DISCRETE EVENT MODELING IN A NEW TRANSPORTATION SIMULATION

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ABSTRACT

This demonstration session will summarize the development a new service based transportation simulation as utilized by the Business Departments at Geneva College and Anderson University. The goals of this session are to present discrete event modeling as a valid business simulation technique and to introduce to current business professors, and/or interested individuals, a new service based simulation. This simulation seeks to model the decisions made by managers of a small trucking firm. It is hoped that this session will help attendees assess the benefits and challenges associated with using a service based simulation.

INTRODUCTION

This paper looks at discrete event modeling as applied to a new transportation simulation. Transportation companies schedule trucks for hauling loads based on availability. This simulation models ten small trucking firms that deliver various products to the marketplace. Nine teams are controlled by the computer and one team is played by the user. Each team begins with different cargo types (consists) but may branch out as the simulation progresses.

DISCRETE EVENT MODELING

In discrete event models, discrete entities change state as events occur in the simulation. Incoming orders, parts being assembled, and customers arriving are examples of discrete events. The state of the model changes only when those events occur; the passing of time has no direct effect. A factory that assembles parts is a good example of a discrete event system. The individual entities (parts) are assembled based on events, i.e. receipt of orders, machines available, etc. The time between events in a discrete event model is seldom uniform.

Discrete event modeling uses a clock to move a set of entities along a timeline. While an entity moves along the timeline it encounters various events. Each event causes the state of the entity to change. Figure 1 depicts such a timeline with four events that affect Entity A. Entity A begins at event start at clock time 0. At clock time 2, Entity A begins activity 1. This activity takes 8 time units to complete. When event 2 occurs, at clock time 10, activity 1 is completed and Entity A continues until clock time 20 when event 3 takes place. Activity 2 begins with event 3 and continues until event 4 at clock time 35. Activity 2 takes 15 time units to complete. At clock time 50, Entity A has completed all processing, and event end occurs.

In discrete event modeling, each entity must know which event is next and the time it begins. Each activity encountered takes a finite amount of time to complete. Figure 2 shows the values of the simulation variables (clock, next time, and next event) for Entity A as it is moved down the timeline described in Figure 1. For example, the clock variable is set to 0, next event is set to 1 and next event is set to 2 at the start of a simulation run. Upon reaching time 2, the clock is set to 2, next event is set to 2 and next time is set to 10.

Figure 1 Example Timeline

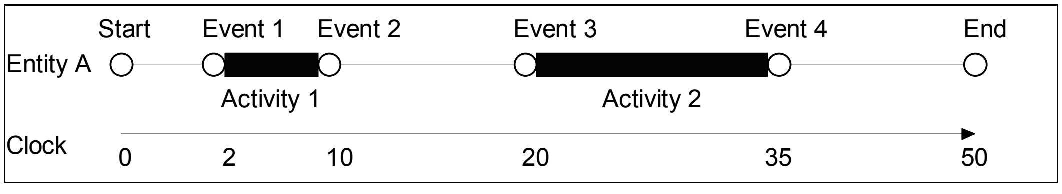
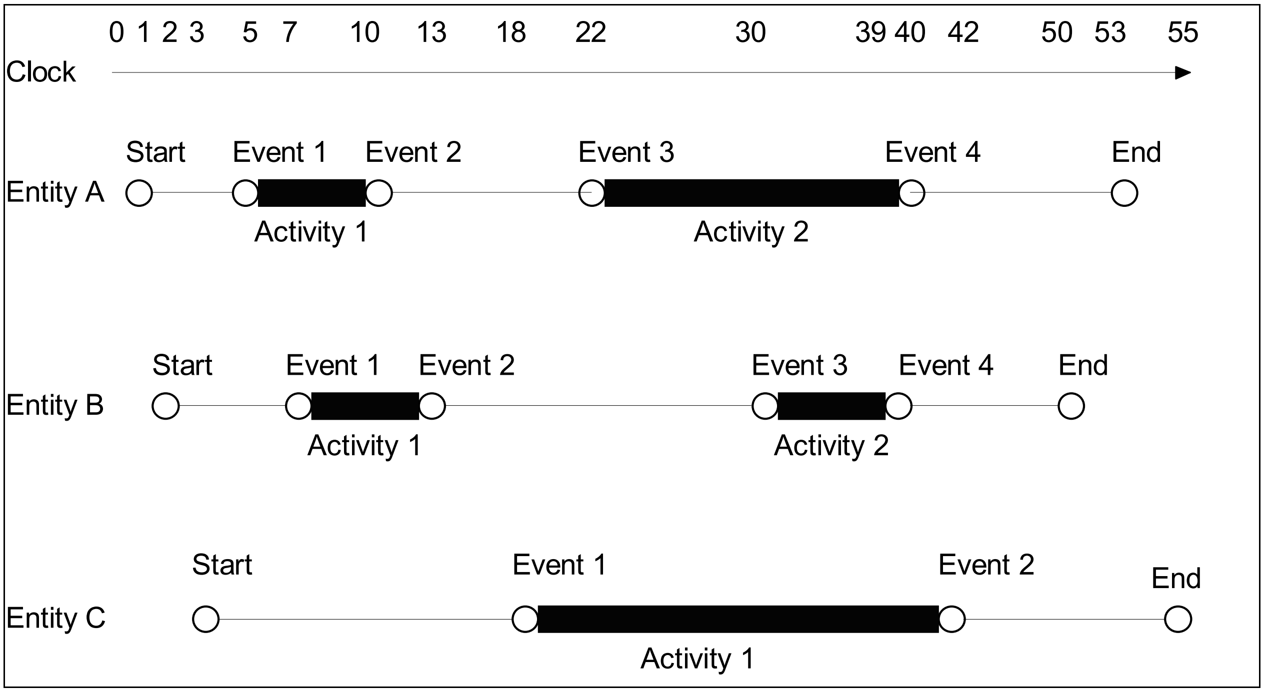


Figure 2 Values of Simulation Variables for Example Timeline

Clock	Next Event	Next Time
0	1	2
2	2	10
10	3	20
20	4	35
35	End	50
50		

Figure 3 Multiple Entity Example



With multiple entities, each entity is started and moved down the timeline. As the clock advances, the simulation must know which entity has an event occurring next on the timeline. This requires a check of all entities and the activities to be performed, after each advance of the clock. Figure 3 displays an example of multiple entity coordination. . There are three entities (A, B, C) in this example that start and change state several times before reaching the end of their respective advances down the timeline. Each entity is coordinated by the master clock that represents the system time.

Figure 4 summarizes the necessary information to run the first seven steps of the example shown in Figure 3. To begin the run, the clock starts at time 0 and knows it must advance to time 1 to start Entity A. When it reaches time 1 and Entity A is started, the clock looks to the next event and time, which is start Entity B at time 2. When the clock reaches time 2 and Entity B is started, the clock sees that the start event for Entity C at time 3 is next. This process continues until the clock has reached the end of the timeline.

TRANSPORTATION SIMULATION

BusSim® Transport and BusSim® Supply model a small trucking firm that delivers various products to the marketplace. Each truck belonging to the firm transports a specific product from producer to market continuously over a three month period. Each truck is subjected to a series of events as it travels between producer and market. Some events are deterministic, that is they are determined by the player of the simulation, while other events are uncertain and controlled by probabilistic outcomes.

Figure 5 shows the timeline (clock) and events modeled in these simulations. The dimension of the clock is in hours and shows there are 520 hours simulated each quarter. Trucks begin at their assigned terminal and move to their scheduled producer. All travel times and speeds are determined by the driver of the truck and the distance to the next event. After arriving at the producer the truck takes on its cargo. The load time varies. The truck then travels to the scheduled market and unloads its cargo. During any

Figure 4 Multiple Entity Simulation Variables

Clock	Next Event	Entity	Next Time
0	Start	A	1
1	Start	B	2
2	Start	C	3
3	1	A	5
5	1	B	7
7	2	A	10
10	2	B	13

Figure 5 Transportation Simulation Events

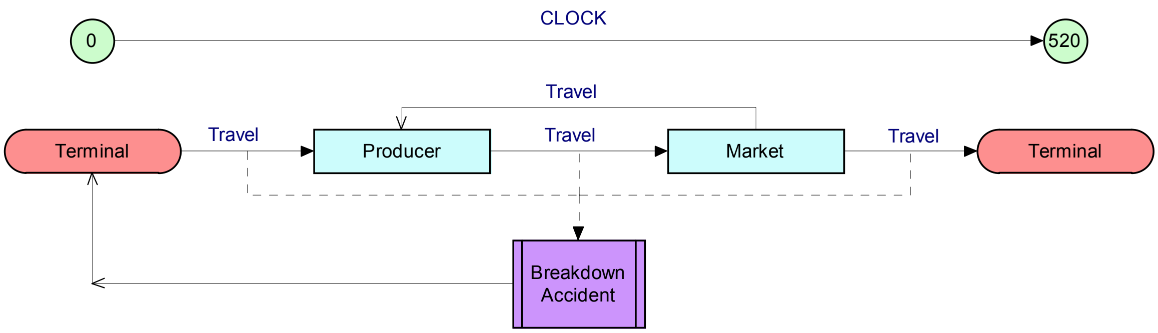


Figure 6 Chance Events

Event	Likelihood	Lost Time	Cost
Accident	Safety Rating	1 - 4 Days	1,000 - 50,00
Terminal Breakdown	Prev Maint	1 - 2 Days	500 - 10,000
Road Breakdown	Prev Maint	4 - 12 Hrs	100 - 5,000

travel activity, the truck may experience a chance event. Three chance events, each with different outcomes, costs and final locations, are modeled in this simulation. Figure 6 summarizes these chance events. When the trucks complete as many runs as possible in the quarter, they return to their respective terminals where other activities, such as preventive maintenance, may occur.

In BusSim® Transport ten teams with similar goals compete within a single industry. Nine teams are controlled by the computer and one team is played by the user. Each team begins with different cargo types (consists) but may branch out as the simulation progresses. For example, the user's team begins with five trucks each hauling chemicals to five different markets. As play progresses, the user's team may decide to haul fuel and purchases the appropriate equipment. Up to five trucks may be assigned to each producer/market route. Figure 7 shows the list of producers and their products that may be purchased and transported by any firm.

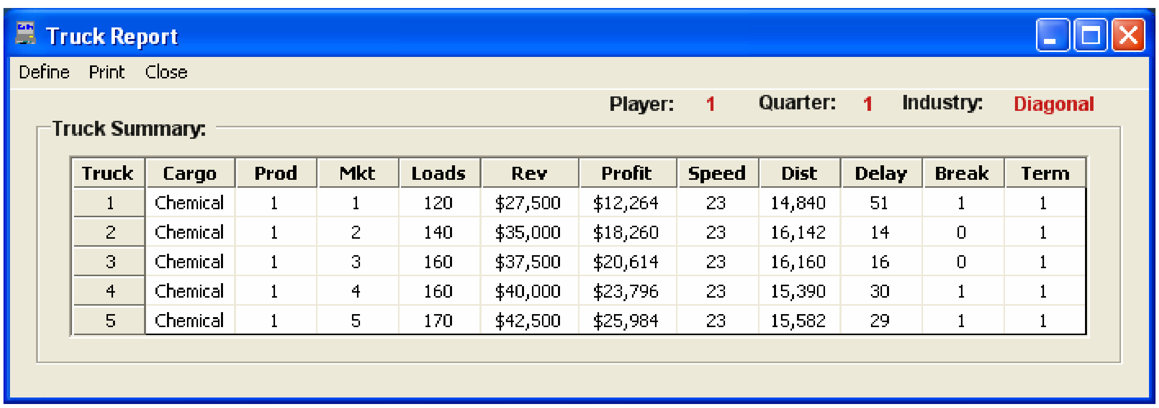
Figure 8 displays an example of one of the most important reports in this simulation. It shows the results for each truck that transports goods from producer to market. Information displayed includes cargo type, producer, market, loads delivered, revenue generated, truck profit, speed of advance, total distance traveled in miles, delay time in hours, number of breakdowns and the home terminal for each truck.

A demonstration of this simulation will take place during the annual conference. We will also present some spreadsheet tools that are provided to the students in their analysis.

Figure 7 Producer Data

Producer	Product	Capacity	Price	Location
1	Chemicals	1,600	$1,250	0
2	Fuel	2,500	$2,700	11
3	Steel	1,200	$4,600	22
4	Lumber	2,000	$750	33
5	Grain	2,500	$400	44
6	Autos	1,500	$19,650	55
7	Dairy	3,000	$600	66
8	Meat	3,000	$650	77
9	Produce	2,500	$500	88
10	Goods	3,000	$950	99

Figure 8 Example Truck Report



Truck	Cargo	Prod	Mkt	Loads	Rev	Profit	Speed	Dist	Delay	Break	Term
1	Chemical	1	1	120	$27,500	$12,264	23	14,840	51	1	1
2	Chemical	1	2	140	$35,000	$18,260	23	16,142	14	0	1
3	Chemical	1	3	160	$37,500	$20,614	23	16,160	16	0	1
4	Chemical	1	4	160	$40,000	$23,796	23	15,390	30	1	1
5	Chemical	1	5	170	$42,500	$25,984	23	15,582	29	1	1