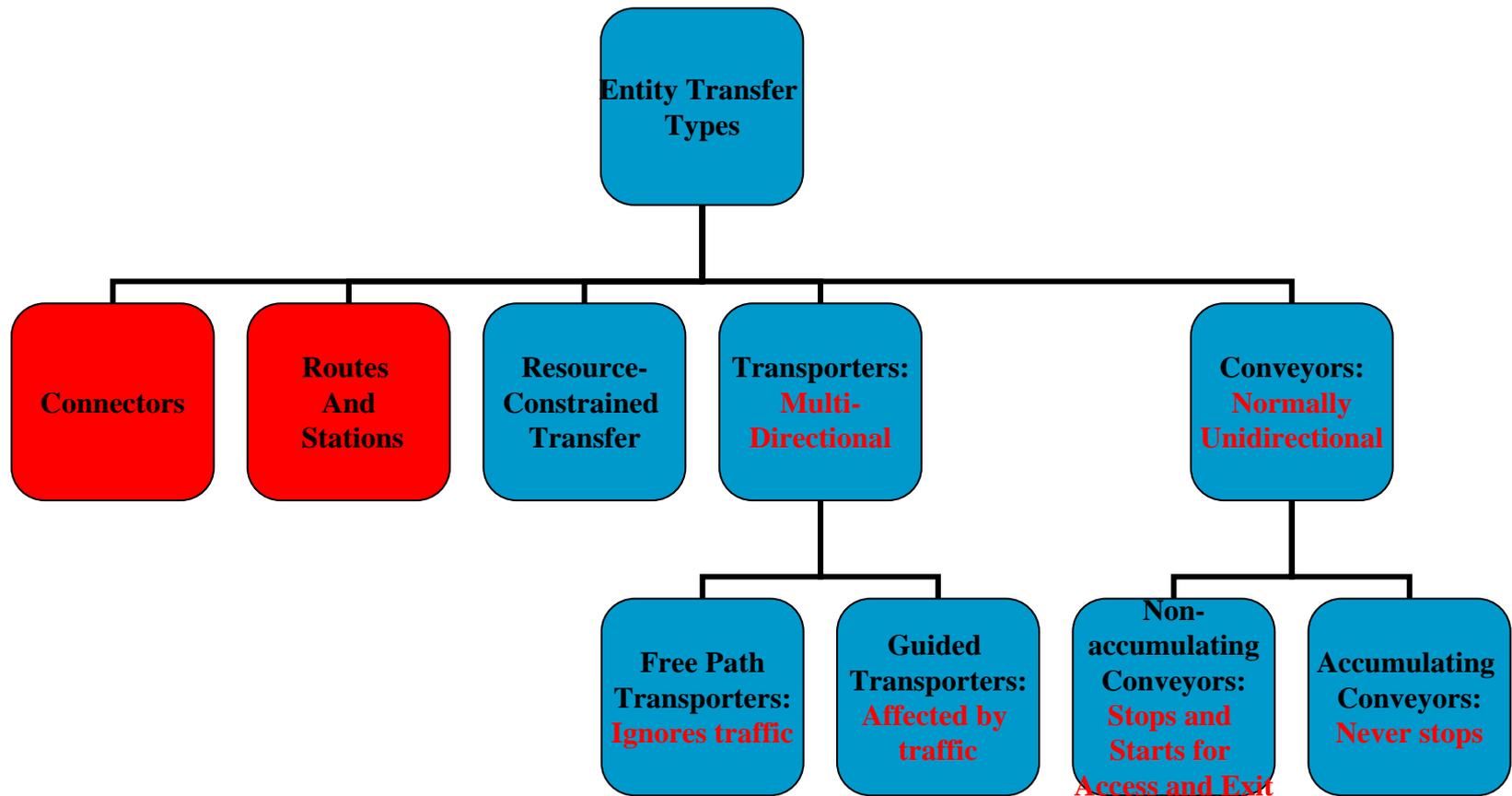


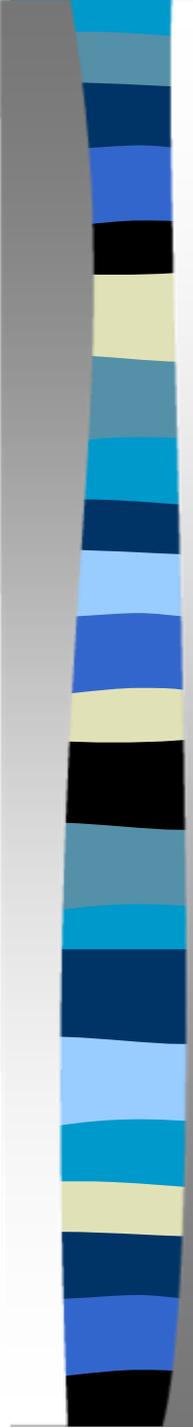
Systems Modelling and Simulation (Lab session 5-3)

After this session you should understand

- Modelling multiple process plans for different parts.
- More on entity transfer

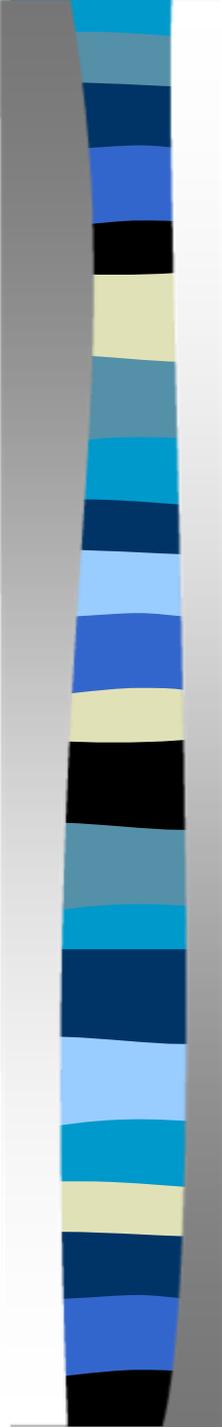
Overview of Entity Transfer Types





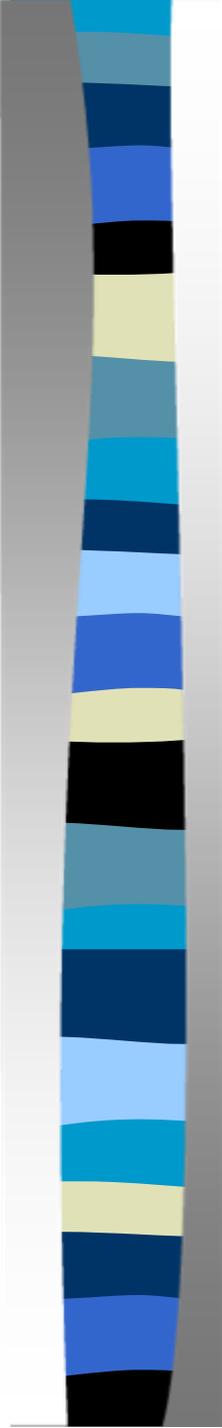
Entity Transfer types so far

- Connect – No Delay
- Routes
 - Delay
 - Direct route or entity sequence
 - **Limit less**
- Entities move along system by themselves



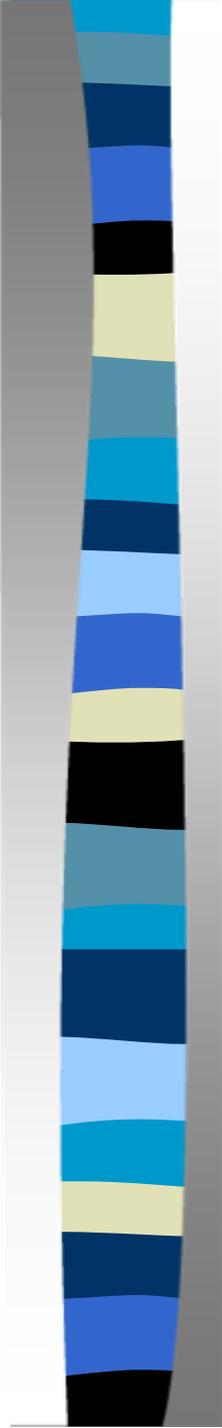
New Entity Transfer Type

- ***Resource-constrained*** transfers
 - Limit total number of entities in transit at a time
 - Examples: Health care (Patients walk-in), Telecommunications (number of packets), Logistics (number of vehicles)
- Material-handling devices
 - ***Transporters (multi-Directional)***
 - Examples: AGVs, fork lifts, trucks, carts, cranes, etc
 - Limited number of entities, capacity of transporters
 - *Like a Resource, except moveable*
 - ***Conveyors (Normally unidirectional)***
 - *Belts, hook lines, escalators*
 - *Usually limited space on conveyor, speed*
 - *Non-accumulating vs. accumulating*



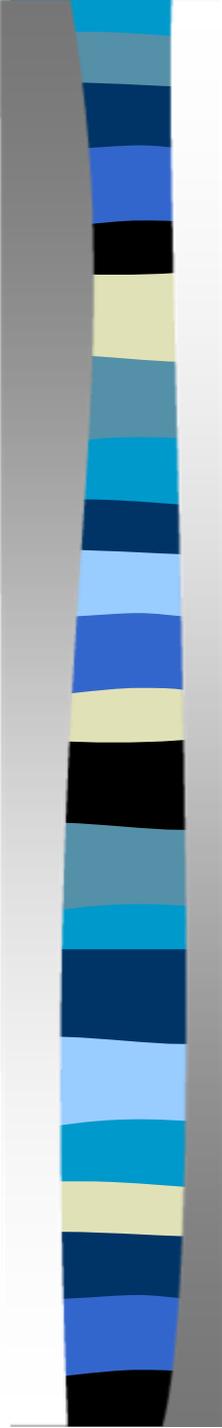
Model 8-1: Small Manufacturing System with Resource-Constrained Transfers

- Upload (Model 7-1)
 - Assumed all transfer times = 2 minutes
 - No limit on number of parts in transit at a time
- **Change**— no more than 2 parts can be in motion at a given time
 - If other parts are ready to go, they must wait until there's room to go
- Model via existing constructs
 - **Model; imagine a road with**
 - *Limited number of Units that can seize the road (resource) at beginning of trip*
 - *Release it at end of trip*



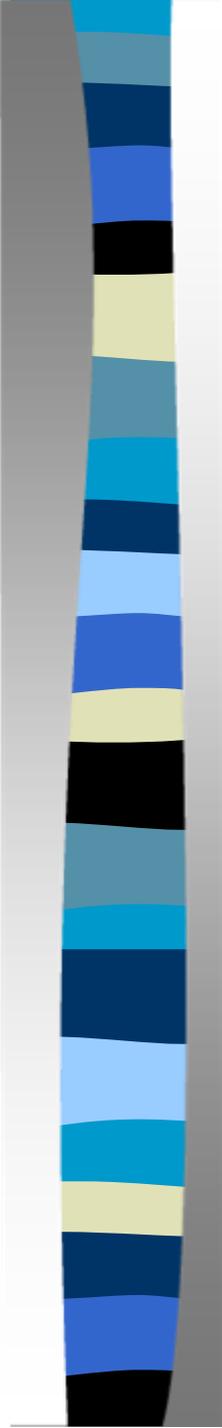
Changes to Model 7-1

- Replace *Route* with *Leave* (Adv. Transfer Panel)
 - **Transfer out : Seize Resource** (Transfer)
- Replace *Station* modules with *Enter* modules (Adv. Transfer panel)
 - **Defines the Station**
 - **Transfer In: Release** Transfer **resource**
- Run model compare with 7-1 slight changes in WIP and Cycle Times



Transporter Concepts

- Entity is ready to move from point A to Point B, it needs to be “picked up” and moved
- Use *Transporters* — “moveable” resources
- Activities: *Request*, *Transport*, *Free*
 - **Transporter Selection Rule: If > 1 transporter is available when Requesting**
 - **When freed and > 1 entity is waiting: Priorities, closest one**
- Two types of Transporters
 - ***Free-Path*** (we’ll do)
 - *Travel time depends only on velocity, distance*
 - *Ignore “traffic jams” and their resulting delays*
 - ***Guided*** (won’t do)
 - *AGVs, intersections, etc.*

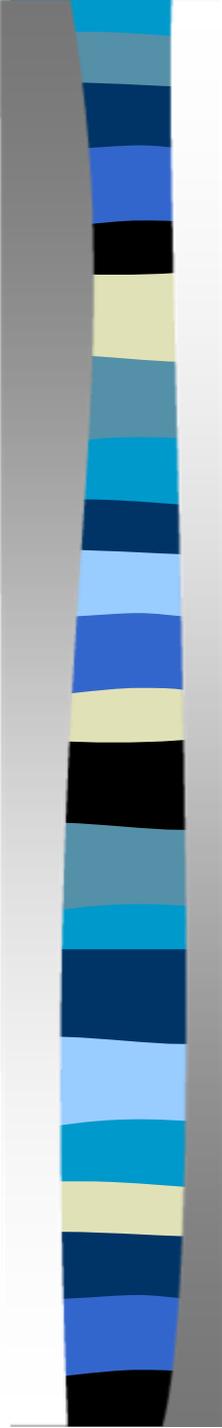


The Small Manufacturing System with Transporters

- There are two carts for transporting parts
 - A cart can carry one part at a time
 - Carts move at **50 feet/minute**
 - *Will need to specify accurate distances between Stations*
 - It takes **0.25 minute to load part on a cart, 0.25 minute to unload it from a cart**
- Modify Model 8-1 to Model 8-2

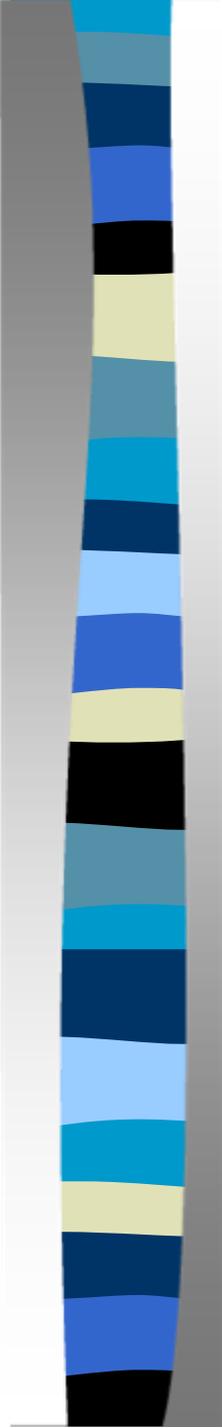
The Small Manufacturing System with Transporters (cont'd.) 8-2

- Create Transporter in Transporter data module (Advanced transfer panel)
 - **Name = Cart, Capacity = 2, Velocity = 50**
 - **Default the Distance Set (later), Units = Per Minute, Initial Positions**
 - **Mind the units**
 - *Animation picture for Cart Transporter*
 - **Transporter button (Animate Transfer toolbar)**
 - **Identifier = Car  pictures for Idle, Busy, Inactive states**



The Small Manufacturing System with Transporters (cont'd.)

- Request a Cart – modify existing Leave modules
 - **Delay = 0.25 Minute for load time**
 - **Transfer Out = Request Transporter**
 - **Transporter Name = Cart**
 - **Selection Rule = Smallest Distance**
 - *Applies when > 1 transporter is available*
 - *Others: Cyclic, Random, Preferred Order, Largest Distance*
 - *Save Attribute = **Cart #***
 - *Connect Type = **Transport***
 - *Move Time disappears ... determined by Velocity, Distances (later)*
 - **Station Type = Sequence**
- Instead of Leave: Request-Delay-Transport
 - **More complex, more flexible – book has details, examples**



The Small Manufacturing System with Transporters (cont'd.)

- Free the Cart – modify existing Enter modules
 - **Delay = 0.25 Minute for unload time**
 - **Transfer In = Free Transporter**
 - **Transporter Name = Cart**
 - **Unit Number = Cart # attribute of part entity**

Distances for Transporters

- Define contents of Distance Set `Cart.Distance`
- Distances (in feet) moved by parts:

	Cell 1	Cell 2	To Cell 3	Cell 4	Exit System
Order Release	37	74			
Cell 1		45	92		
Cell 2	139		55	147	
Cell 3				45	155
Cell 4		92			118

Units!!

- **Blank cells: part movements that don't occur**
- Enter these data in Distance data module (Advanced Transfer panel)
 - **Name = `Cart.Distance`**
 - **Stations button, add 11 rows with Beginning Station, Ending Station, Distance for above data**
 - **Direction is implied; could be asymmetric**

Animating Transporter Movement

- Add distances to animation
- Delete all the old Route Path animation objects
 - **But leave the Station animations**
- Add animated transporter distances with Distance button 
Animate Transfer toolbar
 - **Dialog, placement similar to Route Paths**
 - **Identifier = `Cart.Distance`**
 - **Click in Beginning Station marker, intermediate clicks, Ending Station marker**
 - **Options for Rotate, Flip**
 - **Grid, Snap to help place animated transporter distances**

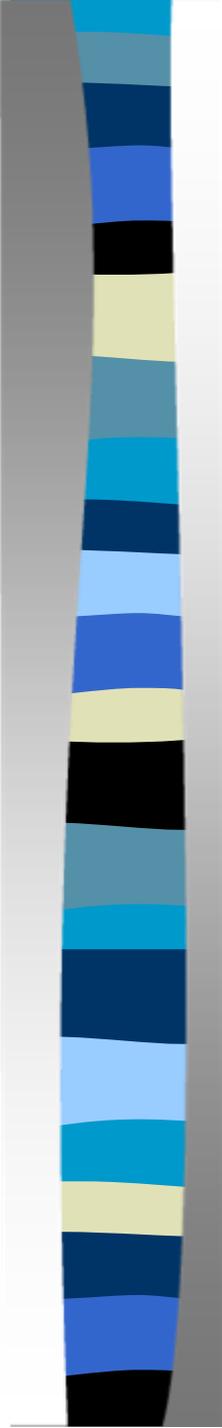
Parking Areas for Transporters

- Animate transporters when they're free
- Parking button , Animate Transfer toolbar
 - Like a Queue animation – Point vs. Line, Shift, Rotate
 - Cursor becomes cross hairs, click near lower left of Station marker to start, click for first Point or head of Line
 - More clicks for more Points (double-click to end), or second click to end Line
 - Want enough points/space for all transporters (2 here)
 - Repeat for all Stations where Transporters could be freed

More Distances — Empty Transporters

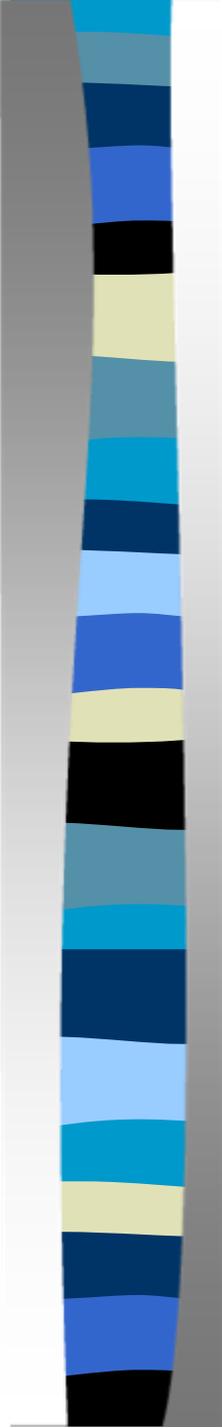
- Above Distances incomplete — only for part movements along their sequences
- Transporters must also move when empty
 - **In general, $n(n - 1)$ distances need definition for network with n nodes**
- more distances to define in Distances data module (not grayed):

		To					
		Order Release	Cell 1	Cell 2	Cell 3	Cell 4	Exit System
From	Order Release		37	74			
	Cell 1	155		45	92	129	
	Cell 2	118	139		55	147	
	Cell 3	71	92	129		45	155
	Cell 4	34	55	92	139		118
	Exit System	100	121	158	37	74	



Conveyor concept

- Entity is ready to move from point A to Point B, it needs to Access a conveyor, be conveyed then exit.
- Requires conveyor segments to be defined.
- Activities: *Access, Convey, Exit*
- Two types of Conveyors
 - ***Non-accumulating (we'll do)***
 - *Starts and stops for Access and Exit*
 - *Spacing between entities traveling on Conveyor constant*
 - ***Accumulating (won't do)***
 - *Never stop moving*
 - *Stopped entity blocks entities arriving at same location*
- Go to Model 8-4



Modelling Conveyors

- Resource-Constrained transfer;
 - **Seize, Route and Release**
- Transporters
 - **Request, Transport and Free**
 - **Needs Distances to be defined**
- Conveyors
 - **Access, Convey and Exit**
 - **Needs Segments to be defined**