INTEGRATING SUPPLY CHAIN MANAGEMENT TO CATER FOR DEMAND AND SUPPLY IN SMALL SCALE INDUSTRIES

MINI PROJECT REPORT

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in partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING

IN

COMPUTER SCIENCE AND ENGINEERING

SRI SAI RAM INSTITUTE OF TECHNOLOGY
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JUNE 2022

SRI SAI RAM INSTITUTE OF TECHNOLOGY

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ACKNOWLEDGEMENT

A successful man is one who can lay a firm foundation with the bricks others have thrown at him. —*David Brinkley*

Such a successful personality is our beloved Founder Chairman, **Thiru.MJF.Ln. LEO MUTHU.** At first, we express our sincere gratitude to our beloved chairman through prayers, who in the form of a guiding star has spread his wings of external support with immortal blessings.

We express our gratitude to our Chairman and CEO **Mr. J.SAI PRAKASH LEOMUTHU** and our Trustee **Mrs. J. SHARMILA RAJA** for their constant encouragement for completing this project.

We express our sincere thanks to our beloved Principal, **Dr. K. PALANIKUMAR** for having given us spontaneous and whole hearted encouragement for completing this project.

We are indebted to our HEAD OF THE DEPARTMENT **Dr. B. SREEDEVI** for her support during the entire course of this project work.

We express our gratitude and sincere thanks to our guide **Ms. H. KAVIETHA** for his valuable suggestions and constant encouragement for successful completion of this project.

Our sincere thanks to our project coordinator **MR. P. ANNADURAI** for his kind support in bringing out this project.

We thank all the teaching and non-teaching staff members of the Department of Computer Science and Engineering and all others who contributed directly or indirectly for the successful completion of the project.

ABSTRACT

Supply chain management in small and medium-sized enterprises is aimed at ensuring both short- and long-term effectiveness and efficiency of these enterprises. Management practically ensures that small and medium-sized enterprises, as dynamic, self-controlled, controlled and open systems, adapt to the operating environment, which is inherently dynamic, open and stochastic. Traditional approach to management of small and medium-sized enterprises is associated with overstocking and providing excessive capacity as a means of protection against demand variability. Owing to the possibility of rapid and major changes in the marketplace, this approach presents a great risk with potential adverse effects. Contemporary approach to management of small and medium-sized enterprises implies that these enterprises operate following the "feel and react" principle, as opposed to the traditional "produce and then sell" principle. A fast response to the demand variability requires efficient solutions for all elements that constitute the supply chain: demand management, planning, procurement, warehousing, production, transport and distribution. For these very reasons, there is a need to address the issue of supply chain optimization, inasmuch since every organizational system wants to utilize the synergistic effect of a whole and be as efficient and effective as possible. As the synergistic effect depends heavily on both the strategy chosen and managerial decisions made by the managers at the operational level during adjustment of work processes, they are requested to make decision closely tailored to the entire organizational system. Taking the above mentioned problem into account, a growing number of researchers have recently been asking questions and searching for a solution on how chosen strategies and managerial decisions made by the managers at the operational level during adjustment of work processes may contribute to enhancement of effectiveness and efficiency of the entire enterprise

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CHAPTER 1

1.1 INTRODUCTION

Supply chain management is the management of the flow of goods and services and includes all processes that transform raw materials into final products. It involves the active streamlining of a business's supply-side activities to maximize customer value and gain a competitive advantage in the marketplace.

Typically, SCM attempts to centrally control or link the production, shipment, and distribution of a product. By managing the supply chain, companies can cut excess costs and deliver products to the consumer faster. This is done by keeping tighter control of internal inventories, internal production, distribution, sales, and the inventories of company vendors.

1.1.1 WHAT IS SUPPLY CHAIN MANAGEMENT

Supply chain management is the management of the flow of goods and services and includes all processes that transform raw materials into final products. It involves the active streamlining of a business's supply-side activities to maximize customer value and gain a competitive advantage in the marketplace.

KEY TAKEAWAYS

- Supply chain management (SCM) is the centralized management of the flow of goods and services and includes all processes that transform raw materials into final products.
- By managing the supply chain, companies can cut excess costs and deliver products to the consumer faster and more efficiently.
- Good supply chain management keeps companies out of the headlines and away from expensive recalls and lawsuits.
- The five most critical elements of SCM are developing a strategy, sourcing raw materials, production, distribution, and returns

1.1.2 SUPPLY CHAIN

A supply chain is the network of individuals, companies, resources, activities, and technologies used to make and sell a product or service. A supply chain starts with the delivery of raw materials from a supplier to a manufacturer and ends with the delivery of the finished product or service to the end consumer.

CHAPTER 2

SUPPLY CHAIN MANAGEMENT

2.1 PARTS OF SUPPLY CHAIN MANAGEMENT

The supply chain manager tries to minimize shortages and keep costs down. The job is not only about logistics and purchasing inventory. According to Salary.com, supply chain managers “oversee and manage overall supply chain and logistic operations to maximize efficiency and minimize the cost of organization's supply chain."

Productivity and efficiency improvements can go straight to the bottom line of a company. Good supply chain management keeps companies out of the headlines and away from expensive recalls and lawsuits. In SCM, the supply chain manager coordinates the logistics of all aspects of the supply chain which consists of the following five parts.

2.1.1 PLANNING

To get the best results from SCM, the process usually begins with planning to match supply with customer and manufacturing demands. Firms must predict what their future needs will be and act accordingly. This relates to raw materials needed during each stage of manufacturing, equipment capacity and limitations, and staffing needs along the SCM process. Large entities often rely on ERP system modules to aggregate information and compile plans.

2.1.2 SOURCING

Efficient SCM processes rely very heavily on strong relationships with suppliers. Sourcing entails working with vendors to supply the raw materials needed throughout the manufacturing process. A company may be able to plan and work with a supplier to source goods in advance. However, different industries will have different sourcing requirements. In general, SCM sourcing includes ensuring:

- The raw materials meet the manufacturing specification needed for the production of goods.
- The prices paid for the goods are in line with market expectations.
- The vendor has the flexibility to deliver emergency materials due to unforeseen events.
- The vendor has a proven record of delivering goods on time and in good quality.

Supply chain management is especially critical when manufacturers are working with perishable goods. When sourcing goods, firms should be mindful of lead time and how well a supplier can comply with those needs.

2.1.3 MANUFACTURING

At the heart of the supply chain management process, the company transforms raw materials by using machinery, labor, or other external forces to make something new. This final product is the ultimate goal of the manufacturing process, though it is not the final stage of supply chain management.

The manufacturing process may be further divided into sub-tasks such as assembly, testing, inspection, or packaging. During the manufacturing process, a firm must be mindful of waste or other controllable factors that may cause deviations from original plans. For example, if a company is using more raw materials than planned and sourced for due to a lack of employee training, the firm must rectify the issue or revisit the earlier stages in SCM.

2.1.4 DELIVERING

Once products are made and sales are finalized, a company must get the products into the hands of its customers. The distribution process is often seen as a brand image contributor, as up until this point, the customer has not yet interacted with the product. In strong SCM processes, a company has robust logistic capabilities and delivery channels to ensure timely, safe, and inexpensive delivery of products.

This includes having a backup or diversified distribution methods should one method of transportation temporarily be unusable. For example, how might a company's delivery process be impacted by record snowfall in distribution center areas?

2.1.5 RETURNING

The supply chain management process concludes with support for the product and customer returns. Its bad enough that a customer needs to return a product, and its even worse if its due to an error on the company's part. This return process is often called reverse logistics, and the company must ensure it has the capabilities to receive returned products and correctly assign refunds for returns received. Whether a company is performing a product recall or a customer is simply not satisfied with the product, the transaction with the customer must be remedied.

Many consider customer returns as an interaction between the customer and the company. However, a very important part of customer returns is the intercompany communication to identify defective products, expired products, or non-conforming goods. Without addressing the underlying cause of a customer return, the supply chain management process will have failed, and future returns will likely persist.

2.2 TYPES OF SUPPLY CHAIN MODEL

Supply chain management does not look the same for all companies. Each business has its own goals, constraints, and strengths that shape what its SCM process looks like. In general, there are often six different primary models a company can adopt to guide its supply chain management processes.

- **Continuous Flow Model:** One of the more traditional supply chain methods, this model is often best for mature industries. The continuous flow model relies on a manufacturer producing the same good over and over and expecting customer demand will little variation.
- **Agile Model:** This model is best for companies with unpredictable demand or customer-order products. This model prioritizes flexibility, as a company may have a specific need at any given moment and must be prepared to pivot accordingly.
- **Fast Model:** This model emphasizes the quick turnover of a product with a short life cycle. Using a fast chain model, a company strives to capitalize on a trend, quickly produce goods, and ensure the product is fully sold before the trend ends.
- **Flexible Model:** The flexible model works best for companies impacted by seasonality. Some companies may have much higher demand requirements during peak season and low volume requirements in others. A flexible model of supply chain management makes sure production can easily be ramped up or wound down.
- **Efficient Model:** For companies competing in industries with very tight profit margins, a company may strive to get an advantage by making their supply chain management process the most efficient. This includes utilizing equipment and machinery in the most ideal ways in addition to managing inventory and processing orders most efficiently.

- **Custom Model:** If any model above doesn't suit a company's needs, it can always turn towards a custom model. This is often the case for highly specialized industries with high technical requirements such as an automobile manufacturer.

2.3 EXAMPLE OF SCM

Understanding the importance of SCM to its business, Walgreens Boots Alliance Inc. decided to transform its supply chain by investing in technology to streamline the entire process. For several years the company has been investing and revamping its supply chain management process. Walgreens was able to use big data to help improve its forecasting capabilities and better manage the sales and inventory management processes.

This includes the 2019 addition of its first-ever Chief Supply Chain Officer, Colin Nelson. His role is to boost customer satisfaction as the company increases its digital presence. Beyond that, in 2021, it announced it would be offering free two-hour, same-day delivery for 24,000 products in its stores.

2.4 SUPPLY CHAIN STRUCTURE

The supply chain in production systems is an integrated set of business processes that guide all activities of the enterprise, from forecasting, planning, and inventory management to the delivery of finished products to the end user.

The main objectives of an effective and efficient supply chain are included in the JIT (Just in Time) concept, i.e. the demand to deliver the right product at the right time, in the right amount and in the right place. To meet these demands, goal-oriented activities must be taken in order to ensure that all processes of the supply chain function efficiently.

Benefits	Obstacles	Intermediaries
Enhanced reaction to customer demands	Inadequate information exchange	Higher management support
More stable on-time delivery	Poor/ambiguous performance measurements	Open and fair information sharing
Shorter order fill	Inconsistent operations goals	Correct and understandable measures
Reduction in inventory costs	Organizational culture and structure	Alliance based on trust Guidance and rationalization of the supply chain
Better utilization of assets	Resistance to changes – lack of trust	Exchange of managerial experience
Lower prices of purchased items	Lack of cooperation in business practice	Process documentation and ownership
Higher product quality	Lack of vision – misconception of the supply chain	Education and training
Ability to react to unexpected events	Lack of managerial decisions	Supervisory authorities
Faster implementation of product and process innovations	Limited resources	Usage of pilot projects
Desirable and appropriate relations		

TABLE 2.1 Supply Chain Structure

Accordingly, supply chain management of small and medium-sized enterprises and production activities should include management of the following processes

- Forecasting, often defined as a survey of the future in order to obtain trustworthy information on factors in external and internal environment vital for business activities of the enterprise in the future. The main goal of forecasting procedures is to minimize the uncertainty of actions in the future.

- Planning, often defined as a systematic design of events in the future. The task of production planning is to fulfil customer orders on time, reduce inventory and interoperation time with optimum utilization of material, labour and machinery.
- Stock management, usually defined as a problem-solving setting and maintaining the necessary amount of raw material, semi-finished and finished products in order to ensure production and sales continuity. Therefore, the goal of inventory management of materials in the supply chain should not be just ensuring process continuity, but also providing the minimum requirements needed for the reproduction process, in order to increase effectiveness and efficiency of the production systems.
- Production and assemblage, encompassing all activities taking place from the moment raw materials enter the production process to the finished product release. Here, on the basis of elaborate technological procedures and production plans, accompanied by a provision of the necessary production elements, changes in status (transformations) of the raw materials into products occur, i.e. inputs of the enterprise are converted into its outputs.
- Sales and delivery of finished products, with a task to carry out packaging, transport, invoicing and charging for delivered products, depending on a production program, type of production, and environment within which the enterprise operates.

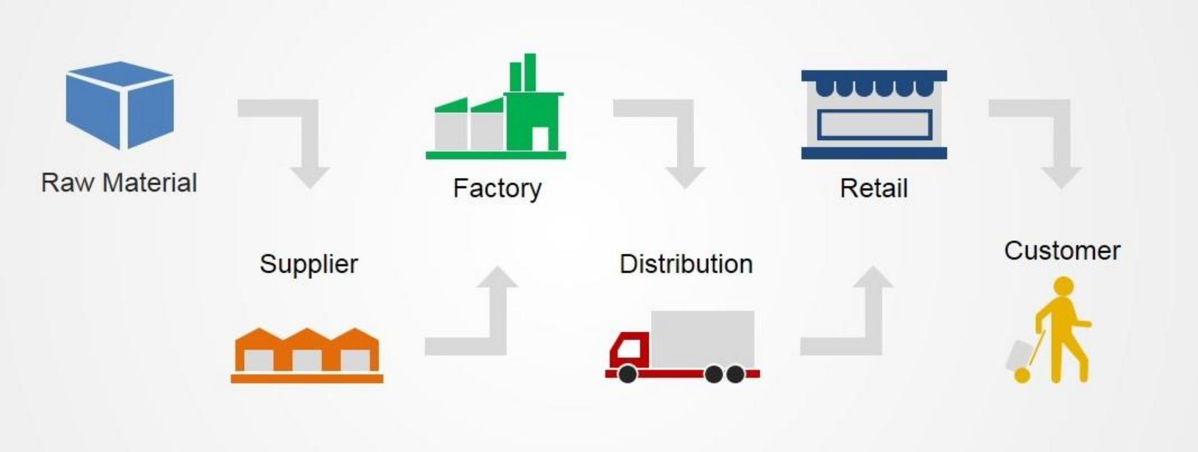


Fig 2.1 Supply Chain Structure

2.5 SUPPLY CHAIN PERFORMANCE

Supply chain performance measurement is used to determine effectiveness and/or efficiency of the supply chain, as well as to compare different alternatives through a value determination of the supply chain variables, which provide the most desirable level of performance. According to Kotler (1984), from a marketing standpoint, enterprises can accomplish their goals by meeting customer demands more effectively and efficiently than their competitors. Accordingly, they can derive multiple benefits from an assessment of the level of effectiveness and efficiency along the entire length of their supply chain. According to Lambert & Pohlen (2001), absence of a widely accepted definition of supply chain management and vaguely defined supply chain structure complicate the assessment of the supply chain effectiveness. In addition, somewhat difficult information exchange between differentsupply chain elements, accompanied by rejection of information exchange between different entities, make this procedure even more complicated.

However, in accordance with different approaches for defining the supplychain, different approaches for defining the supply chain performance exist. According to Rolstad (1995), when developing a system for supply chain performance measurement one should keep in mind the following:

- System needs to support a decision-making process, showing where and how to act, and the type of consequences arising from implemented action plans.
- System has to control the impact of strategic plans, so that amendments can be made to guarantee the achievement of long-term goals.
- Measurement is necessary for tracking the realization of internal corporate goals, as well as for meeting the demands of different external participants.
- System needs to have analytical properties, so that it supports the alarm system prior to business performance decline.
- Measurement should be an integral part of the continuous improvement process.

Although every supply chain is unique, in most cases, the following four categories can be applied to group performance and performance measures (Stadler & Kilger, 2002; Gunasekarana et al., 2004; Goknur & Turan, 2010):

1. Delivery performance – It has an impact on the customer sales, and therefore on the supply chain competitiveness. This performance is typically measured in terms of deviation between the actual delivery date and the customer requested delivery date. Different measurements for this performance can be found in the literature, the most common being: service level, order fill rate, on time delivery, forecast accuracy, etc.

2. Supply chain flexibility – It is the ability of the supply chain to adapt to changes, and represents one of the most important conditions for the survival of supply chains in a business environment. Flexibility can be expressed in terms of different variants (alternatives) through which a system can adapt to changes. Alternatives can refer to the possibility of changes in the system elements, as well as in the planning and management domain. In addition, taking into account the aspect of service reply, flexibility can be measured in terms of speed through which an adaptation of the system to new conditions can be reached. It can be expressed as a reaction time or reaction costs.
3. Working capital - Working capital of the supply chain encompasses receivables, inventory, facilities, and equipment owned by the chain. The most important performance measures of the working capital management typically include:
    - Flow of working capital, which is defined as the ratio between total revenue and total working capital, and
    - Cash flow coefficient, which represents a derived measurement used to describe the average number of days needed for the cash flow to be carried out, from the money investment in raw materials to the payment made by the end user.
4. Stock – It represent a constituent of the working capital of the supply chain, which significantly affects effectiveness and efficiency of the chain itself. To determine the optimal level of stock in the supply chain, an adequate stock analysis covering the aspects of its place in supply chain, its function, structure, value, management strategies and parameters, costs etc. must be carried out.

From the physical aspect, common performance measures in the stock domaininclude:

- Stock flow, which is defined as the ratio of total material consumption over atime interval and the average level of stock in the same time interval.
- Stock life cycle, which is defined as the average time the products are being keptin stock.
- Average stock level, which represents an adequate performance measure when comparing supply chain performance in different scenarios.

CHAPTER 3

MODEL AND CASE STUDY

3.1 STIMULATION MODEL DEVELOPMENT

Simulation is one of the operations research techniques. The concept of simulation, in a broader sense, is seen as a set of activities associated with experimental determination of the effects that occur in a system, process or model which imitates them. Therefore, simulation is a basis for the analysis of acquired results, and a place where the validity (validation) testing (verification) of the model, based on developed criteria, is being performed. Since experimentation on real-life objects is not always possible, experimenting on a simulation model provides information on behaviour of the elements in a real-world system. As numerous observed systems are becoming more complex, classical mathematical findings are no longer sufficient enough to determine their dynamics (Letić, 2001; Dragić, 2010).

Simulation on models enables the industrial systems to explore and improve their conditions through application of the appropriate methods and techniques, but primarily through monitoring a time course of the changes associated with the effects of work processes in the system. To better understand the appropriateness of applying this approach, it should be noted that the material and information flows are often highly stochastic, which causes unpredictable system behaviour. For this reason, analytical methods cannot always provide an adequate quantification of the system behaviour through which an overall functionality of the system could be observed.

The aforementioned changes of environmental conditions and disturbances in the business processes of small and medium enterprises require development of a flexible model for supply chain simulation. Such a model has to meet specific requirements, and these are reflected in:

- necessity to follow different trends in demand for finished products,
- need for simulation of planning procedures and adjustment of work processes,
- requirements for continuous monitoring of materials in stock, work in processand finished products, and
- need for continuous harmonization of the finished products distribution inaccordance with customer demands.

It is also necessary to meet the specificity of small and medium-sized enterprisesand production activities, which is reflected in (Dragić, 2010):

1. a wide range of products,
2. usage of a wide range of different materials,
3. preparation and execution of the production process, usually in small batches,
4. need for the development of technical documentation, mostly for the modifiedproducts, because, in many cases, it is necessary to modify technical documentation, and
5. continuous requests to reduce the elapsed time between receiving a customerorder, placing a bid and manufacturing a product.

General process of simulation basically involves procedures in simulation model development, planning and execution of simulation experiments, result analysis and drawing conclusions. Taking this into account, simulation model development can be represented as a series of activities which include (Radenković 1999, Stadler & Kilger 2002):

6. Problem definition - This step defines a desired objective and purpose of the simulation, system boundaries and level of detail, constraints and assumptions tobe applied, etc.

7. Verbal description of the model - It is a representation of the model in spokenlanguage, and is commonly presented in a written form.
8. Model development - This step defines controlled and uncontrolled elements ofthe model, their behaviour, decision rules and performance measures.
9. Making a flowchart of the model - This step facilitates computer programmingand helps to clarify logic of the model.
10. Model programming – At this stage, a user program is being written using some of the programming languages (C, Visual Basic, Java ...) or ready-made solutions.

For the purpose of performing a simulation of the supply chain processes in small and medium-sized enterprises, a modular approach to simulation model development is a preferred option. This approach involves development of a model out of discrete units (modules), with each unit having its own objective, decision rules and performance measures. The advantages of this approach in simulation model development are reflected in:

- easier definition of the purpose of each module,
- simplified verbal, mathematical and logical description of the model,
- adjustment of the level of details of the modules to the simulation process requirements,
- possibility to improve certain modules without the need to make changesin other modules,
- ability to engage professional staff for individual modules,
- easier error detection in a model,

- easy monitoring of the simulation process results, and
- possibility of a modular approach to simulation program development.

The intensity and frequency of changes in the business environment have imposed the need for integration of a demand estimation model with a dynamic system behaviour model. As such, this integrated model might serve the industrial systems as the basis for conducting simulation experiments and analysis of obtained results. Modules of a proposed model for the supply chain simulation in small and medium-sized enterprises, with its allotted performance measures, are given in below Table 3.1

MODULES		PERFORMANCE MEASURES		
No.	**Name**	**Trend**	**Name**	**Definition**
M.1.	**FORECASING AND INITIATION OF CUSTOMER DEMANDS**			
M.2.	**PREPARATION AND EXECUTION OF PRODUCTION PROCESSES**	↑	**Capacity utilizatio n**	The relationship between the required and available capacity
		↓	**The flow coefficient**	Dimensionless number that shows the actual production cycle is greater than the theoretical production cycle in ordinal terms switch series from one operation to the other
		↓	**The average level of work inprogress**	The average value of work in progress
M.3.	**INVENTORY MANAGEMENT**	↓	**The average level of materials in stock**	The average value of finished goods over a period
		↑	**Inventoy turnover**	The ratio of total material consumption in a certain period and intermediate levels of inventories in the same time interval
M.4.	**SALES AND DELIVERY**	↑	**Fulfillment of orders from theexisting stock**	Percentage of the amount of goods that customers require and that can be filled with existing supplies
		↑	**Timeliness ofdelivery**	The percentage of orders that are filled before or as scheduled/promised delivery date.
		↑	**The value of realized orders**	*The total value of orders received in the relevant period.*
		↓	**The average level of finishedgoods inventory**	The average value finished goods inventory over a time

Table 3.1 Supply Chain Performance measures

3.2 CASE STUDY

This chapter describes a case study concerning the application of simulation in supply chain optimization of a small enterprise manufacturing metal products. The developed model helps the enterprise managers to make decisions at the operational level by enabling them to recognize the impact of their decisions on the performance of other processes, and thus on the overall performance of the enterprise business operations.

3.2.1 PLANNING THE MANAGEMENT

To conduct the supply chain simulation of an enterprise as efficiently and effectively as possible, the experiment planning stage needs to be carried out first. The experiment plan will be primarily used to determine temporal parameters of the simulation execution. A period of one hour (1 hour) was adopted as a basic defining unit. Simulated period corresponds to the period of one quarter. Assuming that the enterprise works 5 days a week, the total time covered by the simulation experiment will be 65 working days, or 520 defining units.

The results of the simulation experiment are expressed through the supply chain performance measures of the simulated system. The goal is to define the system parameters which will lead to a satisfactory level of supply chain performance. As the dependency of the supply chain performance measures and the model parameters of the system is not uniformly defined, it is necessary to conduct the experiment several times (varying the model parameters).

The basic version of the experiment was conducted using the model parametersadopted from the actual data of the simulated production system. It should be notedthat not all system parameters are liable to change or that their change will not be thesubject of this research. This primarily applies to the normative of materials and time, the product development time and the time required for the procurement of materials. Different variants of the experiment are obtained by changing (more or less)

the model parameters. In that sense, there are many possible variants of the experiment. However, the number of its variants can be reduced by a targetoriented variation of the model parameters, i.e. by a variation aimed at direct improvement of one or more performance measures of the supply chain. The experiment needs to show how such changes affect other performance measures.

The adopted plan for conducting multiple experiments with the plan of model parameter variations is given in Tab. 3.2.

Experiment mark	*Description of an experiment variant*		**Model parameters**				
			Signal quantity of finished products	*Max. quantity of finished products*	*Capacity of work*	*Signal quantity of raw materials*	*Max. quantity of raw materials*
E.0.	*Basic variant of the experiment* *Model parameters are set in accordance with data collected from the enterprise database. Obtained results will be used as a basis for the result comparison of other experiment variants.*	*indicating a change of the model parameters*	**0**	**0**	**0**	**0**	**0**
E.1.	*Variant with an increased level of finished products in stock* *Increased level of finished product in stock aims to increase the level of customer service.*		+	+	**0**	**0**	**0**
E.2.	*Variant with increased available capacity* *Increase of available capacity (introduction of new machines) is primarily aimed at affecting reduction of the production cycle and the level of work in process. Changes should be made to job groups that have the highest capacity utilization.*		**0**	**0**	+	**0**	**0**
E.3.	*Variant with reduced level of raw materials in stock* *The aim is to examine to what extent the reduction of stock levels influences other system parameters. Stock reduction should be performed on raw materials which have the largest financial stake in the total stock value.*		**0**	**0**	**0**	**-**	**-**

Key : **0** - Without a change of model parameters +/- · Increase / decrease of model parameters

TABLE 3.2 Planning the management

3.2.2 RESULT ANALYSIS

By varying the model parameters, different behaviour of the simulated system was obtained. Such behaviour was observed by tracking the performance measures, i.e. by tracking the dependency of supply chain performance measures to the model parameter values. The obtained values of performance measures are shown in Tab.4. By analyzing the obtained results, it can be concluded that:

1. Increase in stock level of finished products leads to an increase in the total level of customer services, with an undesirable increase in the level of work inprocess.
2. Increase in available production capacity entails a number of positive effects on performance measures (better customer service, lower levels of work in process and a lower flow coefficient), with a poorer capacity utilization.
3. Decrease in raw materials stock increases their flow in a warehouse with no significant effect on other performance measures. However, it should be noted that the reduction in the inventory level was carried out only to the extent where no disturbances occurred in the supply of raw materials needed for production. If the stock level fell below this limit, other performance measures of the supply chain would certainly be affected by these disturbances.
4. Variations of the model parameters do not have to be directed in only one of the three above mentioned directions. The optimal choice of the model parameters is obtained by combining the aforementioned effects and a constant monitoring of the supply chain performance measures.

Supply chain performance measure		Values			
		E.0.	E.1.	E.2.	E.3.
↑	*Fulfilment of orders from existing stock*	*4.82%*	*8.62%*	*5.21%*	*4.82%*
↑	*Timeliness of delivery*	*49.43%*	*74.79%*	*53.44%*	*49.43%*
↑	*The value of realized orders*	*331350.00€*	*352238.00€*	*337250.00€*	*331350.00€*
↓	*The average level of finished goods inventory*	*14208.81€*	*15108.67€*	*14189.90€*	*142208.81€*
↑	*Capacity utilization*	*39.90%*	*42.52%*	*34.92%*	*39.90%*
↓	*The flow coefficient*	*1.83*	*1.81*	*1.47*	*1.83*
↓	*The average level of work in progress*	*32323.12€*	*36092.98€*	*28634.54€*	*32323.12€*
↓	*The average level of materials in stock*	*45977.67€*	*46564.81€*	*46092.20€*	*36217.14€*
↑	*Inventory turnover*	*3.89*	*3.96*	*3.88*	*4.81*

TABLE. 3.3 A comparative overview of the experiment results

It is clear that finding a set of model parameter variants, which would result in the simultaneous improvement of all performance measures, is not possible. Therefore, it is only possible to find one set of variants that would direct the performance of the supply chain towards a desired (target) level. The optimal variant of the supply chain parameters needs to be observant of the enterprise capacity (for example, to expand the capacity), as well as of its financial, human resources and marketing policies. Therefore, Table 3. provides only guidelines for improvement of the performance measures, in order to level them off, if not perfectly, then at least acceptably.

CHAPTER 4
SYSTEM REQUIREMENTS

4.1 SOFTWARE REQUIREMENTS

OPERATING SYSTEM – Windows 7 or Higher

APPLICATION SOFTWARE – Beta analytics

4.2 HARDWARE REQUIREMENTS

PROCESSOR	: Intel(R)core(TM)i5-2410M CPU@2.30GHz
SPEED	:2.30 GHz
OPERATING SYSTEM	: 64-bit operating system
RAM	:4 GB RAM

CHAPTER 5
SYSTEM DESIGN

5.1 ARCHITECTURE

The UI for the application is made using the *tkinter* package for python. Various modules are created to undergo individual tasks. Firstly, there is a timer module which countdowns the time in decrements and notifies when the Shift has ended. Once the Shift has ended, an automatic email is sent to respective authorities. The email consists of an excel file which contains the Shift details. The Automatic Mail sending module is made possible using the *smtplib* and *email* package available in python.

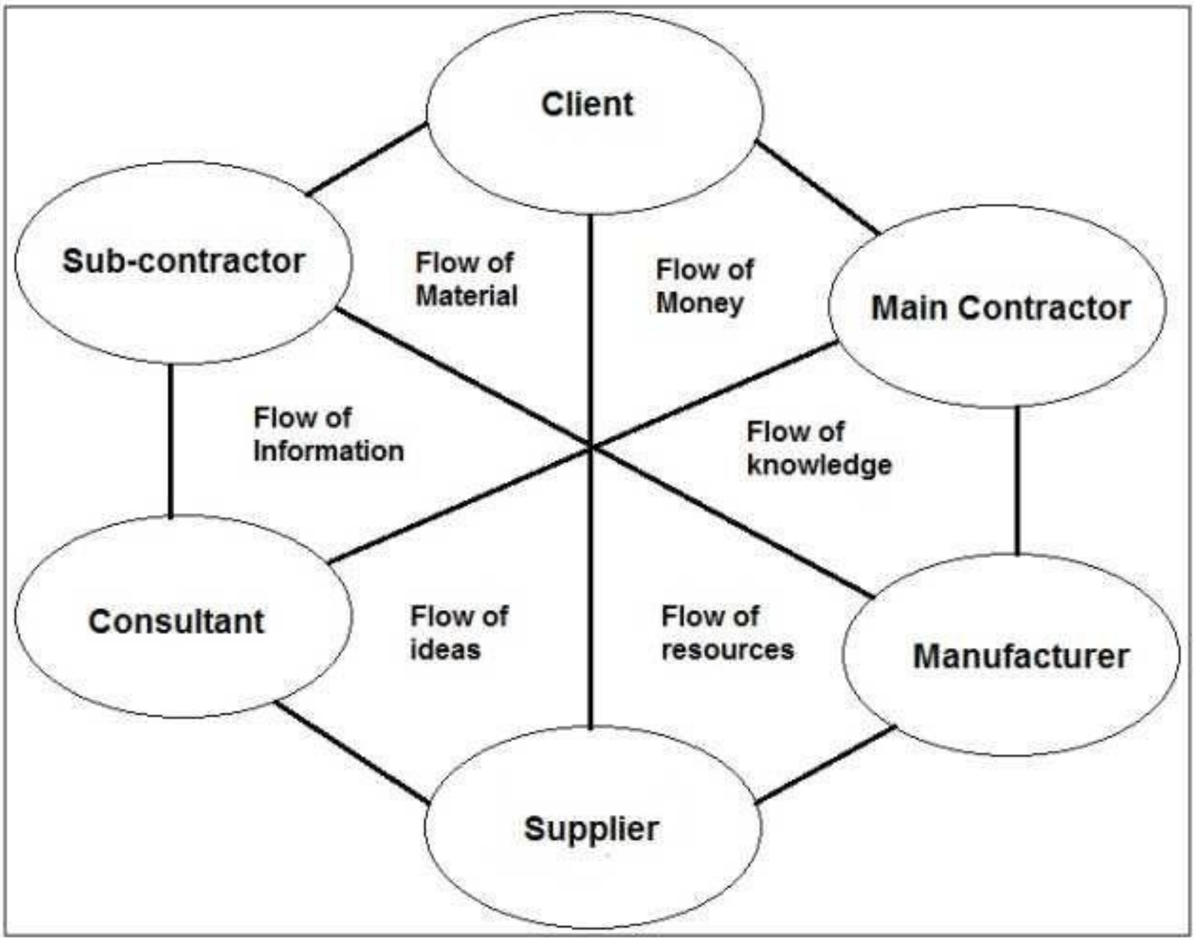


FIG 5.1 Workflow of Supply Chain

In case, the report of the shift is required in between the shift/before the shift ends, there is a Generate Report button. This button calls the module which is responsible for generating the report at the instance when it is clicked. The shift details are stored in an excel file using the *pandas* package. The excel file is named as the date and time at which the report was generated.

In order to get the live updates of the good and bad count from the Manufacturing Unit to the Assembly Unit, the values are published to a MQTT server online. In this case, we have used HiveMQ MQTT server. Using the *paho-mqtt* package in python, we would be able to call the necessary functions and publish the required values to the server. Simultaneously, the Assembly Unit would be receiving the values by subscribing to the respective topic in which it is getting published. Again, these values are displayed in the Assembly Unit application with *tkinter* being its base UI.

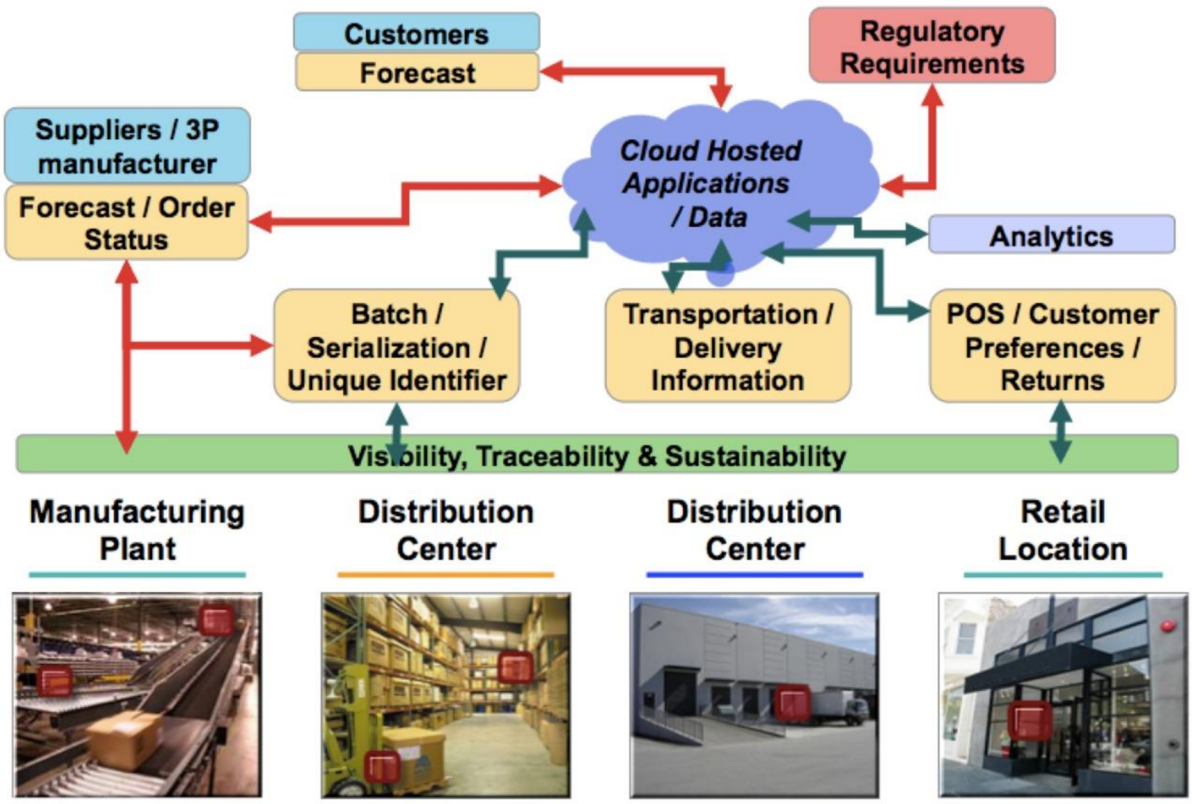


FIG 5.2 Architecture of Supply Chain

CHAPTER 6
CONCLUSION

The supply chain management revolution is in its early stages. The basis of its development, propelled by man's steady progress in managing evermore complex systems aided by technological advances, is evidence enough that supply chain management has a long future marked by continuous, sometimes breakthrough, progress.

Integrated supply chain management is a straightforward concept made possible by modern science hardware and software technologies. These technologies enable the integrated design and coordinated management of the multiple functions that transfer m raw material to finished products delivered to the custom er at the right place and time. Supply chain integration is a powerful concept because it can simultaneously reduce costs, improve service, and increase revenues. Supply chain management has developed thanks in large measure to information technology tools that help managers deal with ever greater degrees of complexity. The reach of supply chain management has expanded dramatically in the past decade and will continue to expand, encompassing more functions and more decision factors for decades to come.

Supply chain essentials and the basic interrelationships are eminently applicable from the domestic food supply chain serving our homes to the worldwide manufacture, distribution, consumption, and recycling of consumer products or high-tech medical equipment.

But at the same time, supply chain management is difficult. The key elements are constantly changing because of technology developments, dynamic world economics, and marketplace shifts. Historically independent work groups must com e together as teams focussed on the total supply chain performance, often at the expense of their individual work group performance.

Since the pace of change never slow s but only increases, supply chain professionals need to keep focused on some key success factors. Finally, a list of key success factors are:

- Always keep foremost the needs and desires of the end custom er.
- Measure, measure, measure to make quantitatively based decisions.
- Communicate, communicate, communicate all through the totalsupply chain.
- Design flexibility into the supply chain for rapid response to changing conditions

The goal of supply chain management is value creation and a company creates value by offering products or services to its customers by managing
processes (delivering a product from raw materials to the consumer), managing resources (e.g. information, assets, products) and managing
capabilities (e.g. the people who work within the supply chain) in sustainable (where there are embedded value for customers),
energy efficient (due to corporate social responsibilities) and profitable (the goal of every for-profit entity) ways.

Supply chain management is an important part for every organization as it improves the effectiveness, efficiency, management of resources, etc.
it also establish god and prominent relations with the stake holders like suppliers, customers, etc. it integrates and combines the entire business activities and take care of each and every step that ultimately helps in

achieving satisfaction of the customers and goals of the company.

By implementing SCM in small scale industries that are not exposed to the tech we aim to bring the proportional level of advantages that scm offers to current large scale industries to small scale enterprises

APPENDIX-1

SAMPLE CODINGS

Publisher Source Code:

```
from tkinter import *
from tkinter import ttk
import tkinter as tk
import time
import random
```

```
import pandas as pd
import xlsxwriter
from datetime import date, datetime
from datetime import datetime
import getpass
import os
import smtplib
from email.message import EmailMessage
import paho.mqtt.client as paho
from paho import mqtt

qwe = [0,0,0,'0']

def on_connect(client, userdata, flags, rc, properties=None):
print("Connection Success! Received with code %s." % rc)

# with this callback you can see if your publish was successful
def on_publish(client, userdata, mid, properties=None):
print("mid: " + str(mid))

# print which topic was subscribed to
def on_subscribe(client, userdata, mid, granted_qos, properties=None):
print("Subscribed: " + str(mid) + " " + str(granted_qos))

def on_message(client, userdata, msg):
print(msg.topic + " " + str(msg.qos) + " " + str(msg.payload))

#Sends Automatic Mail once the Shift gets over
def automaticEmail():
sender_email= "mayoisnicee@gmail.com"
sender_pass="Mayonnaise24"
receiver_email="balakumarbk03@gmail.com"

msg = EmailMessage()
msg['Subject'] = "REPORT"
msg['From'] = sender_email
msg['To'] = receiver_email
msg.set_content('Shift Report Has Been Attached...') #to be filled


#User Name
user = getpass.getuser()

file_directory=["C:/Users/"+ user + "/Documents/" + qwe[3] + ".xlsx"]

for file in file_directory:
with open(file, 'rb') as f:
file_data=f.read()
file_name=qwe[3]+'.xlsx'
print("filename",file_name)
msg.add_attachment(file_data, maintype='application',
subtype='octet-stream', filename=file_name)


with smtplib.SMTP_SSL("smtp.gmail.com", 465) as smtp:
smtp.login(sender_email,sender_pass)
smtp.send_message(msg)
```

```
Label(root, text='Report Generated!', font = 'arial 15 bold').place(x=800, y=450)
print("Mail Sent!")
def vals(count,good,bad):
qwe[0] = count; qwe[1] = good; qwe[2] = bad
#Generates the current report when the Generate Report Button is clicked.
def generateReport(): #(t,number,name,count,good,bad):
#Date Time
now = datetime.now()
dt_string = now.strftime("%B %d %Y,%H-%M-%S")
qwe[3] = dt_string
#User Name
user = getpass.getuser()
count_val,good_val,bad_val,shift_dt = [0],[0],[0],[0]
count_val[0] = qwe[0]
good_val[0] = qwe[1]
bad_val[0] = qwe[2]
shift_dt[0] = dt_string
df = pd.DataFrame({'Shift Time':shift_dt[0],
'Shift Duration(secs)':t.get(),
'Shift Number':number.get(),
'Supervisor':name.get(),
'Production Count':count_val,
'Good Products':good_val,
'Defected Products':bad_val})
writer = pd.ExcelWriter(r"C:\Users\\"+ user + "\Documents\\" + dt_string + ".xlsx")
# Convert the dataframe to an XlsxWriter Excel object.
df.to_excel(writer, sheet_name='Sheet1',index = False)
workbook = writer.book
worksheet = writer.sheets['Sheet1']
worksheet.set_column('A:G',25 )
writer.save()
print("Report Generated Successfully on "+dt_string)
#Shift Runtime
def shiftRun():
l = []
time_sec = int(t.get())
count = 0; good = 0; bad = 0
while time_sec:
mins, secs = divmod(time_sec, 60)
timeformat = '{:02d}:{:02d}'.format(mins, secs)
#print(timeformat, end='\r')
l.append(timeformat)
#print(l[-1])
count += 1
if random.randint(0,1):
good += 1
```

```
else:
bad += 1
Label(root, text=l[-1], font = 'arial 15 bold').place(x=800, y=50)
Label(root, text="Production Count: "+str(count), font = 'arial 20 bold').place(x=20, y=360)
Label(root, text="Good: "+str(good), font = 'arial 20 bold').place(x=20, y=400)
Label(root, text="Defects: "+str(bad), font = 'arial 20 bold').place(x=20, y=440)
client.publish("test/Bosch_Good",payload=str(good),qos=0)
time.sleep(1)
time_sec -= 1
root.update()
vals(count,good,bad)
Label(root, text='Shift Ended!', font = 'arial 15 bold').place(x=800, y=80)
generateReport()
automaticEmail()
try:
client = paho.Client(client_id="", userdata=None, protocol=paho.MQTTv5)
client.on_connect = on_connect
# enable TLS
client.tls_set(tls_version=mqtt.client.ssl.PROTOCOL_TLS)
client.username_pw_set("industry4.0", "Qwerty@123")
client.connect("1d1587d792b6466fa8f2db432d9d3db2.s1.eu.hivemq.cloud", 8883)
client.on_message = on_message
client.on_subscribe = on_subscribe
client.on_publish = on_publish
root = Tk()
root.geometry('1000x500')
#production_name = input("Production Name(Eg: Bulb/Indicator/Housing/Electrical): ")
Label(root, text = 'Indicator Production' , font = 'arial 20 bold').pack()
#Starting Protocols
Label(root, font ='arial 15 bold', text = 'Set Time').place(x = 20 ,y = 50)
t = Entry(root,width=15)
t.place(x=180, y=55)
Label(root, font ='arial 15 bold', text = 'Shift Number').place(x = 20 ,y = 80)
number = Entry(root,width=15)
number.place(x=180, y=85)
Label(root, font ='arial 15 bold', text = 'Supervisor').place(x = 20 ,y = 110)
name = Entry(root,width=15)
name.place(x=180,y=115)
#Start Button
Button(root, text='START', bd ='5', command = shiftRun, font = 'arial 10 bold').place(x=80, y=160)
#Generate Report Button
Button(root, text='Generate Report', bd ='5', command = generateReport, font = 'arial 10 bold').place(x=800, y=400)
```

```
#Quit Button
ttk.Button(root, text="Quit", command=root.destroy).place(x=450,y=450)
root.mainloop()
print("Press 'Ctrl+C' to close the application.")
client.loop_forever()
except KeyboardInterrupt:
print("Byeeee!!")
pass
```

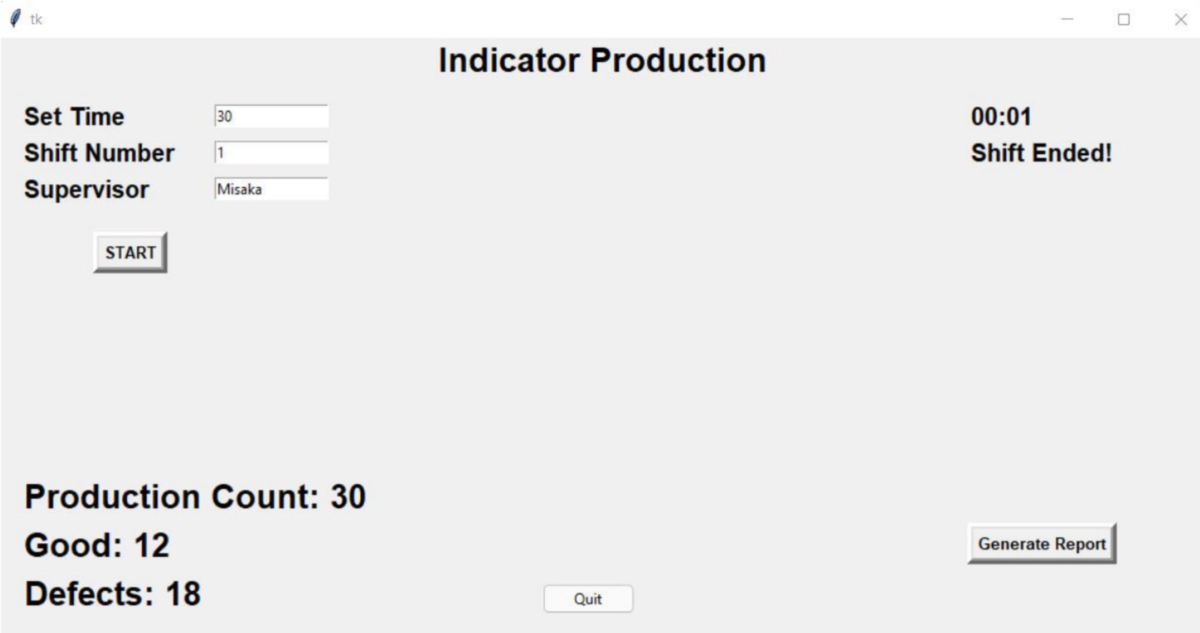
Subscriber Source Code:

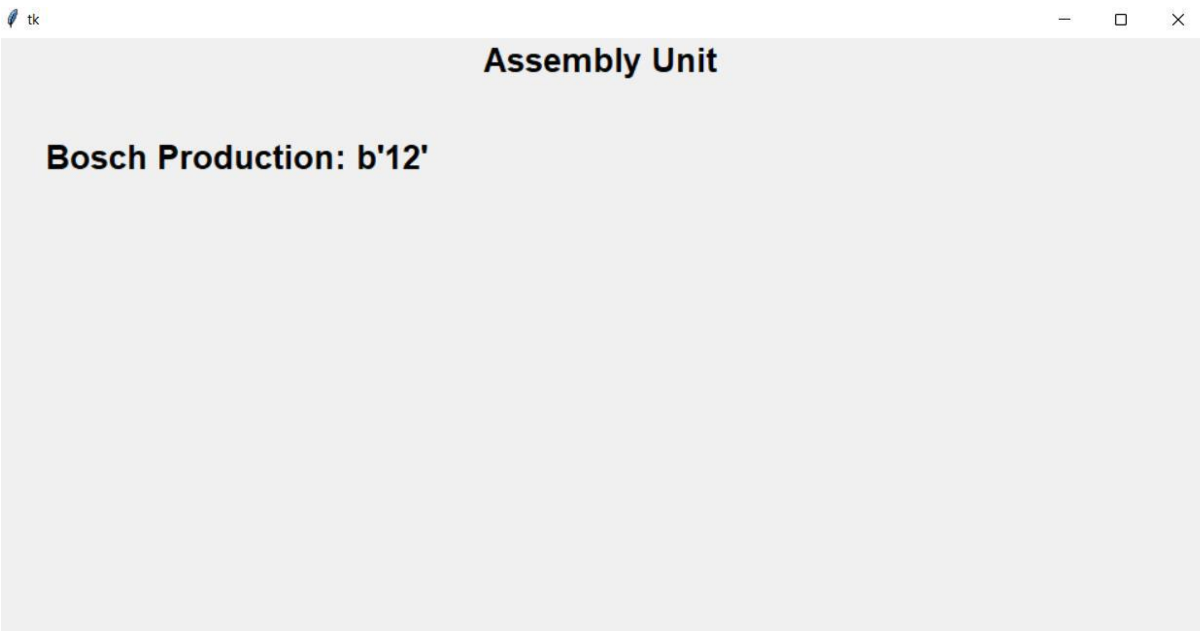
```
import time
import paho.mqtt.client as paho
from paho import mqtt
from tkinter import *
from tkinter import ttk
import tkinter as tk
def on_connect(client, userdata, flags, rc, properties=None):
print("Connection Success! Received with code %s." % rc)
# with this callback you can see if your publish was successful
def on_publish(client, userdata, mid, properties=None):
print("mid: " + str(mid))
# print which topic was subscribed to
def on_subscribe(client, userdata, mid, granted_qos, properties=None):
print("Subscribed: " + str(mid) + " " + str(granted_qos))
# print message, useful for checking if it was successful
def on_message(client, userdata, msg):
print(msg.topic + " " + str(msg.qos) + " " + str(msg.payload))
topic = msg.topic
payload = msg.payload
if 'Crompton_Good' in topic:
#print("Update Crompton Label: ",payload)
Label(root, text = 'Crompton Production: '+str(payload) , font = 'arial 20 bold').place(x=40,y=200)
elif 'Bosch_Good' in topic:
#print("Update Bosch Label: ",payload)
Label(root, text = 'Bosch Production: '+str(payload), font = 'arial 20 bold').place(x=40,y=80)
root.update()
client = paho.Client(client_id="", userdata=None, protocol=paho.MQTTv5)
client.on_connect = on_connect
# enable TLS for secure connection
client.tls_set(tls_version=mqtt.client.ssl.PROTOCOL_TLS)
# set username and password
client.username_pw_set("industry4.0", "Qwerty@123")
```

```
# connect to HiveMQ Cloud on port 8883 (default for MQTT)
client.connect("1d1587d792b6466fa8f2db432d9d3db2.s1.eu.hivemq.cloud", 8883)

# setting callbacks, use separate functions like above for better visibility
client.on_subscribe = on_subscribe
client.on_message = on_message
client.on_publish = on_publish

# subscribe to all topics of encyclopedia by using the wildcard "#"
client.subscribe("sensor1/#", qos=0)

root = Tk()
root.geometry('1000x500')
Label(root, text = 'Assembly Unit' , font = 'arial 20 bold').pack()

client.loop_forever()
```

APPENDIX-2

SCREEN SHOT


tk
Indicator Production
Set Time
30
Shift Number
1
Supervisor
Misaka
START
00:01
Shift Ended!
Production Count: 30
Good: 12
Defects: 18
Quit
Generate Report


tk
Assembly Unit
Bosch Production: b'12'

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