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# An Algorithm Based Simulation Modeling For Control of Production Systems

Srinivas Viswanath V[1], R Ramanujam[2], VM Nistane[3]
[1,2]*Mechanical Engineering, VIT University, India,*
[3]*Mechanical Engineering, VNIT Nagpur, India.*

***ABSTRAC:*** *This paper describes an algorithm based simulation approach for the design of a flexible production system Which allows the implementation of logic during the system design stage. The Algorithm design approach is built around the basic concept of supervisory control based on limited Automation. We provide the optimal inventory control policy and characterize its structural properties for the single-period model. Through an extensive numerical study, we demonstrate that applied programmed methodology is sufficiently accurate and close to optimal. The system resources are modeled to be monitored for real-time control. Real-time control issues including deadlock resolution, resource failures in various modes of operation and recovery from failures while sustaining desirable logical system properties are integrated into the logical design for simulating the supervisory controller.*

***Keywords:*** *Algorithm, Automated systems, Inventory control, Production systems, simulation.*

## I. INTRODUCTION

Evaluation of existing performance levels of discrete parts production plant design is quite difficult and has to go with Algorithm based simulation models. Current commercial software for the simulation of production system designs does not incorporate models of the sensory data collection and electronic control systems that will eventually drive the operation of the factory that the simulation is modeling. This leaves the control system design architecture as a separate design task to be performed later.

Consequently, the impact of the control system on system performance is evaluated after the construction of the plant. Integration of control system design into plant simulation models requires modeling the plant in terms of events that will have to be monitored, recorded, and used for control. In principle, the software used to control the simulated factory operations could also be used to drive the operations of the actual factory after it is constructed. The traditional hierarchical decomposition approach to the design and control of production systems includes the strategic level (initial design) at the top, followed by the tactical (system configuration) and operational levels (part dispatching) towards the bottom. The control systems as they are referred to in this paper, reside below the operational decisions layer and deal with real-time control of the production system, which includes deadlock resolution and recovery from resource failures.

### 1.2. Algorithm based simulation

The primary contribution of Algorithm based approaches is through their ability to facilitate links between the analysis and specification of a real system and the design and implementation of an action model for that real system where the structure and behavior of entities are readily modeled as objects. An object, in the Algorithm based paradigm, is a collection of data (attributes) together with all the operations (methods) which access or alter that data (Hill, 1996). Some or all of these operations could be used to provide a uniform external interface to other parts of the system. Other objects in the system can interact with this object only through requests for the object to execute its operations. The ability of the Algorithm based paradigm to provide a direct representation for real world objects comes with four unique features associated with it, data abstraction, and dynamic binding.

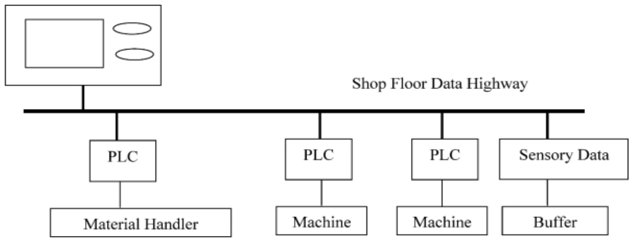


Fig 1.1 System design for Automation

Algorithm based simulations have now been produced in many languages, however it is important to emphasize that the use of Algorithm based methods is not dependent on any particular programming language (Jones & Powell, 1993). This paper presents an Algorithm based design approach for the simulation of flexible production systems. The approach is an extension of Boucher, Yalcin, and Tai (2000) in scope, design and implementation. The methodology in Boucher et al. (2000) integrates real-time supervisory control and physical system simulation using ARENA simulation coupled with control modules developed using C programming language. The proposed approach in this paper extends the scope by integrating resource failures and recovery from failure procedures. The Algorithm based design and implementation approach pursued in this work is also different, and has proven to be more effective with respect to ease of implementation, debugging and extensibility. In this paper, CCC, which is an Algorithm based extension to the C programming language, is used. The important features of the described framework are: (1) integrates control system design into the simulation of the physical process, (2) horizontally and vertically extendible within the production system design and control functions hierarchy (3) the mathematical foundation based on finite automata formalism allows for logical as well as quantitative analysis of the system, (4) facilitates the design and implementation of robust and formal controller models and algorithms that can service a variety of system designs, resolve deadlocks, and accommodate a range of resource failures, and (5) allows an analyst to design and evaluate the impact of different control programs on factory performance, and evaluation of various production system designs in a 'plug' n play" fashion.

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## II. Physical system

The physical system considered is a fully automated flexible production cell that has a number of single capacity machines and a central material-handling device, such as a robot, that interconnects these machines. There is an input and an output buffer where parts can be loaded and unloaded to and from the cell via the material-handling device. Each machine and the material handler are assumed to have their own internal controller as well as a Programmable Logic Controller (PLC) that it is connected to which coordinates its interactions with the rest of the components in the system. The cell controller monitors the machine PLCs for machine failures, repair completions, event start and finish signals, etc.

## III. Algorithm based design framework

In order to simulate the real-time control activities, the system model must consider several factors such as the status of machines and material handlers, processing requirements of the parts in the system, sequencing of the operations required by these parts and contingencies such as equipment breakdowns. The proposed Algorithm based design approach contains constructs to model: (1) production cell, (2) the control structure to accomplish desired system behavior, and (3) communication between the cell and its controller. The modeling of the cell includes the definition of machines, robots, input and output buffers, their interactions and associated contingencies such as resource failures.

## IV. Methodology

### 4.1. Mathematical Model:

As discussed earlier in the previous chapter the production process WIP inventory was increasing and there was increase in the loss of utilization of resources as well. So there is a need of proper scheduling technique which takes care of this problem. The Gantt charts can be one of the techniques to tackle this problem but the problem with the technique is that it is a slow and time consuming process [5]. Each and every time we need to charts and also beyond a certain limit of time span it is difficult to read the charts. As the number of operations or number of batches in the scheduling increases in order to accommodate the larger time span either the Gantt charts have to be huge or the resolution has to be sacrificed. If there is a mathematical tool by which we can solve the above discussed problem then it will be much easier to get the schedule. Inventory has problems. The proposed technique requires the daily attainment of the track grinding that is the last operation of production process. Here the logic of process is reverse type of process i.e.., last process requests number of parts for before process. The same amount of parts are prepared and sent, no excess parts are send. So inventory levels are balanced and no excessive stocks are maintained.

MATHEMATICAL MODEL FORMULATION LOGIC:

| Day | BGTG | ODG | FG | SB | Heat | GS | total inventory |
|---|---|---|---|---|---|---|---|
| 1 | 3536 | 0 | 3438 | | 30000 | | 37974 |
| 2 | 3555 | | 8000 | | 22000 | | 33555 |
| 3 | 3495 | 8000 | | | 14000 | | 25495 |
| 4 | 3668 | 0 | 8000 | | 6000 | | 17668 |
| 5 | 3778 | 0 | 0 | | 36000 | | 39778 |
| 6 | 3356 | 0 | 0 | | 28000 | | 31356 |
| 7 | 3669 | 8000 | 0 | | 20000 | | 31669 |
| | | | | | | | |
| | | Average Inventory | | | | | 29702 |

### 4.2 Calculation of Buffer Stock / Inventory Levels

The Proposed system supports level production. It helps to maintain stable and efficient operations. The question of how many proposed to use is a basic issue in tuning a proposed system. If your factory makes products using mostly standard, repeated operations, the number of proposed can be determined using the formula The number of proposed you need dependent on the number of pallets or containers and their capacity. Lead times, safety margins or buffer inventory , and transportation time for proposed retrieval are also important factors. Several questions must be answered when deciding the number of proposed to use.

- How many products can be carried on a pallet?
- How many transport lots are needed, given the frequency of transport?
- Will a single product or mixed products be transported?

### 4.3. Inventory Level:

Inventory level is very important in between the process. That is also called as safety stock level which is calculated as below.

Inventory level = [Daily Production Requirement * (1+$\alpha$)]

Daily Production requirement for COMPONENT 1

Outer Ring = 4000 components

According to monthly plan If safety factor $\alpha$=1,

Inventory level for COMPONENT 1

Outer Ring =DR * (1+ $\alpha$) =4000 * (1+ 1) = 8000.

### 4.2. Simulation inputs

The input files to the simulation describe the processing times and the routing of the part types in the cell representing the full set of alternative production sequences for the parts. There are two types of files. Thepartplantstate[i].txt specifies the machine which can perform the required operation on part typeiin a particular state. The partprocessplan[i].txt describes the state transitions for the part typei and the processing time for that part in each state. Together, they contain all the information to generate the corresponding Finite Automata models of the parts. At the beginning of each simulation, the user also specifies the number of machines in the cell model and the number of parts to be processed in the plant during the simulation. The user may also simulate resource failures in the plant by specifying failure-rates and repair rates for the resources. These set of details are complete in themselves in describing the structure and behavior of the plant comprehensively.

The constructor of the cell class is used as an initialization procedure to create the buffer, the machine, the material handler and the part objects that form the cell object, and to create certain information-arrays from the input files. These arrays capture all the information on the cell behavior and are henceforth, used by the supervisor to formulate a control strategy.

### 4.2. Simulation logic

The simulation logic is implemented in the object-oriented model through the updating of the attributes of the component objects and the interactions among these components are modeled through the message-passing facility in the object-oriented approach. The event handler object monitors the buffers and the machines in the cell and queues and relays appropriate event signals to the supervisor object. The supervisor object then evaluates the request based on the current state of the system and the control strategy and sends back the decision to allow/disallow the request back to the cell object, which executes the move if it is allowed. If the move is not allowed, it is sent to the end of the queue of events requested in the event handler object to be evaluated again when the system state changes. The flow of information within the simulation is illustrated in flow chart.The simulation starts with the arrival of a part to the input buffer. The event handler sends the load new part signal to the supervisor based on the change in the buffer object's attributes. The supervisor generates a new control pattern, evaluates the move requested using theevaluate_newpart_request( ) and the evaluate_move_request( ) methods. The response is evaluated by theevaluate_response( ) method of the cell, and if it is allowed, theexecute_event( ) method of the material handler, load_machine( ) method of the cell andload_part( ) method of the machine are sequentially invoked. The current states of the cell, the machine and the part are updated using their respectiveupdate_state( ) methods. Based on the processing time of the required operation, themark_event( )method of the event handler object schedules the part to be unloaded when the processing is complete.

## V. Implementation Phase

### 5.1 Action Plan:

In this section action plan has been discussed.

**5.1.1 To Decide Proposed Methodology**:

After study of the existing process it was found that maximum inventory and lack of utilization of available resources is with production process. In the
Process of production WIP inventory was increasing more so to avoid this it was decided to implement Toyota Production System PROPOSED Methodology.

### 5.2 Monitoring Phase:

Having implemented Proposed Algorithm Methodology the next most important step is to monitor the flow of materials. This step is important so as to know whether an Just In Time, Toyota implementation is successfully running or not.

**5.2.1 Steps in Monitoring Phase:**

- Daily production fulfillments according to Monthly plan
- Attend daily Production Meeting
- Update Current status of Notice Board
- Attend breakdown and know the root cause
- Calculation of WIP inventory at starting of

Take every problem for discussion with team and after answering it design the solution on paper and gather necessary tools to implement these solution. Getting proposal from top management is major thing it depend on understanding solution designed and how that can solve the problem associated with the existing process.

**5.2.2 Simulation logic:**

The simulation logic is implemented in the Algorithm based model through the updating of the attributes of the component objects and the interactions among these components are modeled through the message-passing facility in the Algorithm based approach. The event handler object monitors the buffers and the machines in the cell and queues and relays appropriate event signals to the supervisor object. The supervisor object then evaluates the request based on the current state of the system and the control strategy and sends back the decision to allow/disallow the request back to the cell object, which executes the move if it is allowed. If the move is not allowed, it is sent to the end of the queue of events requested in the event handler object to be evaluated again when the system state changes.

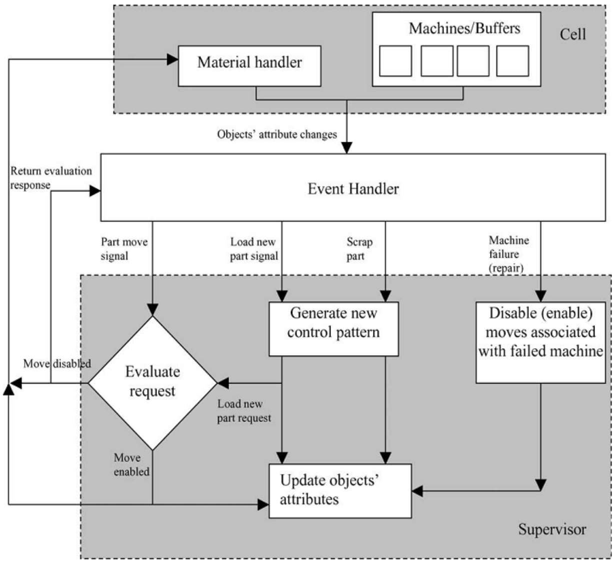


Fig 5.1 Flow of materials and Application Logic

Simulation outputs the output produced by the simulation model is captured in data files and includes event trace information, system performance information, and supervisory controller computation complexity information. The trace information includes a trace of the events ordered by time for understanding the behavior of the system. The system performance information includes measures such as the throughput, resource utilization, etc. Also, included are the state space and response time of the supervisory controller to keep track of computational complexity.

## VI. Summary and conclusions;

Integration of control requirements into plant simulation models requires modeling the plant in terms of events that have to be monitored, recorded, and used for control. In this paper we describe an Algorithm based approach to the design of flexible production system simulation that allow the implementation of control logic during the system design phase. The Algorithm based design approach is structured around formal supervisory control theory. While Algorithm based design approaches have several advantages for software development, especially in specifying intra-object relationships, the interactions between objects in a complex system are difficult to capture.

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