Development of Material Requirement Planning System for Snack Manufacturing Company.

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Abstract

Working in tandem with a leading snack manufacturing company, this project addresses the manufacturer's request of developing an MRP system that is flexible and can be easily integrated into the systems used in the company. A solution to develop an MRP system using excel was agreed upon as the software is familiar to both the administration and the plant managers and is a part of the established workflow. The basics of an MRP system are the three inputs those being: Bill of Materials, Demand Forecast, and Inventory status Files. Producing the Desired outputs of a production plan and a raw material Ordering Schedule. Using excel as a repository for demand and inventory data and taking into factor the material ratios, calculations are done using excel and produce both a dynamic purchase report and production schedule. Additional supporting data are also present in the form of pivot tables that show how much raw material can be rationed and distributed among products that have common components to further reduce the chances of stockouts.

Keywords

MRP, Excel, System, Logic and Relationships.

1. Introduction

This research addresses an issue that a snack Manufacturing company faced, that being lengthy order lead times and finite inventory space that can only house two weeks' worth of materials required for production. Thus, an MRP system is needed to assist in the decision-making process and provide the required supporting information. While there is ready-made software that utilizes MRP calculations and principles, ease of integration and implementation is an issue. Introducing a new system to the current workflow of both administrative employees and production plant managers would be a heavy investment in both time and money. As inputs for the MRP system need the cooperation of both departments to produce the outputs and decisions needed for production. The proposed solution of building an MRP system in a powerful and familiar software such as Excel is an optimal solution for both problems as the learning curve is greatly reduced to the familiarity of the software and does not require an additional monetary investment. MRP on excel also could be flexible without much computer programing knowledge as the inputs such as demand can be migrated easily from outside the ecosystem into the MRP and processed into the outputs in the form of a finite schedule and pivot tables.

1.1 Objectives

The research hopes to understand and utilize the strengths of Excel while also finding logical workarounds to avoid the sluggishness that is often associated with excel programming. Managing this goal is integral as the MRP system

will use complex calculations and relationships and builds on that basis to produce the reports required for the user's decision-making purposes. The workarounds can be counterintuitive as mishandling how each part of the system is linked to the other might achieve results but at the cost of making the system too rigid or hard to work with. While taking into consideration the technical objective the main driving reasoning of the research is to provide a low-cost system that is easily integrated with the current workflow of users in the establishment.

2. Literature Review

Nuanmeesri and Ploydanai (2013) mentioned the importance of defining relationships in excel while developing an MRP program, with them focusing on the BOM linkages and managing to create a logical algorithm for developing their model. Ptak and Smith (2011), revise Joseph Orlicky's work on Material Requirements Planning and improve on the built work done, while also discussing the evolution of material and supply chain synchronization in the modern landscape. Ptak and Smith (2016), discuss in their book about demand-driven material requirement planning and its foundational principles of it which are the connection between the flow of materials and information to achieve quicker results in decision making.

Mula et al. (2006) researched that developing production models without consideration for uncertainty will produce inferior results and are often unusable, instead, they opted to categorize uncertainty and offer the research as a starting point in developing production models. Lee and Jang (2014) developed a model to evaluate the performance of MRP and DDMRP. Lee and Rim (2018) did work on simulations for safety stock replenishment on DDMRP which gave help in this research in the finite schedule and the inventory rationing model worked. Telsang (2006) wrote a book that houses general information and provides the fundamentals of production planning clearly and concisely. It was used in this research to ensure the fundamentals and concepts are adhered to.

Ram et al. (2006) researched how a flexible BOM could be used to deal with shortages that are unplanned by utilizing both linear programming and the master production schedule.
A variety of research have been conducted on developing MRP models. The process of implementing MRP systems have come a long way and the efficiency and performance of MRP systems have also increased manifold. The principles of production planning and using MRP systems for this purpose have also been studied.

3. Methods

The methods used in the creation of the system on MS excel are first to create a basis for the system logic to work out MRP input and recognize the relationships to produce the schedules and reports. The breakdown of the system sheet by sheet is as follows:

- Demand forecast
  This sheet houses information on forecasted demand and the unit of the product being made in the case of the snack manufacturer the forecast is in cartons of product with each carton housing 38 bags of 15 grams of the product. This data can be migrated from outside the system and is linked and used for calculations in other sheets

- Item Master & supplier master
  Contains data on both finished products and raw materials. such as product description, location, supplier, and lead time in days. This data in this sheet is used in formulas further down in the system and supports associating materials with the numbers required.

- BOM
  This sheet contains A single-level Bill of Material structure and provides the quantity of materials that make a single finished product. This sheet is used to quantify material usage and used by formulas in the other sections of the system.

- Purchase Orders
  Lists ongoing orders from suppliers and the date at which they are scheduled to be delivered

- Finite schedule
  The logic in the finite schedule works as follows:

- the first job is the "Product running now"
- and the "Quantity committed" is specified
- the duration of the job is calculated from the speed and shown in the "Run hours" column
- a separate column for each product records the projected inventory level at the end of each job
- at the end of each job, the inventory level of one product has risen, and the other four products have fallen.
- the opening inventory is recorded at the top of the columns and would typically come from an inventory management system.
- the inventory at the end of the job is the opening inventory, less the forecast sales for the duration of the job, plus the production quantity of the job.
- another bank of six columns expresses the projected inventory level as days of cover.
- the product with the lowest cover at the end of the job is identified as the next product to be made.
- the quantity to make is that required to increase the inventory level to the maximum, plus sufficient to replenish the amount sold while the job was running.
- the duration of the next job is calculated, and the cycle begins again.
- if the projected inventory level of the lowest cover product is above its minimum, then an idle period is scheduled.
- the duration of the idle period is the time it will take for forecast sales to reduce the inventory to the minimum and trigger the next run.
- It produces a chart of inventory cover, and the model attempts to keep the inventory of each product between the minimum and maximum.

- Production Runs
  A PivotTable of the Finite Schedule on the previous sheet for each product, lists the start time, and numbers for each production run.

- BOM x 3
  This sheet is like the BOM sheet it allows for 3 production runs of each product. The Bill of Materials is repeated 3 times, and the quantities of each component required for each production run are calculated.

- Allocate inventory
  A Pivot Table utilizing the previous sheet producing and the purchase order sheet to produce a report that details inventory data while allocating materials to the earliest production runs first.

- Purchase action report
  Components that will be required after inventory has been exhausted are listed here and compared with components on order by using the previous worksheet formula is used to calculate the projected inventory of each component. The negative projected inventory indicates that orders need to be chased or placed to support scheduled production.

- Inventory rationing
  The last three sheets are used to produce a report detailing product rationing as follows:
  The finished product inventory and forecast are used to calculate finished product inventory cover. In other words, how many weeks the finished product inventory will last if sales are according to the forecast. The forecast usage of each component is calculated from the sales forecast of the products they are used on, times the quantity used in each case of product. From this, the average cover of each component is calculated. Finished products with a cover above the average, then have their components and forecast eliminated from the calculation, and the average is re-calculated. The quantity of each product that can be made is constrained by the component with the lowest average cover. Components are allocated to products on that basis, the new projected inventories of products and components are calculated, and the Second Pass Calculations repeat the logic again to determine what products could be made with the components that are leftover.

- Table of links
  This table shows the worksheets that have links to other worksheets, either by having formulae that refer to other worksheets, or by having a PivotTable based on a database in another worksheet.

Worksheet \ Links to :	The Business	Item Master	Supplier Master	Bill of Material	Purchase Orders	Finite Schedule	Production Runs	BOM x 3	Allocate Inventory	Purchase Action Report
The Business										
Item Master			F							
Supplier Master										
Bill of Material		F								
Purchase Orders		F	F							
Finite Schedule	F	F								
Production Runs						P				
BOM x 3				F			F			
Allocate Inventory		F			F			P		
Purchase Action Report									P	

Formula link:	F
PivotTable link:	P

4. Data Collection

Sample data was collected from the snack manufacturing company to ensure that the inputs are in line with the current working methods of the establishment and to build the basis of the relationships. The type of data collected is as follows:

- demand forecast information.
- Product information
  - Product identifier codes
  - Units of measurement
  - Lead time
  - Warehouse location
  - Product descriptions
- Supplier information
- Previous purchase order reports

In addition, information was collected using surveys regarding the current capability of production and inventory capacity.

5. Results and Discussion

The result of the research is an MRP model on excel that generates reports based on the aforementioned inputs and the logic of excel. The reports given are shown and explained below.

5.1 Numerical Results

									CH100	CH101	CH102	CH103	CH104	CH105	CH106	CH107
Start of the first job:		2022-03-20														
Product running now:		CH100			Speed - cartons per hour				111	111	111	111	111	111	111	111
Quantity committed:		1,200			Forecast sales - cartons per week				2,180	2,639	836	1,048	1,608	1,679	832	340
					Min cover - weeks				0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Utilization:	67.99%				Max cover - weeks				2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
					Min cover - cartons				1,090	1,320	418	524	804	840	416	170
					Max cover - cartons				4,360	5,278	1,672	2,096	3,216	3,358	1,664	680
Product	Force	Qty	Force	Idle hours	Force	Run hours	Start	Stop	Projected Inventory - units							
					Opening stock:			20/3 8:00	1,545	1,582	1,882	1,690	1,847	1,672	1,380	637
CH100		1200		0.0		10.9	20/3 8:00	20/3 18:51	2,604	1,411	1,828	1,622	1,743	1,563	1,326	615
Idle		0		5.8		0.0	20/3 18:51	21/3 0:42	2,528	1,320	1,799	1,586	1,687	1,505	1,297	603
CH101		4615		0.0		41.8	21/3 0:42	22/3 18:27	1,986	5,279	1,591	1,325	1,287	1,088	1,091	519
Idle		0		24.8		0.0	22/3 18:27	23/3 19:16	1,664	4,889	1,468	1,171	1,050	840	968	468
CH105		2769		0.0		25.1	23/3 19:16	24/3 20:19	1,339	4,495	1,343	1,014	810	3,358	843	418
Idle		0		0.6		0.0	24/3 20:19	24/3 20:56	1,331	4,485	1,340	1,010	804	3,352	840	417
CH104		2,641		0.0		23.9	24/3 20:56	25/3 20:50	1,021	4,110	1,221	861	3,216	3,113	722	368
CH100		3784		0.0		34.2	25/3 20:50	27/3 7:04	4,361	3,572	1,051	648	2,889	2,771	553	299
Idle		0		19.9		0.0	27/3 7:04	28/3 2:57	4,103	3,260	952	524	2,698	2,572	454	259
CH103		1666		0.0		15.1	28/3 2:57	28/3 18:01	3,907	3,023	877	2,096	2,554	2,422	379	228
CH106		1,345		0.0		12.2	28/3 18:01	29/3 6:11	3,749	2,832	816	2,020	2,438	2,300	1,664	204
Idle		0		16.6		0.0	29/3 6:11	29/3 22:45	3,534	2,572	734	1,917	2,279	2,135	1,582	170
CH107		520		0.0		4.7	29/3 22:45	30/3 3:27	3,473	2,498	710	1,887	2,234	2,088	1,559	680
Idle		0		58.8		0.0	30/3 3:27	1/4 14:14	2,711	1,575	418	1,521	1,671	1,500	1,268	562
CH102		1313		0.0		11.9	1/4 14:14	2/4 2:06	2,556	1,388	1,672	1,447	1,558	1,381	1,209	537
Idle		0		4.4		0.0	2/4 2:06	2/4 6:28	2,500	1,320	1,650	1,420	1,516	1,338	1,187	529
CH101		4615		0.0		41.8	2/4 6:28	4/4 0:13	1,958	5,279	1,442	1,159	1,116	920	981	444
Idle		0		8.1		0.0	4/4 0:13	4/4 8:18	1,853	5,152	1,402	1,109	1,039	840	941	428
CH105		2769		0.0		25.1	4/4 8:18	5/4 9:21	1,528	4,758	1,278	952	799	3,358	817	377
CH104		2,647		0.0		23.9	5/4 9:21	6/4 9:18	1,217	4,382	1,158	803	3,217	3,119	698	329
Idle		0		9.8		0.0	6/4 9:18	6/4 19:06	1,090	4,228	1,110	742	3,123	3,021	649	309
CH100		3705		0.0		33.5	6/4 19:06	8/4 4:37	4,360	3,701	943	533	2,802	2,686	483	241
Idle		0		1.4		0.0	8/4 4:37	8/4 6:03	4,342	3,679	936	524	2,789	2,672	476	238
CH103		1666		0.0		15.1	8/4 6:03	8/4 21:07	4,146	3,442	861	2,096	2,644	2,521	402	208

Figure 1: Finite Schedule (Make to Inventory Schedule)

The Finite Schedule (Figure 1) is an output of the MRP system, basically it generates the production plan for about two weeks depending on multiple factors which are sales forecast, inventory level, production speed, and selected maximum and minimum cover of each product.

the schedule has three inputs that are manually filled by the user which are the date and time for the first production round, the currently produced product, and the committed quantity starting with that the schedule generates the first production run with the selected product. At the end of each run, the produced product inventory level will rise while the rest will fall. After production runs completely the system, looks for the inventory level of each product and then compares it with each product's sales forecast. Depending on the selected minimum cover, the system selects the lowest product that has the minimum cover. If the cover levels of all products are above minimum cover, then the production operation shifted to idle.
The schedule also shows the projected inventory level at the end of each job to keep the user informed of the inventory levels of all products.

CH100	CH101	CH102	CH103	CH104	CH105	CH106	CH107	Lowest Cover	Offset	Next Prod	Inventory	Speed	For-cast	Min Cover	Min cartons	cartons	To make
Projected Cover - weeks																	
0.71	0.60	2.25	1.61	1.15	1.00	1.66	1.87										
1.19	0.53	2.19	1.55	1.08	0.93	1.59	1.81	0.53	2	CH101	1411	110.52632	2639.236111	0.5	1320	5278	4508
1.16	0.50	2.15	1.51	1.05	0.90	1.56	1.77	0.50	2	CH101	1320	110.52632	2639.236111	0.5	1320	5278	4615
0.91	2.00	1.90	1.26	0.80	0.65	1.31	1.53	0.65	6	CH105	1088	110.52632	1679.199561	0.5	840	3358	2496
0.76	1.85	1.76	1.12	0.65	0.50	1.16	1.38	0.50	6	CH105	840	110.52632	1679.199561	0.5	840	3358	2769
0.61	1.70	1.61	0.97	0.50	2.00	1.01	1.23	0.50	5	CH104	810	110.52632	1608.205409	0.5	804	3216	2635
0.61	1.70	1.60	0.96	0.50	2.00	1.01	1.23	0.50	5	CH104	804	110.52632	1608.205409	0.5	804	3216	2641
0.47	1.56	1.46	0.82	2.00	1.85	0.87	1.08	0.47	1	CH100	1021	110.52632	2180.211988	0.5	1090	4360	3784
2.00	1.35	1.26	0.62	1.80	1.65	0.66	0.88	0.62	4	CH103	648	110.52632	1047.865497	0.5	524	2096	1534
1.88	1.24	1.14	0.50	1.68	1.53	0.55	0.76	0.50	4	CH103	524	110.52632	1047.865497	0.5	524	2096	1666
1.79	1.15	1.05	2.00	1.59	1.44	0.46	0.67	0.46	7	CH106	379	110.52632	832	0.5	416	1664	1345
1.72	1.07	0.98	1.93	1.52	1.37	2.00	0.60	0.60	8	CH107	204	110.52632	340	0.5	170	680	485
1.62	0.97	0.88	1.83	1.42	1.27	1.90	0.50	0.50	8	CH107	170	110.52632	340	0.5	170	680	520
1.59	0.95	0.85	1.80	1.39	1.24	1.87	2.00	0.85	3	CH102	710	110.52632	835.9210526	0.5	418	1672	1007
1.24	0.60	0.50	1.45	1.04	0.89	1.52	1.65	0.50	3	CH102	418	110.52632	835.9210526	0.5	418	1672	1313
1.17	0.53	2.00	1.38	0.97	0.82	1.45	1.58	0.53	2	CH101	1388	110.52632	2639.236111	0.5	1320	5278	4535
1.15	0.50	1.97	1.35	0.94	0.80	1.43	1.55	0.50	2	CH101	1320	110.52632	2639.236111	0.5	1320	5278	4615
0.90	2.00	1.73	1.11	0.69	0.55	1.18	1.31	0.55	6	CH105	920	110.52632	1679.199561	0.5	840	3358	2680
0.85	1.95	1.68	1.06	0.65	0.50	1.13	1.26	0.50	6	CH105	840	110.52632	1679.199561	0.5	840	3358	2769
0.70	1.80	1.53	0.91	0.50	2.00	0.98	1.11	0.50	5	CH104	799	110.52632	1608.205409	0.5	804	3216	2647
0.56	1.66	1.39	0.77	2.00	1.86	0.84	0.97	0.56	1	CH100	1217	110.52632	2180.211988	0.5	1090	4360	3561
0.50	1.60	1.33	0.71	1.94	1.80	0.78	0.91	0.50	1	CH100	1090	110.52632	2180.211988	0.5	1090	4360	3705
2.00	1.40	1.13	0.51	1.74	1.60	0.58	0.71	0.51	4	CH103	533	110.52632	1047.865497	0.5	524	2096	1656
1.99	1.39	1.12	0.50	1.73	1.59	0.57	0.70	0.50	4	CH103	524	110.52632	1047.865497	0.5	524	2096	1666
1.90	1.30	1.03	2.00	1.64	1.50	0.48	0.61	0.48	7	CH106	402	110.52632	832	0.5	416	1664	1322

Figure 2: Finite Schedule (Make to Inventory Schedule)

The second part of the finite schedule (Figure 2) which shows the lowest product cover after each production run, and the next product to be produced with the forecasted quantity. (Demand)

		Sum of Qty			
Prod/Run	Prod	Product	Start	Total	Run
CH101/1	CH101	CH101	21/03/2022 0:42	4615	1
CH101/2	CH101		02/04/2022 6:28	4615	2
CH100/1	CH100	CH100	20/03/2022 8:00	1200	1
CH100/2	CH100		25/03/2022 20:50	3784	2
CH100/3	CH100		06/04/2022 19:06	3705	3
CH105/1	CH105	CH105	23/03/2022 19:16	2769	1
CH105/2	CH105		04/04/2022 8:18	2769	2
CH103/1	CH103	CH103	28/03/2022 2:57	1666	1
CH103/2	CH103		08/04/2022 6:03	1666	2
CH104/1	CH104	CH104	24/03/2022 20:56	2641	1
CH104/2	CH104		05/04/2022 9:21	2647	2
CH102/1	CH102	CH102	01/04/2022 14:14	1313	1
CH106/1	CH106	CH106	28/03/2022 18:01	1345	1
CH107/1	CH107	CH107	29/03/2022 22:45	520	1
		Grand Total		35255	

Figure 3. Production Runs

Figure 3 is like a summary of the finite schedule which gives the user a summary of the production run results.

Component	Start Date	Product/Run	Total	Componei	Start Date	Item Index	Description	Supplier	Supplier Name	Inventory	Balance Remaining	Get In	On order
FL02001	20-Mar-22	CH100/1	13680	FL02001	20-Mar-22	22	Chilli Flavour	FL01	Flavor for all Co.	39,200	25,520	0	
FL02002	21-Mar-22	CH101/1	52611	FL02002	21-Mar-22	23	Ketchup Flavour	FL01	Flavor for all Co.	46,400	-6,211	6,211	
FL02003	29-Mar-22	CH107/1	5928	FL02003	29-Mar-22	28	Salt flavour	FL01	Flavor for all Co.	44,380	38,452	0	
FL02005	01-Apr-22	CH102/1	14968.2	FL02005	01-Apr-22	24	Barbecue Flavour	FL01	Flavor for all Co.	17,120	2,152	0	
FL02007	23-Mar-22	CH105/1	31566.6	FL02007	23-Mar-22	25	Salt & Vinegar Flavour	FL01	Flavor for all Co.	37,860	6,293	0	
FL02010	28-Mar-22	CH103/1	18992.4	FL02010	28-Mar-22	27	Cheese Flavour	FL01	Flavor for all Co.	18,720	-272	272	
FL02023	28-Mar-22	CH106/1	15333	FL02023	28-Mar-22	26	Jalapeno & Cheddar Fla	FL01	Flavor for all Co.	40,620	25,287	0	
				FL02001	18-Feb-22		Chilli Flavour	FL01	Flavor for all Co.				200,000
				FL02002	28-Feb-22		Ketchup Flavour	FL01	Flavor for all Co.				200,000
				FL02005	14-Feb-22		Barbecue Flavour	FL01	Flavor for all Co.				200,000
				FL02007	18-Feb-22		Salt & Vinegar Flavour	FL01	Flavor for all Co.				200,000
				FL02023	01-Feb-22		Jalapeno & Cheddar Fla	FL01	Flavor for all Co.				200,000
				FL02010	22-Feb-22		Cheese Flavour	FL01	Flavor for all Co.				200,000
				FL02003	16-Feb-22		Salt flavour	FL01	Flavor for all Co.				200,000

Figure 4. Inventory Allocation Schedule

Figure 4 shows the inventory allocation schedule is a fundamental output of the MRP system which gives the user the needed information to avoid raw material running out based on production runs and on-hand inventory. the selected part of the schedule shows the needed raw material quantities on each date and compares it to the on-hand inventory then gives the user the final needed quantity of each raw material element. Also, on the lower part of the schedule, we can see the upcoming orders with the receiving date and quantity based on the date of purchase orders sheet which is an input of this system that can be filled manually

Product/Run	Component	Qty each	Start Date	Production Qty	Component Quantity Required
CH100/1	FL02001	11.4	20-Mar-22	1200	13680
CH100/1	RM01002	183.54	20-Mar-22	1200	220248
CH100/1	RM01004	202.35	20-Mar-22	1200	242820
CH100/1	RM01008	86.07	20-Mar-22	1200	103284
CH100/1	RM01013	77.52	20-Mar-22	1200	93024
CH100/1	RM01001	10.83	20-Mar-22	1200	12996
CH100/1	RM01023	9.12	20-Mar-22	1200	10944
CH100/1	RM01027	0.57	20-Mar-22	1200	684
CH101/1	FL02002	11.4	21-Mar-22	4615	52611
CH101/1	RM01002	183.54	21-Mar-22	4615	847037.1
CH101/1	RM01004	202.35	21-Mar-22	4615	933845.25
CH101/1	RM01008	86.07	21-Mar-22	4615	397213.05
CH101/1	RM01013	77.52	21-Mar-22	4615	357754.8
CH101/1	RM01001	10.83	21-Mar-22	4615	49980.45
CH101/1	RM01023	9.12	21-Mar-22	4615	42088.8
CH101/1	RM01027	0.57	21-Mar-22	4615	2630.55

Figure 5: BOM x 3

Figure 5: BOM x 3 shows similar data of the inventory allocation but in a simpler way to the user. It shows the needed raw material components in each production run.

5.2 Graphical Results

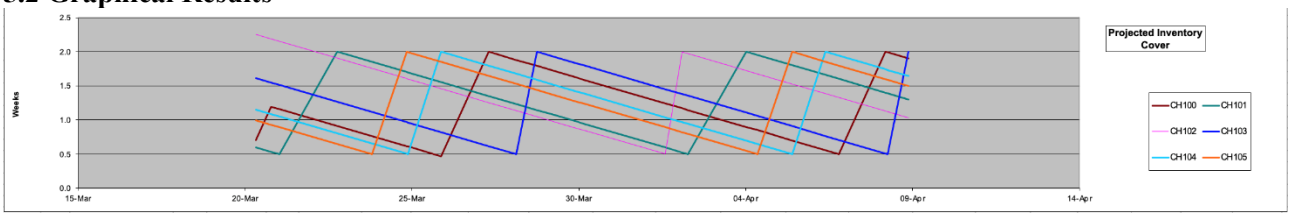

Figure 6. Projected Inventory Cover Graph

to support the users and decision-making.

6. Conclusion

In Brief, the research goals were achieved, and a strategy is proposed as to how an MRP system for snack manufacturing companies can be designed without the sluggishness that is often associated with excel programming. Excel as the current version of the system produces accurate supporting information and gives insight into many of the aspects of the material requirement planning and scheduling process. The relationships and formulas used proved to be easily adaptable and can be tweaked manually as needed. Migration of data from other systems into the inputs is as easy as copying and pasting without having to adjust parameters. In addition, the system is light and portable not requiring significant processing power. The current results tested proved fruitful and additional improvements are a possibility.

Acknowledgment

This work is supported by Alfaisal University. All concepts were researched under review and based on the guidelines of Alfaisal University. The intended use for this paper is for participation in the IEOM Society Conference to be held in Orlando, Florida in 2020.

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