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MODELING OF DISASSEMBLY AND ASSOCIATED TOKEN RING NETWORK OPERATIONS

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ABSTRACT

Communication networks play an increasingly important role in assembly and disassembly systems. Most of the works published recently to analyze such systems use simulation. However, these works have typically focused on Carrier Sense Multiple Access protocol and none of the studies address the performance of Token Ring protocol for such applications. In this paper, we attempt to fill this void. To this end, we analyze a disassembly system that is a combination of physical manifold (performed by machines) and information network (performed by computers). We develop a model to analyze the system's behavior and attempt to obtain an optimal or near optimal solution to maximize the system's performance by minimizing the risk of downtime due to network capacity related problems. A case example is considered to demonstrate the feasibility of the model's implementation.

INTRODUCTION

The rapid development and improvement of products has shortened the lives of most products that has, in turn, given rise to elevated demand resulting in increased quantity of used products scrapped [1]. The bulk of the scrap comes from automobiles, household appliances, consumer electronic goods and at an increasing rate from computers. There is an urgency to find alternative ways to dispose of products because of the alarming rate at which the landfills are being used up. In addition, environmental awareness and recycling regulations have been putting pressure on many manufacturers and consumers, forcing them to produce and dispose of products in an environmentally responsible manner. The regulations are becoming more stringent and, in some cases, manufacturers are required to use recycled materials whenever possible. Furthermore, sometimes they are also required to recycle their products at the end of their useful lives. Some manufacturers are adding disposal costs to the selling price of their products. Product recycling requires disassembly first, so that individual components and materials can be reused or recycled. Research is needed to develop models of the disassembly process, identify software tools to support the disassembly planning, and develop interfaces for sharing data between those tools [2].

Products arriving at a product recovery facility go through several steps before their constituent parts and materials face their end-of-life choices. These steps include cleaning, disassembly and sorting. The parts are sorted for remanufacturing (reuse, repair or reconditioning), recycling (material reclamation) or disposal. Disassembly of returned products could be performed at a single workstation, in a disassembly cell or on a disassembly line. Even though a single workstation or the disassembly cell provides the most flexible environment for sorting parts according to their quantity and quality, the disassembly line provides the highest productivity rate. The disassembly line setting is most suitable for disassembly of large products or small products with large quantities. Furthermore, the disassembly line is the best choice for automated disassembly process, a feature that will be essential in the future disassembly systems. Compared to an assembly line, in a disassembly line, there are serious inventory problems, much more complicated flow process, a high degree of uncertainty in the structure and the quality of the products, and uncertainty factors associated with the reliability of the workstations [3]. The uncertainty

makes disassembly line much more challenging than an assembly line. Therefore, it is important that a disassembly line be flexible and adaptive to manage such uncertainties.

One of the key characteristics of a flexible disassembly line is the information network, which facilitates communication between all workstations and robots and helps control the flow of the items on the line. Such network keeps all workstations abreast of all the needed information on all the parts moving on the line.

In spite of the critical role played by the information network in a disassembly line setting, no research has been reported on this subject. However, some limited work has been done in the manufacturing area. Published work in this area follows a two step approach [4], [5]. In the first step, the operations of the physical plant are simulated while in the second step the communication network is simulated using the statistical data obtained from the physical plant simulation. The disadvantage of this approach is that it excludes the opportunity to see the interaction between the physical plant and the communication network operations. In this paper, we combine the physical plant and communication network operations of a disassembly line in one simulation model, which helps us obtain even deeper insights.

OBJECTIVE

The objective of this paper is to investigate the effects of different token ring network configurations on a disassembly line performance. To this end we do the following.

- Model a disassembly line together with a communication network.
- Analyze the simulation results in terms of the throughput, total communication delay and flow time parameters

CASE EXAMPLE

The case example considered here consists of a disassembly line for the disassembly of television (TV) sets [6]. The flow of the TVs on the line is as follows. TVs enter the facility at the loading area and get manually loaded on to the disassembly line. Once on the conveyor, they first stop at the *Identification Station*. All the TVs are identified and assigned a unique identification number (ID) at this station. IDs are recorded on the magnetic zones of the pallets carrying the TVs. The purpose of this station is to determine if a particular TV has been processed before or not. If such model has been processed before, the system would have information about its size, type, cutting and claw coordinates etc. in its database. This also means that the TV could skip the teaching station, where information for TV encountered for the first time is uploaded into the database.

After the Identification station, the first time TV goes to the *Cut Line Identification Station* (First of two teaching stations). When a TV arrives at any station except the Identification station, the first thing done is to read the ID. After that, depending on the station, either information is sent to the controller to be saved into the database (this is the case at the Teaching stations) or a message is sent to controller to get information about the item. At the Cut Line Identification station, a worker records the rear cover cutting coordinates with a coordinate measuring machine (CMM) and sends the data to the controller along with TV's ID. Controller, which is connected to the database, gets the message over the Local Area Network (LAN) and writes it in the database. Next on the conveyor is *Rear Cover Cutting* station. Here too, the station reads the ID and sends an inquiry to the controller for the rear cover cutting coordinates of the TV. Once it receives the coordinates it starts cutting. After the rear cover is cut, it gets removed at *Rear Cover Removal* station. Rear cover is mostly plywood, so it is sent to a different facility for recycling. Next is the *Cleaning* station. This station does not need any communication, since it is basically a big box and high-pressure air jets. It blows air to make the dust airborne and then sucks it with a vacuum

cleaner, which is at the top of the box. Next is the manual disassembly section, which has three identical *Manual Disassembly* stations. Workers separate parts, which have material value and/or that need to be taken away to increase the purity of materials for recycling. Once the PCBs and such parts are separated, CRT is ready to be taken away. If the TV is a first time model, it stops at the *CRT Mounting Screw Identification* station (second teaching station). A worker with coordinate measurement machine records the locations of the screws and sends it to the Controller. If the TV is a known model, then it goes to *CRT Mounting Screw & Electron Gun Removal* station. At this station the screws are removed and a fast vibrating metal rod destroys the electron gun. CRT and Front panel are removed at the next station. This station needs the CRT and Front Panel holding coordinates from Controller. Front panel is sent to a different facility for materials recycling. CRT goes to CRT disassembly plant and TV disassembly line ends here. Figure 1 shows the schema of the disassembly line and processing times of stations can be seen at table 1.

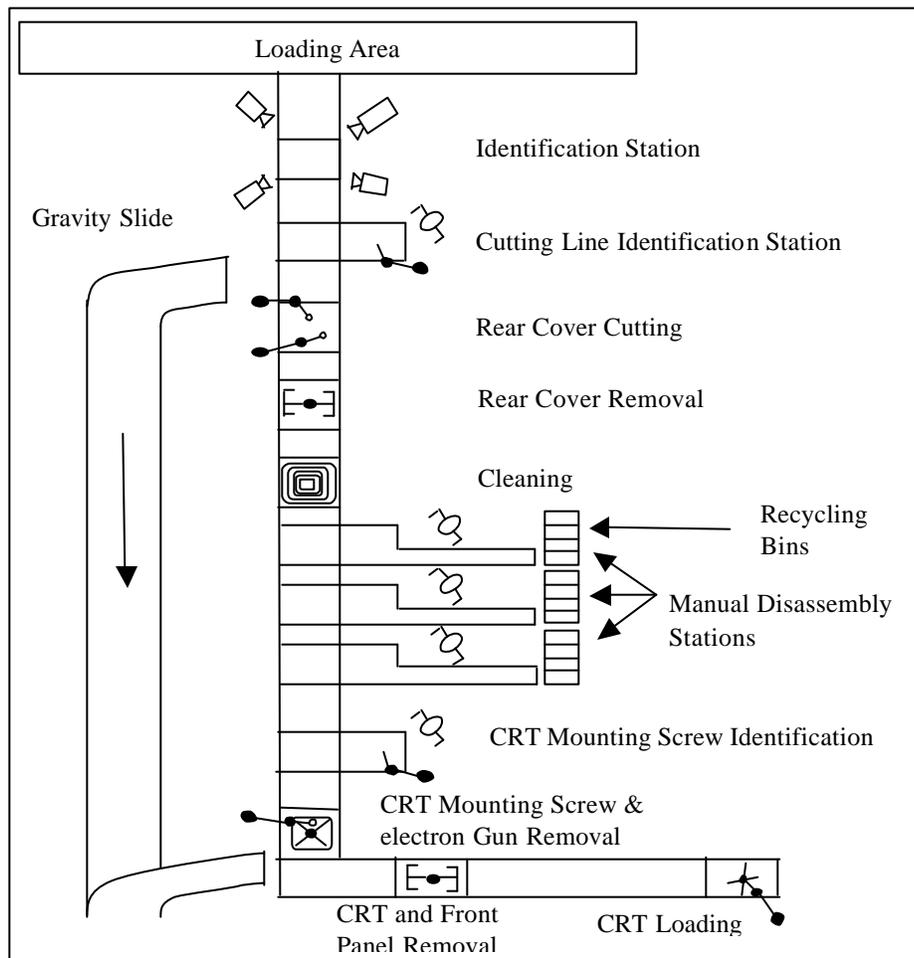


Figure 1: Schematic of one of two parallel TV Disassembly Lines

The schematic diagram of the communication system is given in Figure 2. The token ring network protocol uses a unique sequence of 24 bits (token) to synchronize the communication of the nodes over the network. A node which has a message to send can send the message only when it has the token. Network monitor node assures that there is only one token circling on the line. This setting guarantees that only one message is being sent at any given time.

Each node can hold the token for a set amount of time, which is known as the *maximum token holding time* (MTHT). During that time the node can send as much information as it has or what line can transfer in that time period. Therefore the frame size is not restricted in token ring however the MTHT is restricted. Network administrator can adjust this value to be able to fine tune the network according to the communication characteristics of the nodes on it.

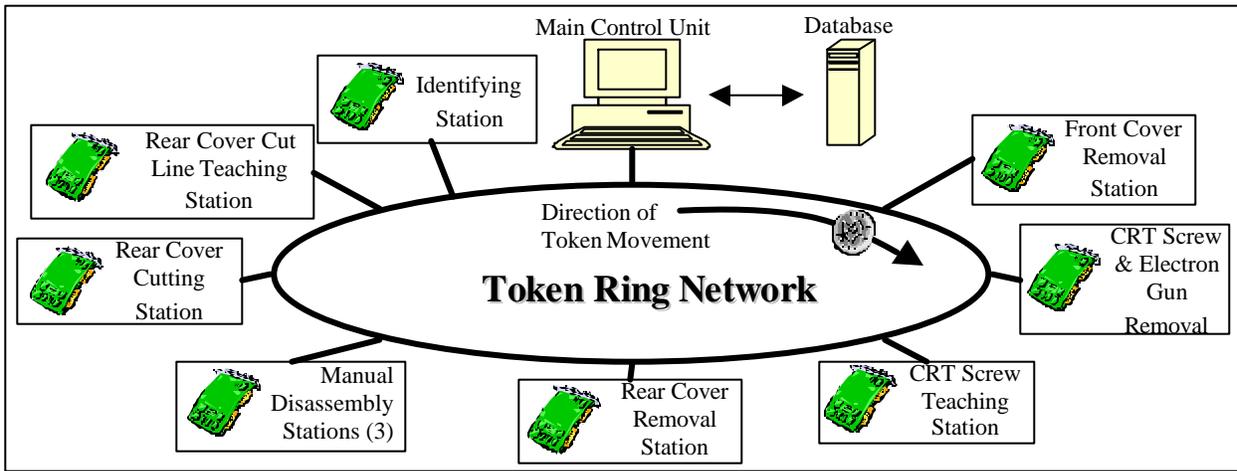


Figure 2: Communication System

The following in the relevant data for the specific example studied in this paper:

- The arrival rate of TVs is normally distributed with a mean of 24 sec and standard deviation of 2 sec.
- There are 12 stations in each line.
- Speed of the conveyor is 30 feet per minute. Each pallet takes up 3 feet of conveyor length. There has to be a minimum of one foot distance between any two pallets on the conveyor.
- Operation times and the communication data of the stations are given at Table 1.

Table 1: Operation times and communication data of stations

Stations	Operation Time			Data
	Distribution	Mean	Std Dev	
Identification	Normal	25 sec	4 sec	234 KB
Cut Line Teach	Normal	36 sec	4 sec	2.41 KB
Cut Rear Cover	Normal	36 sec	5 sec	2.31 KB
Remove Rear Cover	Normal	18 sec	2 sec	2.31 KB
Clean	Normal	29 sec	2 sec	-
Manual Disassembly (3)	Normal	68 sec	7 sec	8.15 MB
CRT Screw Teach	Normal	37 sec	4 sec	2.31 KB
CRT Screw & Electron Gun Removal	Normal	36 sec	4 sec	2.31 KB
CRT & Front Cover Removal	Normal	23 sec	4 sec	2.31 KB
CRT Load	Normal	15 sec	2 sec	-

SIMULATION METHODOLOGY

ARENA simulation software was used to simulate the disassembly line and the information network. The simulation program was divided into two parts, viz., modeling part and the experimental part. The modeling part is used to describe the physical elements and their logical interactions with each other as well as with the entities moving in the system. Experimental part is used to define the experimental conditions (inter-arrival rate, service time, length of the conveyor, etc.). This makes changing the experimental specifications easy as only experimental part needs modification [7], [8].

Following is a brief description of the modules used in the simulation. A schematic representation of the simulation model and its modules are shown in Figure 3.

Used TV module initializes and feeds TVs to the line with statistical arrival rates. *Conveyor module* is responsible for transferring of TVs to the correct station and the time delay that would occur during transfer. *Station Module* introduces station operation delays and sequence of communication with the controller. *Network Module* assures the correct transfer of communication packets and token on network and proper allocation of network resources.

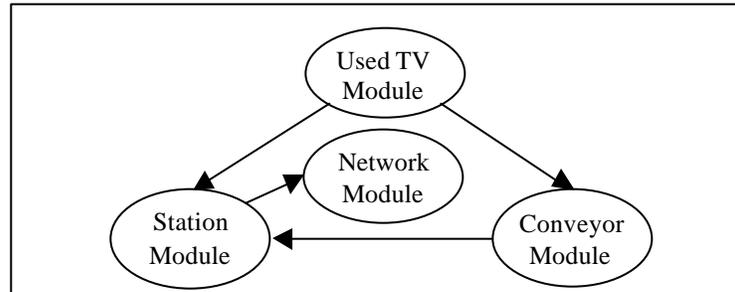


Figure 3: Schematic representation of the simulation model

Following assumptions have been incorporated in the simulation model:

- Operation times of the stations are normally distributed.
- There are always TVs to be disassembles at the loading deck.
- Message processing times are negligible comparing to the network delivery times.
- No ID reading errors occur.
- 60% of the TVs coming in are new to the system so they have to be identified [4].

RESULTS AND ANALYSIS

We focused on four network speeds, viz., 4 Mega bytes per second (Mbps), 16 Mbps, 100 Mbps & 1 Giga bytes per second (Gbps) [9], [10]. The model was simulated 30 times for each setting with two different frame sizes. This gave us dependable insight into the performance of the overall system. Figure 4 shows the delay caused by the communication system.

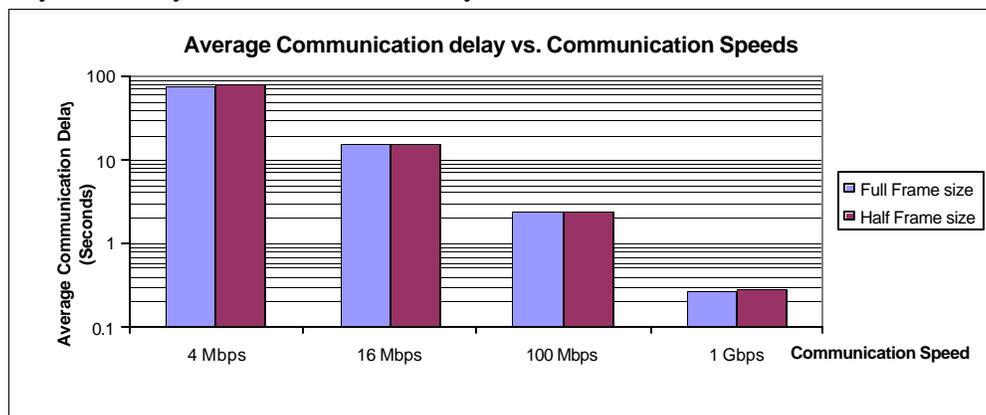


Figure 4: Average Communication Delay vs. Frame Sizes for four different transmission rates

As can be seen from Figure 4, 4Mbps speed causes a delay of 75 seconds in the processing of one TV. Considering that the average flow time of a TV is 510 seconds. 75 seconds is a significant delay caused just by the communication network. Furthermore, it can also be observed that 16 Mbps causes a delay of

about 15 seconds, which is about 3% of overall average flow time. This delay is just over the acceptable level of 1% delay. Results obtained from 100 Mbps and 1 Gbps network speeds are 0.4% and 0.04% of the overall flow time respectively. These results are comfortably within the acceptable level.

Equipment costs of 4 and 16 Mbps networks are same because majority of the equipment is compatible with both speeds. Equipment cost of building a network with either speed for this disassembly line would be around \$2400. On the other hand same cost for a token ring network of 100 Mbps speed would be around \$6000. Even though, the IEEE standard for 1Gbps token ring network [10] is ready, it failed to gain popularity in the industry. Therefore, the equipment and the expertise to build a 1Gbps token ring network are difficult to find besides being expensive.

CONCLUSIONS

This paper suggested that network performance in a disassembly line should be considered when examining the performance of the overall system. To support this, a case example consisting of a TV disassembly plant together with its network system was examined. The paper examined the effects of different token ring network speeds and frame sizes on the overall system performance. This technique of integrating both the plant and communications operations in one model is better in providing realistic performance prediction.

REFERENCES

- [1] Gungor, A. and Gupta, S. M., "Issues in Environmentally Conscious Manufacturing and Product Recovery: A Survey", *Computers and Industrial Engineering*, Vol. 36, No. 4, 811-853, 1999.
- [2] Lambert, A. J. D. and Gupta, S. M., "Disassembly Modeling for Assembly, Maintenance, Reuse, and Recycling", CRC Press, Boca Raton, Florida, ISBN: 1-57444-334-8, 2005.
- [3] Gungor, A. and Gupta, S. M., "Disassembly Line in Product Recovery", *International Journal of Production Research*, Vol. 40, No. 11, 2569-2589, 2002.
- [4] Wang, Q., Chatwin, C. R., Geha, A., Young, R. C. D. and Budgett, D. M., "Modelling and Simulation of Integrated Operations and Information Systems in Manufacturing", *International Journal of Manufacturing Technology*, Vol. 19, 142-150, 2002.
- [5] Bartlett, H. and Harvey, J., "The Modelling and Simulation of a Pick and Place Computer-Integrated Manufacturing (CIM) Cell", *Computers in Industry*, Vol. 26, 253-260, 1995.
- [6] Hirasawa, E., "Recycling Plant for Home Electric Appliances", *Mitsubishi Electric Advance*, Vol. 87, 7-11, Sep, 1999.
- [7] Hoover, S. V. and Perry, R. F., "SIMULATION, A Problem Solving Approach", Addison-Wesley Publishing, 1990.
- [8] Pegden, C. D., Shannon, R. E. and Sadowski, R. P., "Introduction to Simulation Using SIMAN 2nd Edition", System Modeling Corporation, McGraw-Hill, 1995.
- [9] IEEE Std 802.5, "Token Ring Access Method and Physical Layer Specifications", 1998.
- [10] IEEE Std 802.5v, "Part 5: Token Ring Access Method and Physical Layer Specifications. Amendment 5: Gigabit Tokenring Operation", 2001.