

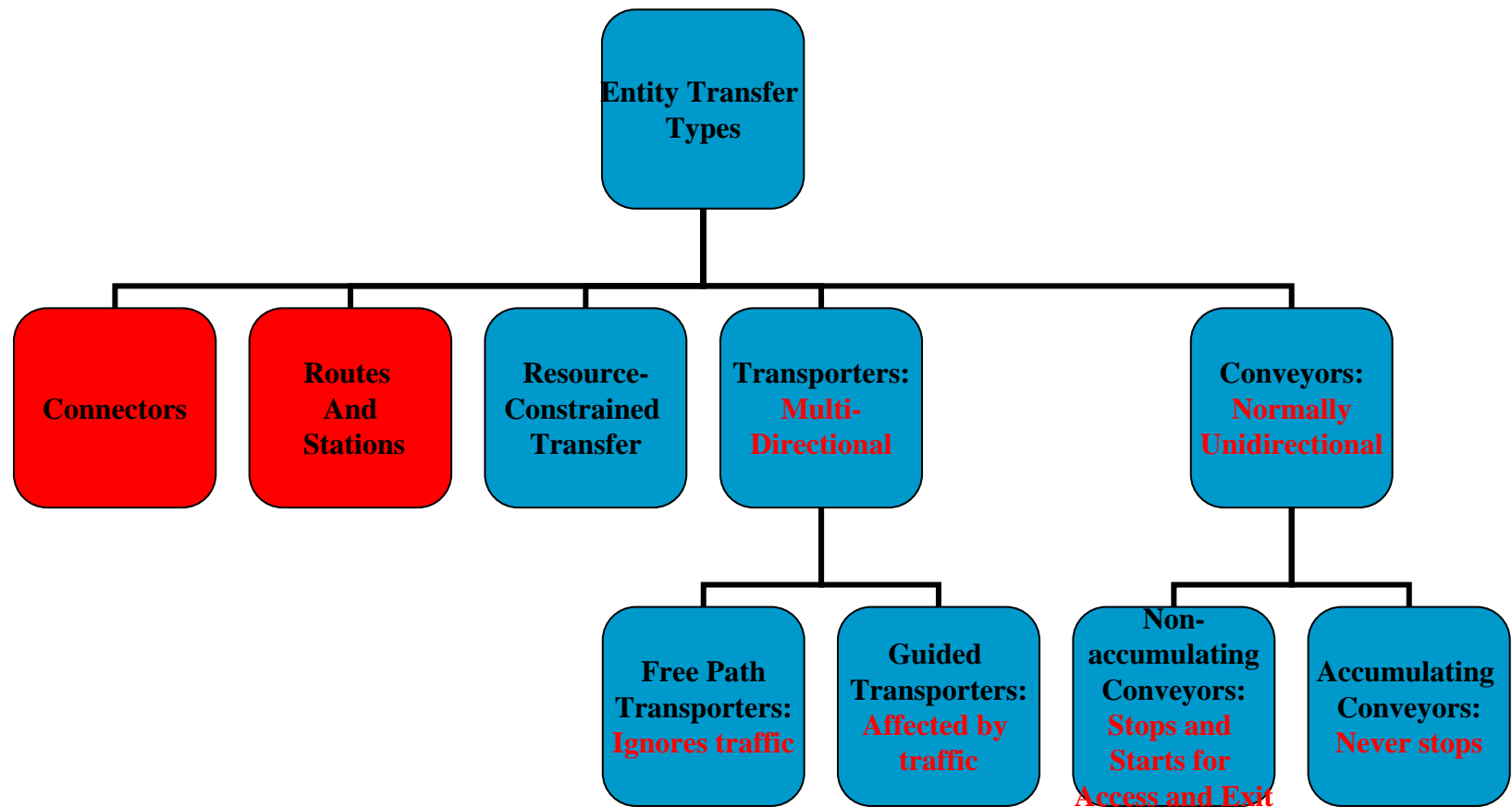
# Systems Modelling and Simulation (Lab session 6)



After this session you should understand

- Modelling multiple process plans for different parts.
- More on entity transfer
- Chapter 8 Kelton et al, Simulation with Arena – 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** = `Cart`  **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**