Adaptive Simulation Using Arena Software

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***Abstract*—A typical automated assembly is a system designed for the assembling of a series of parts which are movable along a guided track in an assembling area. This system consists of a work station that may include a program-controlled robot and a buffer area used for storing sets of parts to be used in the assembly process. An assembly workstation will assemble each set of parts into an assembly before offloading it into a guide path. An automatically-guided vehicle (AGV) or a conveyor system will then transport the assembly, as a unit or in the form of pallets, stopping at points that are predetermined by the guided assembly and unload stations.**

The robots and the transport system, in a typical automated assembly are computer-controlled. As such, these robots can pick and place the given sets of parts in specific positions; and they can also perform other functions such as welding during motion from station to station until the assembly process is completed. The assembly process contains a plurality of workstations as well as a plurality of storage buffer areas. In the event of a robot failure, the control systems automatically redistribute any remaining work of the failed robot to the functional ones. This work is about creating a generic simulation program of an automated assembly which can be used to simulate a given family of assembly. This program is based on the generic algorithm/flow chart and generic assumptions to be used to simulate an automated assembly process. The generic program is based on Arena and program.

I. Introduction

The research in data-driven area has been based on using data from the assembly to input into the simulation model. The data driven simulation can in some cases make use of real-time assembly-plant data to input into the simulation model. Data driven methods are meant to provide an integrated online data simulation modeling technique to model the system changes for scenario studies and decision making.

Purchased components are outsourced from many supplying companies who generally use different data formats, which are not usually compatible. Yet this data must be shared among many companies involved in the assembly process. A generic simulation program will incorporate the data available for operation. This program does not require an experienced programmer to input the plant specific values.

II. Procedure for Paper Submission

A. *AUTOMATION*

Automated assembly is a complex manufacturing system in which products are manufactured from a number of components [1]. Products are made from different materials and require flexible and precise mechanisms, which are computer controlled. The assembly process make use of robots, AGVs, etc. equipped with highly accurate sensory systems [3].

Printed circuit card assemblies form the core of a vast array of contemporary manufactured products. The technologies for assembling printed circuit cards require a hierarchy of complex decisions for grouping card types and processes, staging components at assembly machines, arranging feeders, and sequencing placement operations [4].

Assembly automation has become very expensive, in terms of both acquisition and the technical knowledge for its operation. Thus, it is increasingly important to optimize assembly processes to achieve high levels of utilization without causing work-in-process inventory problems.

There is a need for robust heuristic architectures, i.e., heuristics which can be readily modified to accommodate application specific requirements. The criterion for machine setup and placement sequencing must reflect the specific machine operations.

There is not yet a generic characterization of component placement machines upon which a generic criterion function could be modelled. McGinnis [2] introduced the setup management problem and identified the two major categories of setup management strategies-single setup and multi setup. He also suggested a decision hierarchy that seems to describe current practice, as well as the array of heuristic procedures currently seen in the research literature.

AUTOMOTIVE ASSEMBLY PLANT

In the automotive industry, it takes several years to model hundreds of production lines for initial simulation studies. It also takes longer during the operations stage, such as determining the number of workstation, buffers, and operators [5]. A simulation method normally requires expert knowledge for developing and modifying and takes a longer time to verify and validate. To validate using the given data input faces a challenge of acquiring relevant data. This results in a challenge of the development of real-time data enabled, simulation-based problem-solving capability [6].

The system consists of a work station and these stations could be having program-controlled robot or automatic guided vehicles (AGVs). There is also a buffer area for storing sets of parts within the work station. This work station will assembly each set of parts into an assembly, unload the assembly into the guide path or conveyor, which leads to another work station. A conveyor or AGVs systems are the transport systems of an assembly plant. For the conveyor system, the assembly will be stopping in

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predetermined positions relative to the guided assembly and unload stations/points. Sometimes the work stations are along the conveyor belt.

AUTOMATED ASSEMBLY SIMULATION

Automation process includes the coordination of design and manufacturing activities between many and among supplies of assembly components/parts. Assembly process involves a number of operations, which require assembling together thousands of fabricated and purchased components/parts, subassemblies and systems-coordination. Purchased components are outsourced from many suppliers who generally use different data formats, which are not usually compatible. Yet this data must be shared among many of these companies involved in the production process.

B. *ARENA SPREADSHEET*

The Excel spreadsheet below is the platform from which to control and input the values according to the given plant requirements. In this spreadsheet, one can select the number of workstations in operation and up to ten workstations. All the workstations are along a conveyor. In each workstation there can be a total of up to four components to be assembled. All changes in the program are carried out on the spread sheet.

Table I Input spreadsheet

			Delay Time (Minutes)			Assembly Time (Minutes)		
Work Stat	Componer	% Availabi	Min	Average	Max	Min	Average	Max
1	0	0	5	7	10	1	3	5
	2	100	5	7	10	2	3	5
	3	100	5	7	10	2	3	5
	0	0	5	7	10	2	3	5
2	1	100	5	7	10	0	1	1
	5	100	5	7	10	0	1	1
	4	100	5	7	10	0	1	1
	0	0	5	7	10	0	1	1
3	0	0	5	7	10	2	4	6
	8	100	5	7	10	2	4	6
	7	100	5	7	10	2	4	6
	0	0	5	7	10	2	4	6
4	0	0	5	7	10	2	4	6
	0	0	5	7	10	2	4	6
	0	0	5	7	10	2	4	6

These components can be varied according to their availability. An availability of 100% percent implies that the components are readily available, but if the components are ordered from some source, the availability can be adjusted to suit this source. If a component is not part of the assembly, it can be represented as having an availability of 0%.

The assembly time given reflects the average time of assembling a given component. The component with the longest assembly time determines the speed of the conveyor and the assembly cycle time.

C. *Figures*

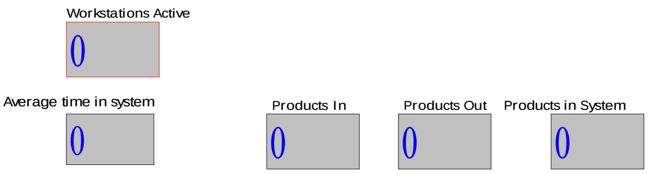

Fig. 1. Control counter and the Workstation arrangement

The figure above shows the number of active workstations, average time of components in the system, number of components in and out of the Assembly process and the work in progress. Shown below is a detailed component assemblers of workstation one and two, which similar to the rest of the stations.

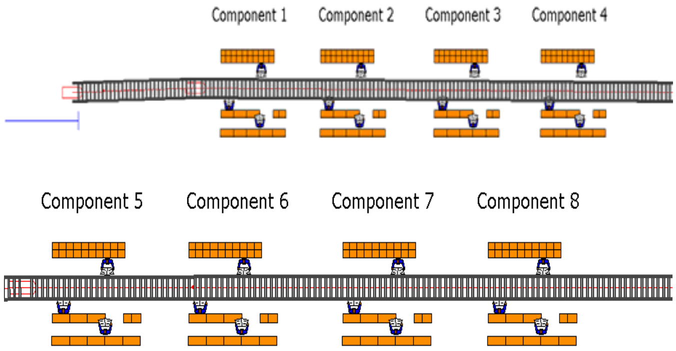

Fig. 2. Workstation Components

Four components can be assembled per workstation; hence the workstations are represented in terms of component assemblers. Figure 2 shows the Arena model program in detail.

D. *Results*

The Arena results are based on two scenarios. Scenario one is based on the use of one workstation, and scenario two is based on all workstations.

SCENARIO ONE ARENA INPUT

Table II Program Input

			Delay Time (Minutes)			Assembly Time (Minutes)		
Work Station	Comp	% Avail	Min	Ave	Max	Min	Ave	Max
1	0	0	5	7	10	1	3	5
	2	100	5	7	10	2	3	5
	3	100	5	7	10	2	3	5
	0	0	5	7	10	2	3	5

Scenario 1 Output

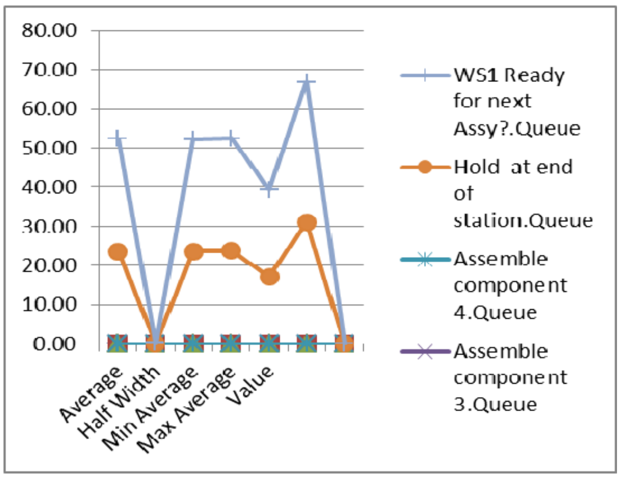

Fig. 3. Components/part usage (Scenario 1)

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Shown in Figure 3 is the status of the component/part during the assembly process

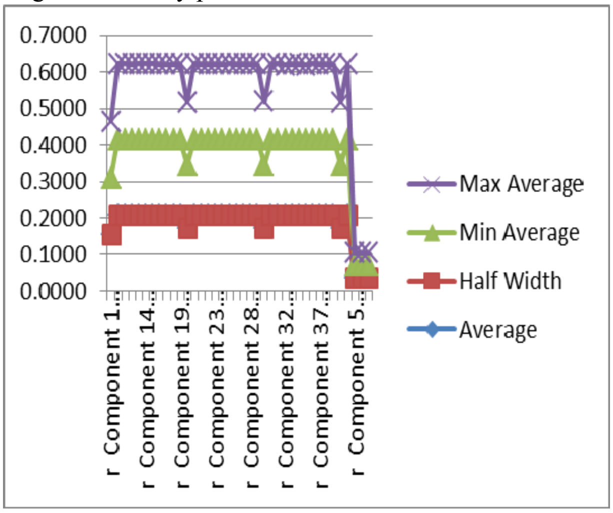

Fig. 4. Resource/ Assembler % utilization (Scenario 1)

At any given time the utilisation of a specific machine or assembler can be analysed.

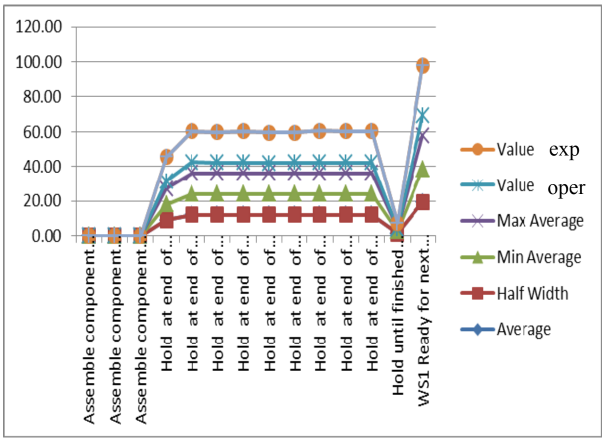

Fig. 5. Components/parts per assembler (Scenario 1)

Failure or damages are detected and incorporated in work-in-progress. Damages or defective units are re-worked in an assembly line. Where a component/part is held, this translates to the assembly process, converting the component to a complete product.

SCENARIO 2 ARENA INPUT

Scenario 2 is based on 10 workstations and 75 component/parts

Table III Scenario 6 Input

The input values are dependent on the assembly process.

			Delay Time (Minutes)			Assemb
Work Stat	Compone	% Availab	Min	Average	Max	Min
1	1	100	5	7	10	1
	2	100	5	7	10	2
	3	100	5	7	10	2
	4	100	5	7	10	2
2	5	100	5	7	10	0
	6	100	5	7	10	0
	7	100	5	7	10	0
	8	100	5	7	10	0

SCENARIO 2 ARENA OUTPUT

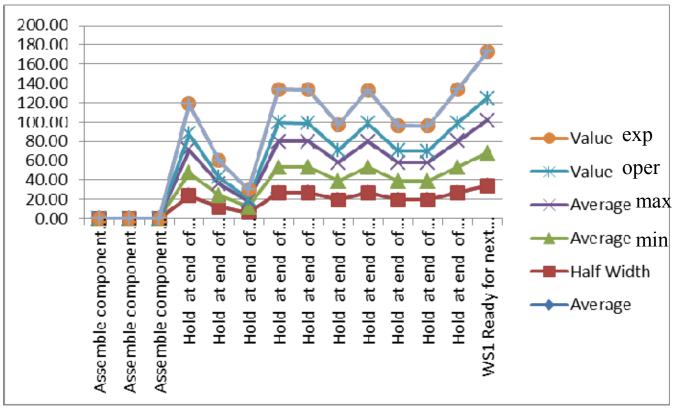

Fig. 6. Components/ parts assembler (Scenario 2)

These are activities pertaining to the assembler. This will show the utilisation of the machines and appropriate decisions can be made. There are two categories of time in a VSM (Value Stream Map) called value added time (VA), and the non-value added time (NVA). For the component/part distribution warehouse inbound process, the VA time accounts for the time where the component/part is moving through the inbound process of the assembly, while the NVA time is the time when the component/part is sitting idle in the buffer waiting to be unloaded from the truck/conveyor, received by the receiver/assembler, etc. Entities in this case are the components/parts in the assembly process. One can trace the position of a part/component in the assembly process.

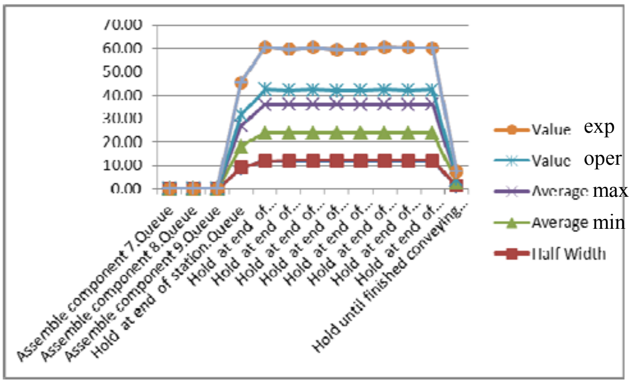

Fig. 7. Components/part usage (Scenario 2)

The figure above shows that the activity in these components. The figures below show the activities between the workstations and the conveyor.

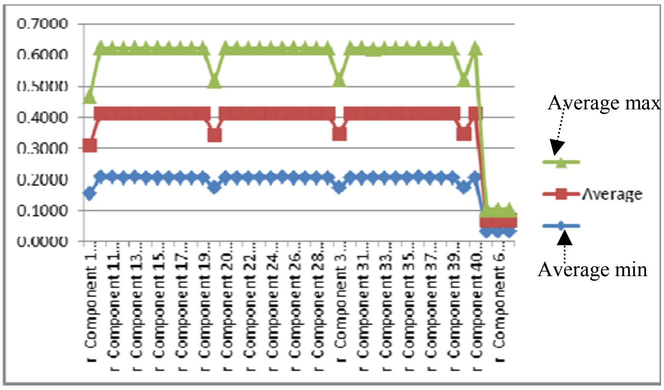

Fig. 8. Resource utilization (Scenario 2)

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Figure 8 shows the utilisation of the workstation at which the given components are assembled.

Table IV Assembly output

	Average	**Half Width**	**Minimum Average**	**Maximum Average**
Time in System	**196.14**	**0.31**	**196.00**	**196.24**
Output				
	Average	**Minimum Half Width**	**Minimum Average**	**Maximum Average**
Units arrived	**7457.33**	**11.20**	**7453.00**	**7462.00**
Units Assembled	**7447.33**	**11.20**	**7443.00**	**7452.00**
WIP	**10.0000**	**0.00**	**10.0000**	**10.0000**

III. Summary

After each run one can then generate reports which include the utilisation of each workstation, number of components used, and number of products or assemblies. These reports will be used to assess the performance of a given plant or assembly process.

This work gives Managers and Engineers the easy access to crucial production information of a manufacturing process. This information can then be utilised to optimise the manufacturing processes, and reduce costs of system design as this is simulated before implementation.

Comparing figures from scenario 1 and 2, one can conclude that there is a clear distinction among the different outputs. It can be shown that in graphical presentations, there exit a visual presentation for use in the analysis of different scenarios. The Arena output figures are useful in the analysis of an assembly process as there is a distinction between the output of Scenario 1 and 2, due to the varied input values into the program.

IV. Analysis and Conclusion

The Arena program is based on two scenarios with two output graphs detailed on figures 1 to 8. Figure 1 shows the output from scenario 1. Scenario 1 is based on a product made-up of four components. This is similar to the Tweel, which is composed of four components: namely Deformable wheel, Flexible spoke, Sheer band and Tread. Figure 1 shows the total number of components used to assembly 5024 products. Workstation 1 has four components assemblers. Scenario 2 is composed of all ten workstations as shown on Scenario 6 Arena input table. The output figure (Fig 6) shows the number of components consumed and the number of workstation involved. The highest number of products is 7443, and the bottle-necks of the assembly are workstations with a high number of components to assemble. Hence workstations with high component input are under-utilized, and determine the cycle time of the assembly.

Comparing figures 1 to 8, one can conclude that the program shows a marked distinction under different operating conditions. The program responds to the changes in the number of workstations. The product output also increases from 5024 to 7443 with a work-in-progress (WIP) of 10 000 (shown in table IV). Hence this program can be used for analysis on a given product whose components/parts fall within the given limit and can be assembled using a maximum of ten workstations.

For future research, the required production data should be collected automatically and directly from the production system of the assembly and, should then be stored in a suitable database format. An error due to manually collected data must be taken into account. Linking the IT system of the assembly and data-driven simulator remains a challenge. However, a real-time simulation can be used in an assembly in order to simulate using real-time data. Available commercial simulation packages can be customised to simulate real-time data, or to link with a given assembly plant using some application programme interface. This enables communication between the external data and the internal events/processes. The data-driven simulator is a what-if-tool without a production plan as input.

Appendix

Value Expected (Value Exp): - number of components consumed in uninterrupted assemble shift.

Value Operational (Value Oper):-The true value of the components consumed per shift

Average value (Average): This is the average number of consumed components recorded for a particular output across all indicated assemblers so far.

Maximum Average (Average max): - This function is the maximum mean value of consumed components for a particular output across all indicated-assemblers/stages.

Minimum Average (Average min): - This function is the minimum mean value of consumed components for a particular output across all indicated-assemblers/stages.

Half-width: - This is the number of components around the mean for a assemble output across all replications run so far, or Work-in-process per unit time.

References

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