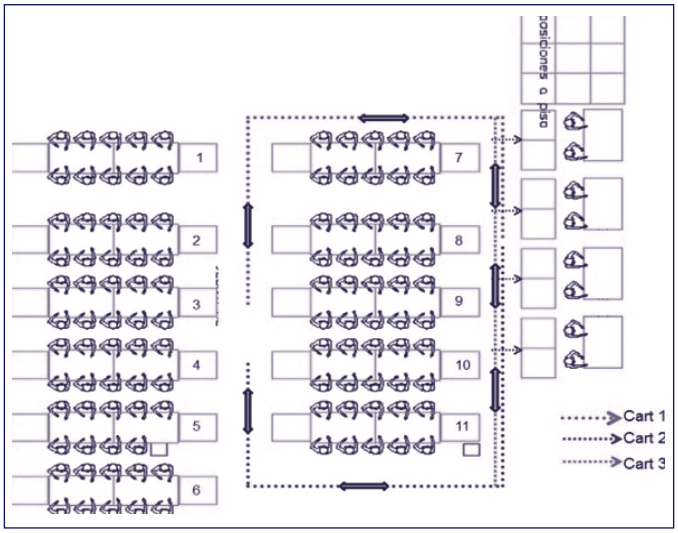


Figure 5.6 Material Handling – Supply Side



The below figure 5.6 shows the material handling for five stage assembly line is broken down into two parts based on master box supply and finished master box transport to bar-coding area. Carts 1 & 2 load master boxes at the pickup point and proceed to point A. At point A, cart 1 goes to fill tables numbered from 1 to 6. Cart 2 goes to filltables numbered from 7 to 11. After unloading at each table, if the empty carts go to the pickup point to loadmaster boxes through the path shown in red. Else

Figure 5.7 From Assembly to Bar-Coding

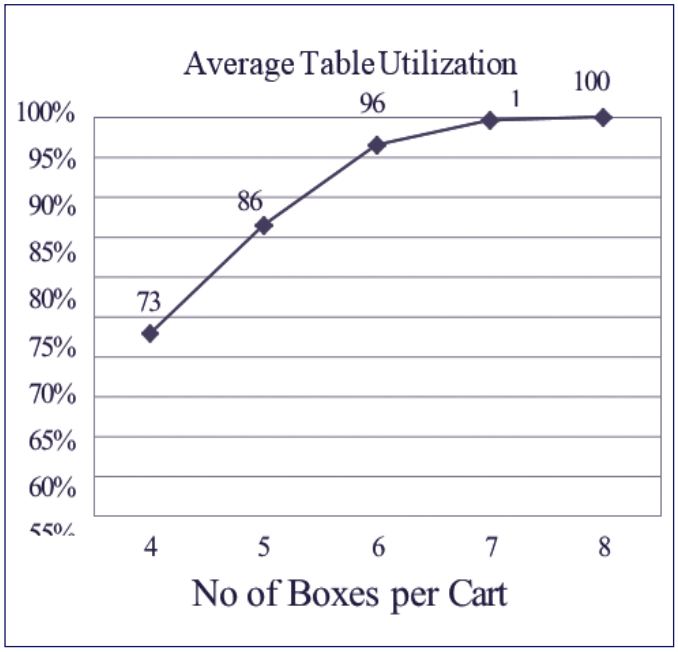


proceeds to the next table at point B, if the cart 2 has enough master boxes goes to fill tables 6 to 1, else goes to the pickup point though the path shown in red. If all the buffers are full, the carts wait at point A Cart 1 is dedicated to tables numbered 1 to 6 and Cart 2 to tables 6 to 11.

Figure 5.7 shows the assembly to bar coding section layout. In the figure 5.5 the movement of the master boxes to the bar coding are is shown in red, blue & pink dotted line from the respective tables. The carts wait until at least one master box is ready at each of the buffers. Cart 1 serves tables1, 2 and 3. Cart 2 serves tables 4, 5 and 6. Cart 3 serves tables 7,8,9,10 and 11. Cart 1 unloads at bar-coding stations BC1, BC2 and in that order. Once empty goes back along the same path to load boxes at tables 1,2 and 3. Cart 2 unloads at bar-coding stations BC4, BC3 and in that order. Once empty goes back along the same path to load boxes at tables 4,5 and 6, Cart 3 starts at table 11 and proceeds to table 7. If full unloads at the corresponding bar-coding station. If it has free space, goes to load at next table and so on. It is assumed that the empty master box is available at the end of table.

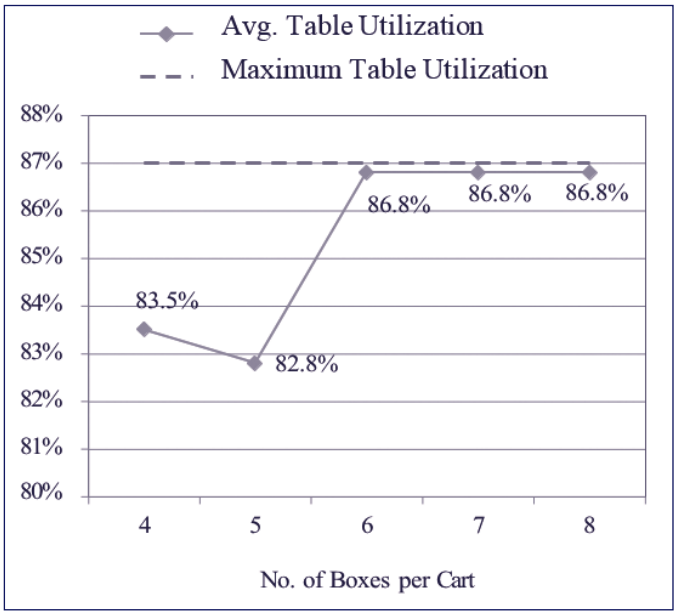
5.4 Material Handling Cart Capacity.For single stage line it can be seen from Figure 5.8 that at cart capacity as 6 boxes maximum utilization is achieved. The idle time for material carts increases when the capacity exceeds 6 units although utilization is 100%, which is not recommended. Similarly for five-stage line, maximum table utilization is observed at a capacity of 6 boxes. So, for both the configurations the material handling cart loads 6 boxes per trip.

Figure 5.8 Cart Capacities for single stage parallel line layout



For five stage serial line layout the green line shows the respective efficiency % for the no. of boxes ^ the box. Table utilization. So, from the graph for both the layouts the material handling cart loads 6 no of boxes for a trip.

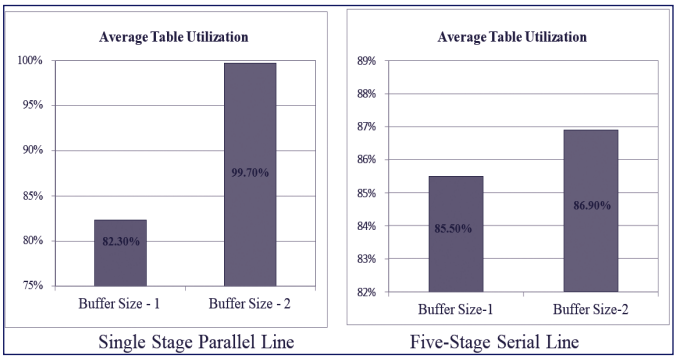
Figure 5.9 Cart Capacities for five-stage serial Line Layout



5.5 Material Handlers Required – Supply Side With the cart capacity fixed as 6 units, iterations are run by varying the cart quantities. For both the configurations, 2 carts are required to supply master boxes to input buffers.

5.6 Input Buffer Size- The assembly tables yield maximum utilization when the input buffer size is 2 units. Figure 5.10 gives the analysis of changing buffer sizes on the average table utilization.

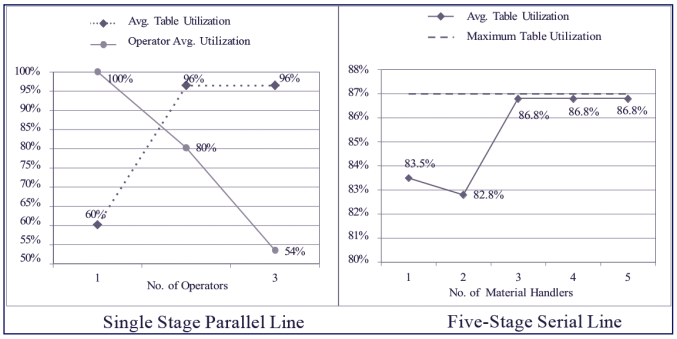
Figure 5.10 Buffer Sizes for Both Configurations



5.7 Output Buffer Size- The output buffer size is determined by performing iterations by varying the output buffer capacity for fixed input buffer sizes, cart capacity and quantity. The output buffer capacity is obtained for single stage line as 5 units and for five-stage line as 2 units per table.

5.8 Material Handlers Required – Bar Coding Side-The single stage line requires two operators to carry finished master boxes to bar coding area. The five-stage line requires three material handlers with carts to transfer master boxes to bar coding area. This is determined based on how the finished box removal from output buffer affects the assembly utilization. The material handling requirements based on the table utilization is shown in figure 5.11.

Figure 5.11 No. of Material Handlers Required



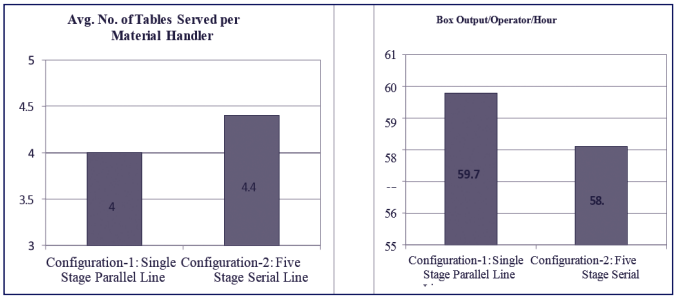
RESULT

The table 5.4 compares the results for the two assembly configurations tested.

Table 5.4 Consolidated Results

Parameter	Single Stage Parallel Line	Five Stage Serial Line
No. of material handlers required – Supply side	Carts with operators 2	Carts with 2 operators
No of material handlers required – Bar coding side	Operators 2	Carts with 3 operators
Cart capacity	Boxes 6	Boxes 6
Input buffer size	Boxes 2	Boxes 2
Output buffer size	Boxes 5	Boxes 2

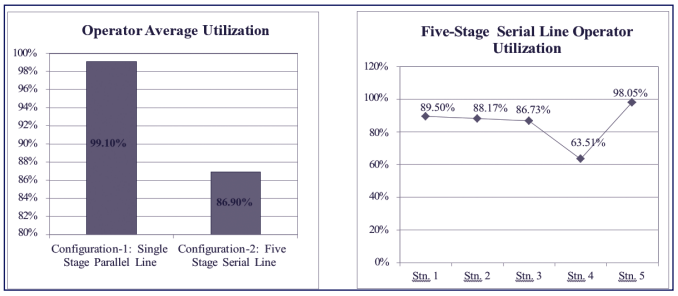
Figure 5.12 Results Comparing Two Configurations



The consolidated results comparing the two assembly line configurations are as follows. Fig. 5.12 shows avg. no of tables Served Per Material Handler**:** Number of tables served by each material handling unit is higher for five stage serial line configuration. Fig 5.13 shows that the five-stage serial line requires less material handlers than the single stage line. The number of tables to be served is lesser in five stage configurations compared to the single stage configuration. But it can be observed that the difference is not highly dominating. Productivity: The single stage configuration gives output as 59.7 boxes/operator/hour where as five stage line gives 58 boxes/operator/hour. There is a considerable improvement in productivity in both the assembly lines from the original

method. Operator Utilization**:** Figure 5.13 shows that the average operator utilization for single stage line is about 99% and for five stage line is 86.9%. For a five- stage line all the operators at different stages of assembly line are not uniformly utilized.

Figure 5.13 Operator Utilization



While solving an assembly line balancing problem, certain amount of imbalance in station times is inevitable. In this case, the level of imbalance has a great impact on the assembly line utilization. It is recommended to implement the single stage parallel line in order to achieve higher productivity and better overall assembly performance.

CONCLUSION

From The current study is used Assembly Line Balancing tool for increasing the productivity of manufacturing industries. Technological advances have driven dramatic increases in industrial productivity since the dawn of the Industrial Revolution. The three-step methodology incorporating Lean principles is applied to a case study problem and two different assembly configurations are developed and compared, namely Single Stage Parallel Line and Five Stage Serial Line. Based on the simulation performance results, the Single Stage Parallel Line is suggested to be implemented. From fig. 6.1 it can be observed that the proposed system results in doubled productivity.The improved assembly line gives an output of 59.8 boxes/operator/hour, which is about a 90% increase in operator productivity from the original method. Also, with this Single Stage Parallel Line, the floor space usage is reduced by half compared to original method.

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AUTHORS

Tejal Raut, Mechanical Engineering Department, VIVA Institute of Technology, Shirgaon, Veer SawarkRoad, Virar (East), Tal-Vasai, Chandansar, Virar – 401 303 (MS)
Email: tejaldraut@gmail.com

Prof. Niyati Raut, HOD, Mechanical Engineering Department, VIVA Institute of Technology, Shirgaon, Veer Sawarkar Road, Virar (East), Tal-Vasai, Chandansar, Virar – 401 303 (MS)
Email: niyatiraut@viva-technology.org

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BUILDING INTUITIVE CHATBOTS FOR HUGE KNOWLEDGE BASES USING INFORMATION RETRIEVAL

Umesh D
Dr. Vikas S

Abstract

Since the beginning of artificial intelligence and machine learning, one of the primary areas of focus has been developing systems capable of comprehending human people and responding to them in the most natural manner possible. This has been one of the primary areas of focus since the beginning of artificial intelligence and machine learning. The simulation of human interaction is the intended end result of a machine-learning system with the same name as the chatbot.

Keywords – IR, LSTM, RCNN, Machine learning.

1. INTRODUCTION

Chatbots are becoming more popular as a kind of application that enables individuals to conduct simple discussions via the use of text [1]. Chatbots may be broken down into two primary categories. The first kind is known as a generative chatbot, while the second type is a retrieval-based chatbot, also known as an IR-based chatbot. The user inputs their question, and the generative chatbot provides an answer to that question automatically. The conversational training set was used as a basis for the replies that were created. The IR-based chatbots always make an effort to provide a response that is the most relevant one out of the preset replies that are included in the dataset. The Ubuntu conversation corpus was used in the development of this IR-based chatbot system.

The Ubuntu Dialogue Corpus is a very extensive database that contains one million different conversations. Context, utterance, and label are included in the dataset. The term could have a good or a negative connotation. The presence of the positive label suggests that the speech in question is suitable for the context in question, whilst the presence of the negative answer shows that the utterance in question is not suitable for the context in question. The training set consists of talks that are marked positively 50% of the time and negatively 50% of the time[3].

The pretrained Glove (Global Vectors for Word Representation) model may be used to produce the word embeddings for the provided text data. [4] When attempting to make a prediction, the word embeddings are sent via an LSTM (long short term memory) network.

The data for the test are organised into columns with one context and 10 utterances each. Only one of the 10 statements will be the ground truth speech, and the others will all be distractors. The ten-dimensional vectors will serve as the values that are expected. The significance is taken into consideration while assigning the values. The speech that is most pertinent would be given the most value among that. Recall @k is the metric that is employed, and k may be any number between one and ten.[5] k is any integer that takes the highest k utterances from 10.

2. RELATED WORK

In the area of human-machine interaction, a lot of research has been carried out throughout the course of time, and many different projects are now being worked on. Manuscript forms are used for the presentation of some of the works that are relevant to the area.Puneet Agarwal [1] in the paper highlighted the challenges they faced while building an emerging commercial chatbot. They builded a chatbot which they referred as trusted friend of every Indian youth. In his study, Ryan Lowe [2] detailed the many components that make up the Ubuntu dialogue corpus. In addition to this, they discussed two methods that are helpful in analysing the Ubuntu Dialog Corpus[6].

3. SYSTEM OVERVIEW

The flow of the paper goes in the following way:

1. **ENCODING**
2. **CREATING THE MODEL TO CLASSIFY DATA:(LSTM)**
3. **PREDICTION**
4. **EVALUATION**

Pre-processing: Stemmatization and lemmatization were applied to the data that was provided (the Ubuntu Dialog corpus). In addition, we eradicated the stop word from both the context and the utterances [7]. In a subsequent phase, we got rid of the underscores and a few words that were meaningless.

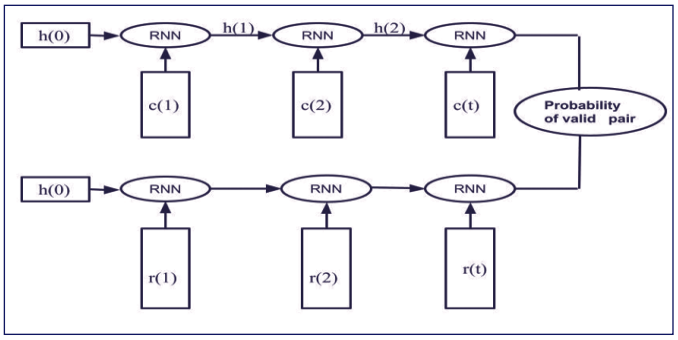
Glove Implementation: We tokenize both context and response. Here tokens represent words

- Every word has to be converted into fixed size vectors. We made use of Glove vectors to initialize the word embeddings of context and responses. In later part of project LSTM model is used for classification purpose. Because the Ubuntu dialogue corpus is such a big database, the pre-trained embedding used in Glove is scalable, making it an ideal choice for this particular project [8].

4. MODEL ARCHITECTURE

The word embeddings obtained are fed to the LSTM (Long Short-term Memory)[10]. The architecture of LSTM model is given below.

Fig 1: Recurrent Neural Network (RNN)



RN Ns are examples of types of neural networks shown in Fig 1. This RNN has a hidden state that is denoted by ht, the hidden state of the state before it is denoted by ht1, the input state is denoted by xt, the weight metric of the input neuron is denoted by W x, and the weight metric of the recurrent network is denoted by W h. The formula for representing the current state is as follows:

$$h_t = f(W_h h_{t-1} + W_x x_t) \quad (1)$$

Long Short Term Memory networks (LSTM)

Th e issue of long-term dependencies in RNNs may be circumvented by the use of a specialized kind of neural network known as an LSTM model, which is what has been used here.

Th e word embedding produces vectors for every word in contexts and utterances. The vectors of context are fed to one neural network and the utterance are given to the other network. The hidden state gets updated every time we feed word to the RNN, and the last hidden state represents the vector of context and utterance. The learned parameters are represented by matrix M. Let the context matrix obtained be c, and let the utterance matrix obtained be uttera.

p(label=1|c,u,M)=(C + b), where b represents the bias in the analysis. (2)

In the last step of the process, the model is trained by minimising th e binary cross entropy of all context-utterance pairs. The loss in binary cross entropy is denoted by the letter L and is determined using the equation that is provided below.

$$L = -\sum_{i=1}^{n} logp(label|c_i, r_i, M) \quad (3)$$

5. RESULTS AND PERFORMANCE

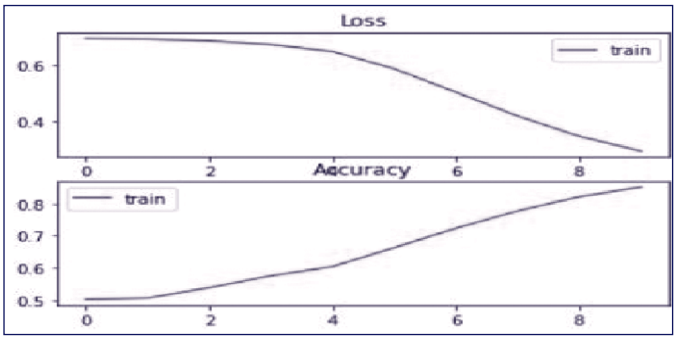
There is one context, one ground truth utterance, and nine replies spread throughout each tuple that makes up the test dataset. These are the elements that are utilised to test the model that has been suggested. While it comes to each answer, the context is taken into consideration when computing the likelihood. If the likelihood is higher, then there is a greater possibility that the reaction will be more appropriate to the situation.

Table 1: Analysis on Predicted Probability

Context	Response	Predicted Probability
what you looking for linuxuz3r? __eou__ no i mean are you looking for a spefic program? __eou__ im not sure if there is anything better then sourceforge __eou__ __eot__ no particular program, anything that interest me then contribute to the source __eou__ iwanna learn how to read code __eou__ __eot__	there is one that escapes me at the moment __eou__ most people use sourceforge __eou__	**0.7910602**
	but, from what to what? Can I hook up a formerly raid'd drive via USB/ SATA bridge like that? __eou__	**0.3378635**

The following graph Fig 2 represents the accuracy and loss of training and was produced as follows:

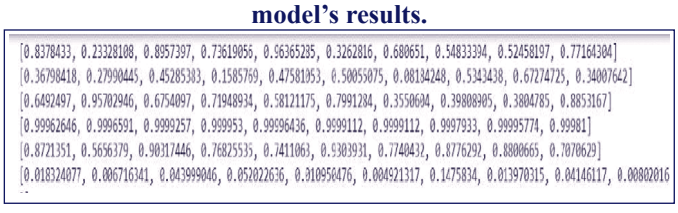
Fig 2: accuracy and loss of training Plot



	LSTM
in 10 R@7 1	0.6990099
in 10 R@8 1	0.8019802

The results of the test are summarised in the table below, with each tuple indicating the likelihood that the context was present with the replies.

Table 2: The table containing the top k recalls for the model's results.



6. CONCLUSION

An algorithm that provides an explanation of the procedure as well as the findings that were reached is described in this work. It has come to our attention that the model that was given and The use of methodology has been shown to be an effective strategy for resolving the issue at hand, and it is possible that its use may contribute to the overall improvement of the matter in question.

7. FUTURE DEVELOPMENT

We were only able to utilise a portion of the data for training since our computing resources were restricted. We would want to apply the training on the whole one million data set in order to create a more accurate training model.

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AUTHORS

Mr. Umesh D, Department of Computer Science, Smt. Indira Gandhi Govt. First Grade Women's College Sagar Karnataka India.
Email: Umesh.sirmv@gmail.com

Dr. Vikas S, Assistant Professors, Department of Computer Science and Engineering, Visvesvaraya Technological University, CPGS Mysuru, Jnana Sangama, VTU Main Road, Machhe, Belagavi – 590 018, (Karnataka) India.
Email: Vikas.smg@gmail.com

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GRADUATESHIP EXAMINATION IN INDUSTRIAL ENGINEERING

The Indian Institution of Industrial Engineering (IIIE), a National Body dedicated to the advancement of the profession of Industrial Engineering. An ISO 9001:2008 certified Institution, IIIE conducts Graduateship Examination every year through a nation-wide network of 33 Chapters and Centres. It provides an opportunity to individuals aspiring to acquire professional qualification for career advancement while contributing to the productivity of the nation. A pass in the Graduateship Examination is deemed at par with a Bachelor's Degree in Industrial Engineering, from a recognized Indian University.

The Institution also publishes a monthly “Industrial Engineering Journal” which is informative and useful to the students, Professionals and Academicians in the field of Industrial Engineering. One who wishes to qualify through the Graduateship Examination of this institution can enroll as a student member (qualifications required are given below). For detailed information about the Syllabus and Application Form, Examination and Project work are available on IIIE website www.iiie-india.com / iiieexamdept@gmail.com .

QUALIFICATIONS REQUIRED FOR STUDENT MEMBERSHIP

- H.S.C (Std. XII with Science) with two years working experience.
- Graduate in Science with one year working experience.
- Diploma in Engg. / Technology (3 years course) with one year working experience.
- Has completed and passed first two years of a regular degree course in Engineering / Technology.
- Degree in Engineering / Technology of a University of India or equivalent qualification recognized by All India Council for Technology Education (AICTE) as equivalent.

Controller of Examinations

BENEFITS OF IIIE MEMBERSHIP

1. Since IIIE is the recognized forum of industrial engineers in India, membership of the Institute itself is considered as a professional accomplishment of a person. Member can use titles MIIE, SMIIE, FIIE with their names.
2. A member can join numerous seminars, workshops, training programs, special lectures, industry visits and other professional activities. Participation in such program is either free or may involve a subsidized fee.
3. A member employed in an organization can acquire additional qualification of degree in industrial engineering by passing Graduateship examination conducted by the institute twice every year.
4. 'Industrial Engineering Journal' the member magazine, is sent to your email id every month, full of current topics, new techniques, and informed opinions, which is useful to the students, professionals and academicians in the field of Industrial Engineering.
5. Volunteer opportunities are available to engineers at every stage of their career. Volunteer to work a single day of a conference, take on a commitment to serve on Chapter Council and/or on National Council. These opportunities broaden your leadership experience and are valuable additions to your resume.
6. A professional member is eligible to contest in the annual election to the Chapter Council and National Council which is the highest policy-making body of the Institution.
7. Institution encourages interested members to offer consultancy services to potential industrial customers.
8. Annual Convention organized by IIIE acts as a forum for interaction and networking of the professionals and an opportunity to present Technical Papers.
9. The CEOs Conference is organized by the Institution every year for Leaders of Industries to participate and share their experiences. The details of deliberations and case studies are made available to the members.
10. The student members may join as member of seminars specifically meant for them and can participate in a number of competitions like essay competition, paper presentation competition, etc.Best Student Awards have been instituted by IIIE.
11. A professional member may get an opportunity to work with various government and non-government bodies in different areas.
12. Only Life Membership is provided.

Kindly attach the following documents with the Professional Membership form (photo Copy):

1] Degree Certificate

2] Experience Certificate

3] DOB proof (PAN Card, Passport copy etc)

and

4] DD of Rs. 6225/- (Including GST) in favour of "Indian Institution of Industrial Engineering, Payable at Mumbai"

Visit us at www.iiie-india.com

INDIAN INSTITUTION OF INDUSTRIAL ENGINEERING NAVI MUMBAI

VISION

- To make continuous contribution to the productivity of all branches of Economic and Social Activities of the Nation.

MISSION

- Enhancement of image of Industrial Engineering Profession
- Assimilation, creation and dissemination of knowledge base in the field of productivity related sciences.
- Providing customer Service, design and installation of integrated system of resource utilisation through IE precepts and practices.

STRATEGIES

- National level survey to identify the state-of-art knowledge base and disseminate finding for enhancement of productivities of all activities.
- To intimate, support and disseminate research in IE perspective and practices.
- To foster and assist Professional Education in Industrial Engineering.
- To foster the application of IE perspectives and practices at all level of management in all activities.
- Intensify Industry - Institution interaction and aggressively **'Market'** the benefits of IE profession.
- Affiliation with international bodies in this profession.
- To provide opportunities for acquiring formal and recognized qualification in the field of Industrial Engineering.
- Offer correspondence and other courses.
- Organise intensive National level seminars and workshop catering to changing needs and emerging environment.
- Confer honors and awards to recognise the contribution to the profession, economy and to the Nation.

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