material handling modeling in anylogic®

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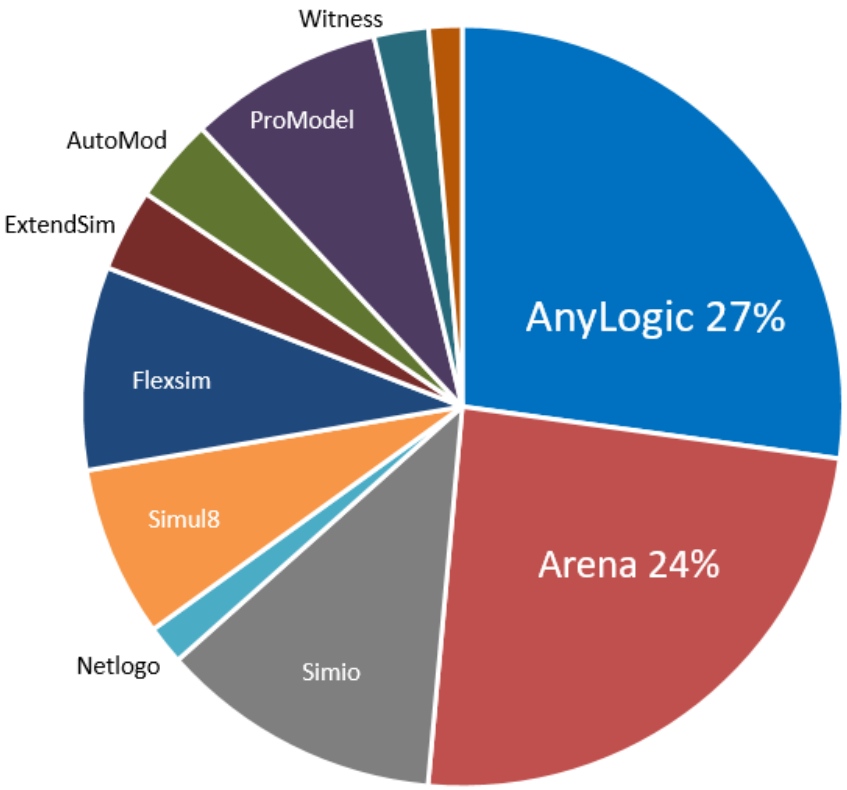
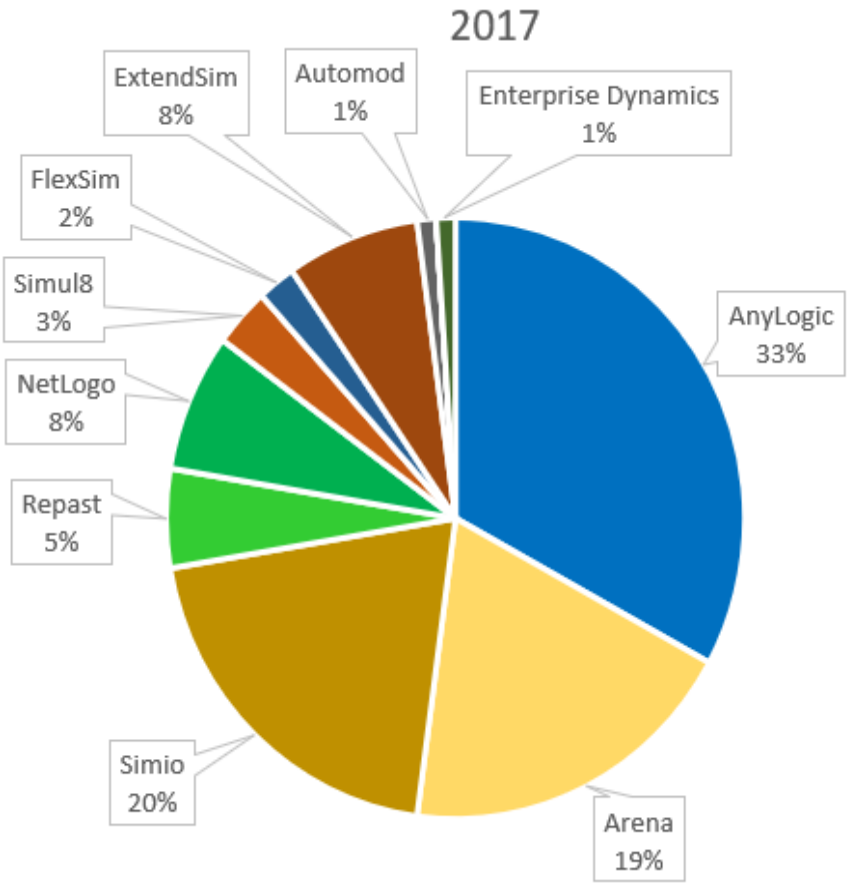
December 2017

THE AnyLogic® COMPANY

AnyLogic is the most used simulation software

- see LinkedIn user group sizes and number of WSC case studies (2017)

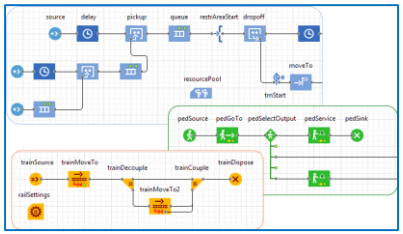


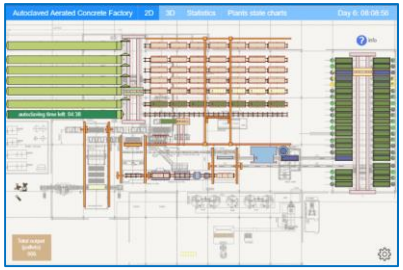


industry leaders choose AnyLogic for simulation

most of simulation tools can do this:

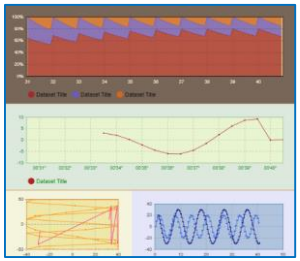
- Discrete event modeling with process flowcharts
- “Discrete rate” modeling
- Scripting in addition to drag and drop
- 2D and 3D animation
- Optimization
- Parameter variation and Monte Carlo experiments
- Built-in database
- Visualize, import and export data

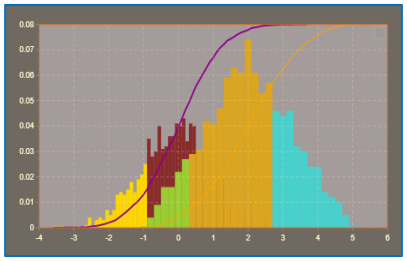




number_of_employees

	branch	employee_type	number
1	Wichita Falls	Back Office	19
2	Wichita Falls	Credit Specialist	20
3	Wichita Falls	Financial Sevices Sales	16
4	Wichita Falls	Business Development Manager	1
5	Wichita Falls	Head of Sales Group	2
6	San Antonio	DSA	1
7	San Antonio	Back Office	56
8	San Antonio	Deputy Regional Director	2
9	San Antonio	Credit Specialist	96
10	San Antonio	Financial Sevices Sales	20

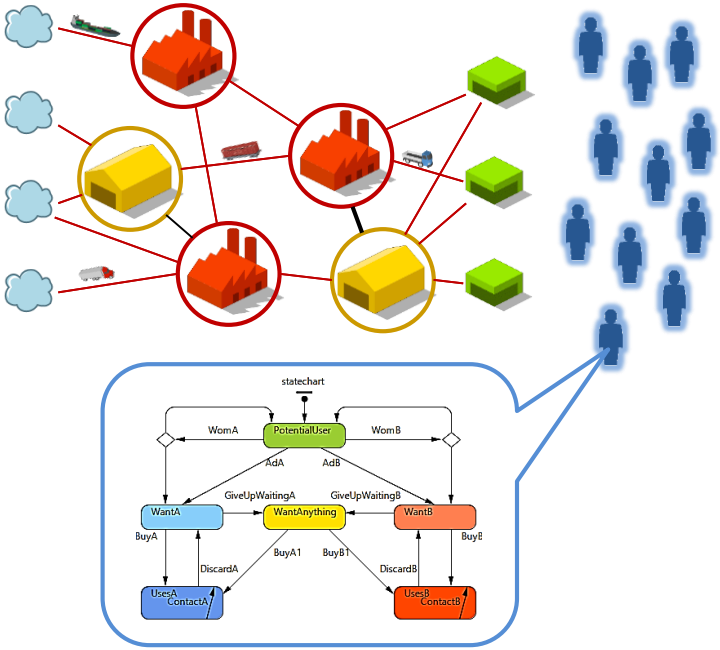




No other simulation tool can do:

- Professional agent based modeling

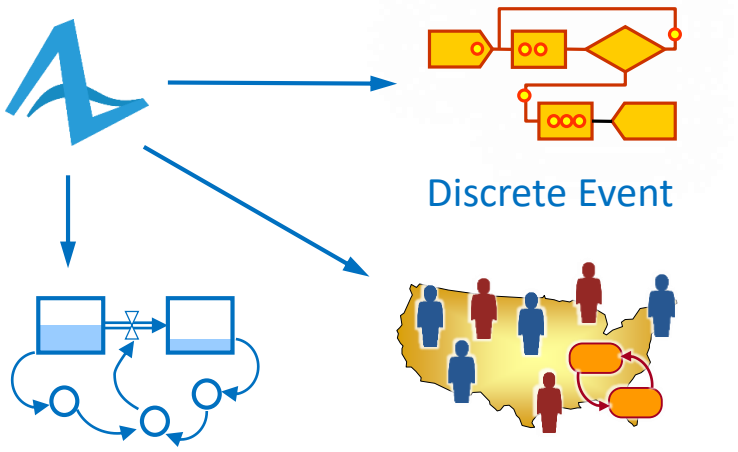
- Apply simulation in the areas where it had not been possible before, like marketing, social and ecosystems
- Bring models from traditional areas, like supply chains and manufacturing, to a new level of flexibility and accuracy



No other simulation tool can do:

- Professional agent based modeling
- Multi-method modeling

- Develop models using all three existing simulation methods in any combination to simulate systems of any complexity
- AnyLogic was the first tool to introduce multimethod simulation modeling, and still remains the only software that has that capability.



No other simulation tool can do:

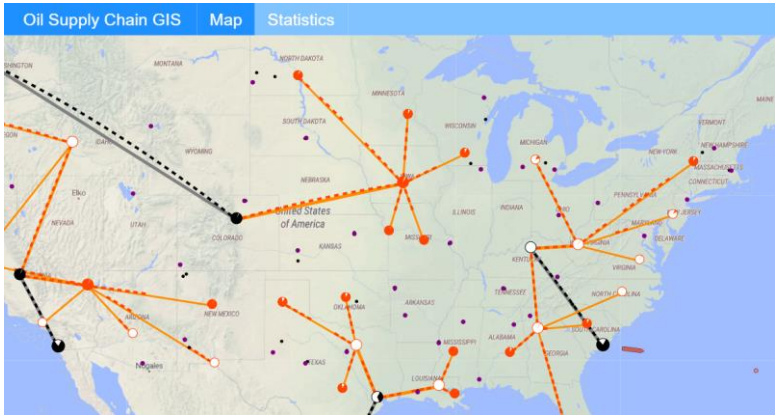
- Professional agent based modeling
- Multi-method modeling
- Industry-specific libraries

- A unique suite of industry-specific tools in one package, at no additional cost
- Process Modeling and Fluid: generic libraries for logical processes with discrete items and bulk/liquid transfer
- Pedestrian, Rail, and Road Traffic: detailed physical-level simulation of objects' movement and interaction
- Material Handling: conveyor networks, stations, AGVs, cranes, robots

No other simulation tool can do:

- Professional agent based modeling
- Multi-method modeling
- Industry-specific libraries
- GIS maps integration

- Use geographic locations
- Search for places, regions, and routes – both at design time and at runtime
- Move objects along the real routes
- Use tiles and shape files
- Choose tile and route providers

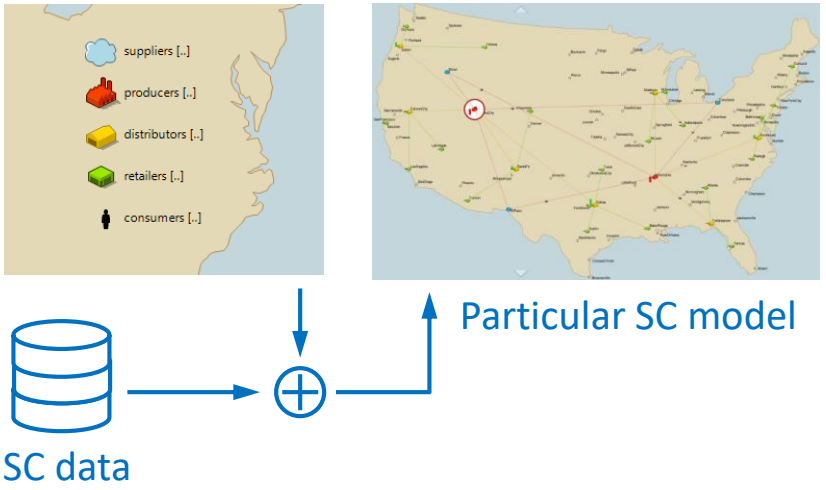


No other simulation tool can do:

- Professional agent based modeling
- Multi-method modeling
- Industry-specific libraries
- GIS maps integration
- Extension and customization

- Create reusable custom objects and object libraries for your application areas and share them with colleagues
- Create flexible models that fully configure themselves from external data source when they are run
- Build custom experiment workflows and extend models with Java

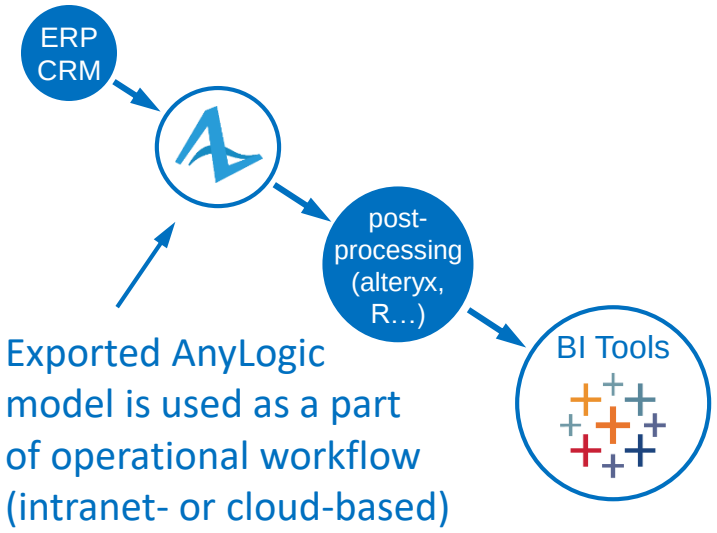
Generic supply chain model



No other simulation tool can do:

- Professional agent based modeling
- Multi-method modeling
- Industry-specific libraries
- GIS maps integration
- Extension and customization
- Model export and integration

- Export models as standalone Java applications to deliver them to clients
- Make models a part of your existing dataflow and integrate them in your operational software like ERP, CRM, MRP, or BI systems for robust planning and risk reduction



No other simulation tool can do:

- Professional agent based modeling
- Multi-method modeling
- Industry-specific libraries
- GIS maps integration
- Extension and customization
- Model export and integration
- Simulation in the Cloud

- Use any device to run your model, including phones and tablets
- Provide online simulation analytics to your clients with web dashboards
- Leverage high-performance cloud computing for complex experiments
- Deliver models privately to your clients using secure web repository
- Share simulations publicly with the community and collaborate in the cloud
- TRY IT RIGHT NOW: cloud.anylogic.com
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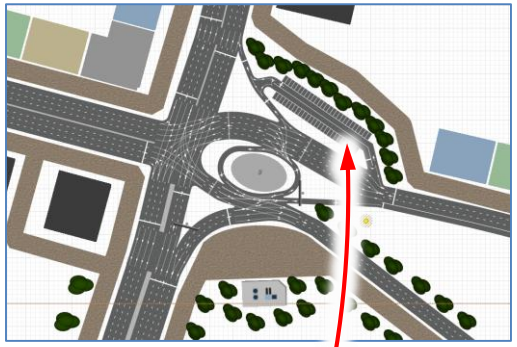
anylogic cloud

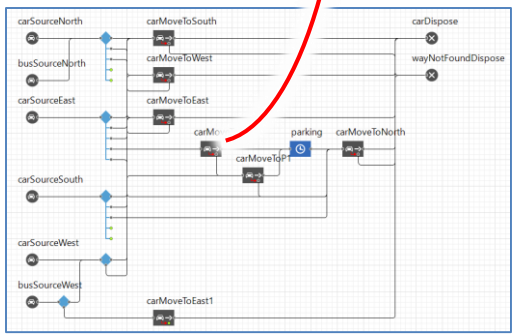
material handling

separation of logic and spatial structure in AnyLogic

- One of the fundamental principles of process modeling in AnyLogic is separation of layout (physical structure) and process logic
  - "Blocks" in the process flowchart may refer to the components of the spatial structure, which are called "markup elements"
  - In some models, e.g. Business Process, there may be very complex process flow (logic) and simple or even none layout
  - In other models (e.g. Pedestrian or Road Traffic) space markup can be very detailed and complex and actually drives the model whereas the logic can be very simplistic ("walk / drive from A to B")
  - Material Handling is definitely of the 2nd type

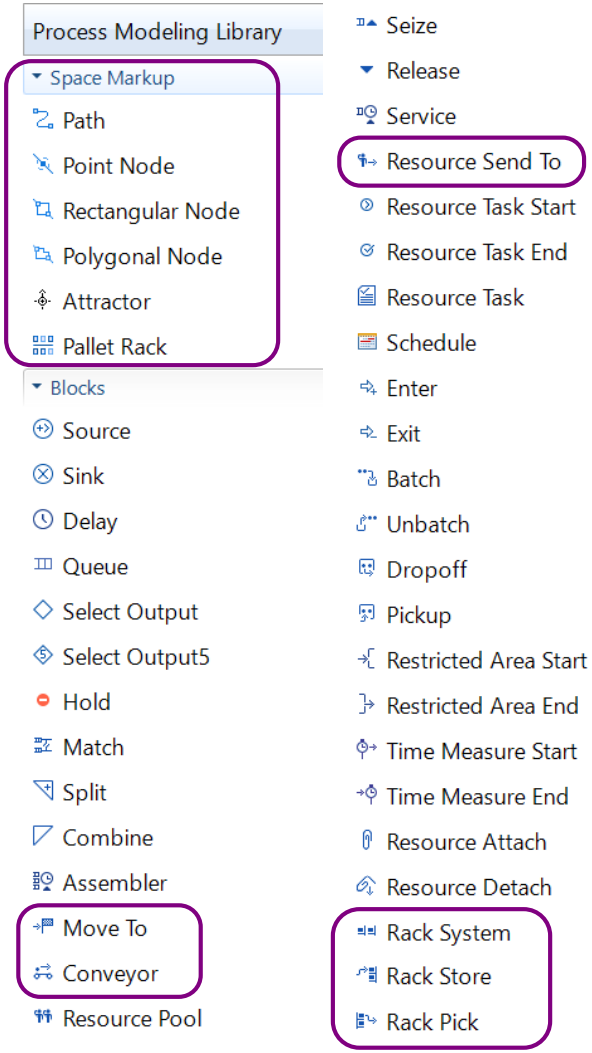


Intersection layout



Traffic flow logic

material handling functionality of AnyLogic (basic)

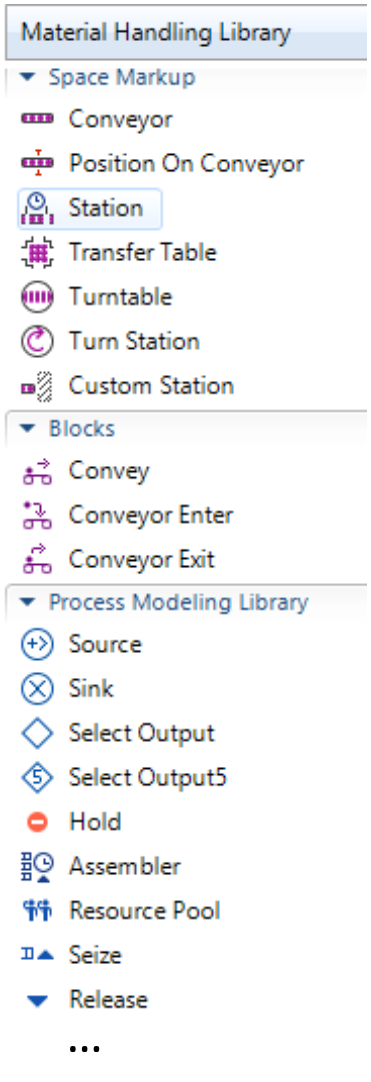


- Generic Process Modeling Library and generic space markup offers basic functionality:
  - All blocks needed for modeling process logic, including resource management
  - Simple spatial network (paths and nodes) and ability to send an agent to a particular location
  - Simple storage (pallet rack, rack system) and store/pick operations
  - Simplistic single conveyor
  - Ability to send resource units over the network, attach and detach them

material handling functionality of AnyLogic (advanced)

- AnyLogic Material Handling Library (release date April 2018) radically extends MH modeling functionality
- Interoperates with all other libraries (as always)
- Includes conveyor & station network with auto-routing:
  - ConveyorPath, PositionOnConveyor, PhotoEye
  - Turnplate, TransferTable, Turntable
  - Station, PickupStation, DropoffStation, CustomStation
- ASRS and modern storage systems
- Robots, cranes, transfer cars
- AGVs with collision avoidance and routing logic

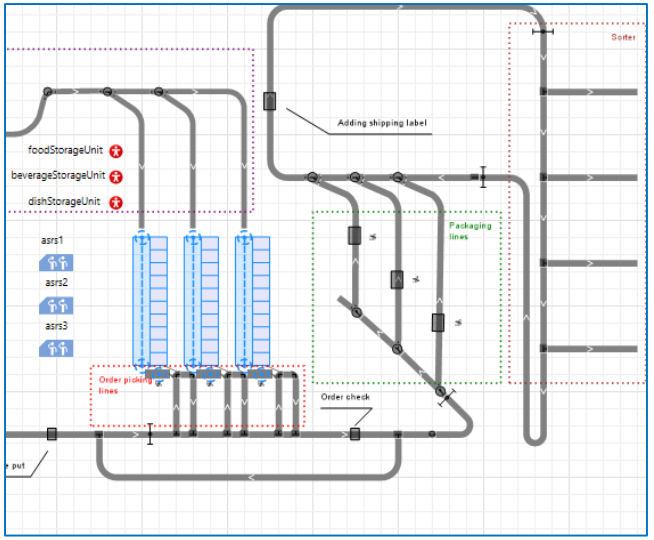
elements of the Material Handling Library (draft)



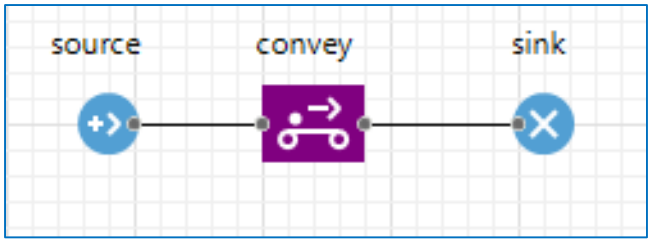
- New markup elements
  - Conveyor Path
  - Elements connecting paths: Transfer Table, Turn Table, Turn Station
  - Stations: Station, Custom Station
  - Auxiliary: Position On Conveyor, Photo Eye
- Few flowchart blocks
  - Actually, just one: Convey
  - Auxiliary: Conveyor Enter/Exit
- A selection of Process Modeling Library (logic) blocks duplicated here for fast access
  - Source/Sink
  - Select Output
  - etc.

how it works

- Markup elements are connected to each other and form Conveyor Network
- Convey block moves material items from through the conveyor network providing automatic routing
- Actions over items (including delays, drop-off, pickup, resource utilization, etc.) are defined at stations, which are a part of markup
- If logic is more complex, use Custom Station and arbitrary blocks from the Process Modeling Library



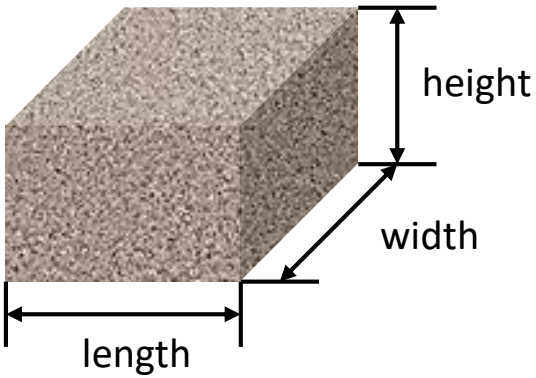
Conveyor network

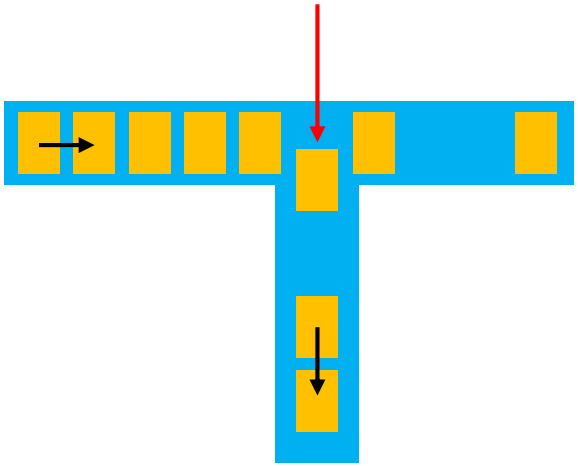


Process logic (in the extreme case)

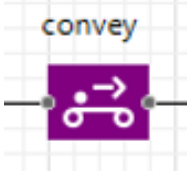
material item (in AnyLogic they are called agents)

- Three dimensions
- Orientation on conveyor
  - Determined as the agent enters the conveyor
  - Can change e.g. after passing a transfer table
  - Can be set manually in a property of the flowchart block or by function call (when agent is not on conveyor)
- Bi-directional mapping agent <-> markup allows you to obtain:
  - The current conveyor network element, if any
  - Position of the agent on conveyor
  - Agents before and after
  - And also, given the conveyor, one can find out which agents are on it



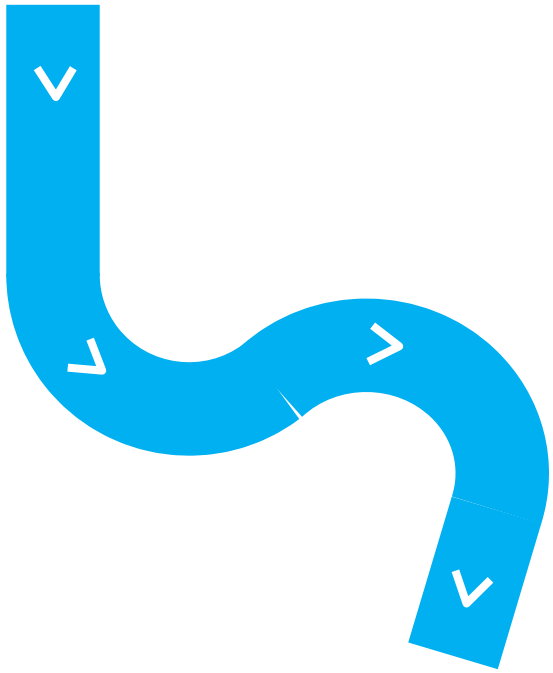


Convey [flowchart block]



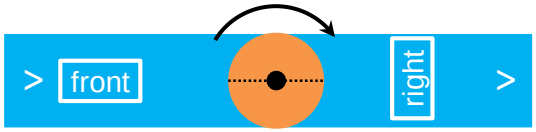
- Manages travelling of material items through a Conveyor Network, including stations, if any
  - Once an agent enters Convey, it starts its journey through the network
  - Convey blocks can follow each other in flowchart
- Routing types:
  - Auto routing: Convey uses the shortest way to the end point avoiding forbidden paths that can be specified
  - Custom routing: the user can specify a list of elements to form a route
- Properties:
  - Source location (Position On Conveyor, Path+offset, current)
  - Target location (Position On Conveyor, Path+offset, Custom Station)
  - Option of changing orientation on conveyor
  - Option of keeping agent on conveyor after reaching destination

Conveyor Path [markup element]



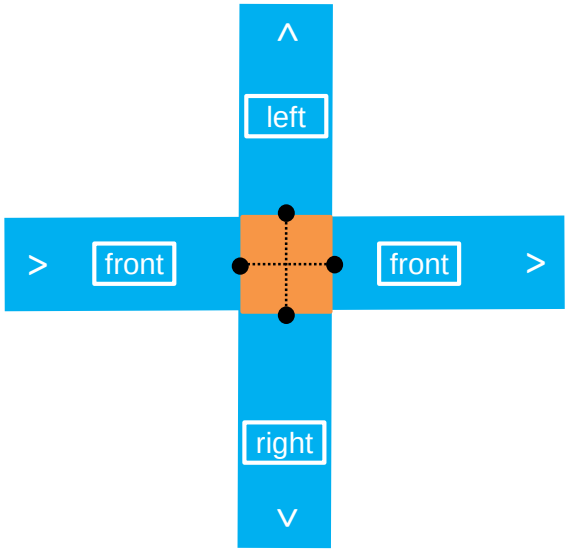
- Represents a single continuous conveyor
  - Geometrically, this is a multi-segment path with straight and arc segments
- Properties:
  - Type (belt, roller, fixed cell)
  - Path form and Width (defined graphically)
  - Speed
  - Gap size
  - Acceleration/Deceleration
  - Reverse movement - ?
- Accumulation capability is defined by conveyor path type
- Conveyor Paths can be connected:
  - To special elements connecting conveyors: Transfer Tables, Turntables, Turnplates
  - To other paths directly or via Split / Merge elements

Turn Station [markup element]



- Connects two conveyor paths (or breaks one) along a straight line
- Passing a Turn Station involves time delay and may change orientation of the agent
- Use cases:
  - Setting the same orientation for all agents (e.g., before scanning)
  - Rotate all passing agents by a specific angle (to model wrapping or reeling processes)
- Parameters:
  - New agent orientation
  - Rotation angle
  - Rotation speed
  - Speed of passing through

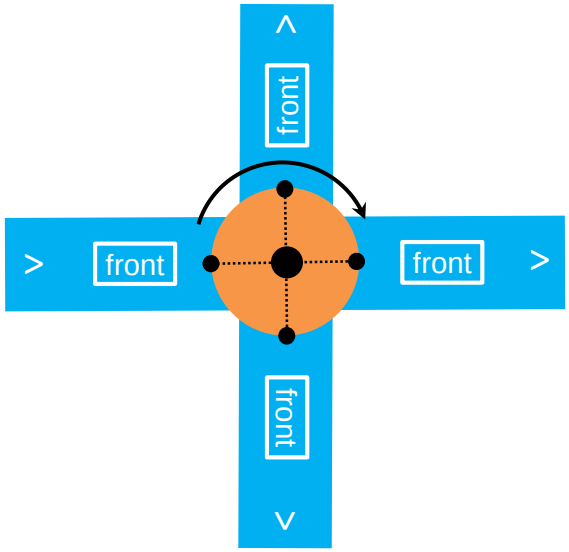
Transfer Table [markup element]



- Connects from 2 to 4 Conveyor Paths and routes agents
- Has at least one input and one output path
- Looks like a rectangle; Conveyor Paths can be connected to the center of any of the four sides
- Orientation of the agent changes according to the transfer logic
- Properties:
  - Switching delay time
  - Speed of passing through

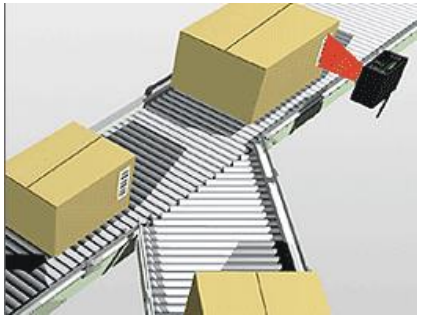
Turntable [markup element]

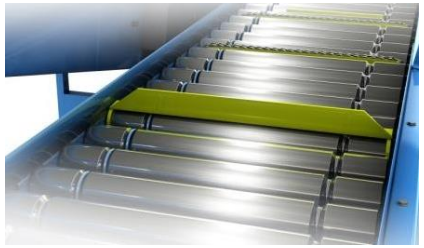
- Connects N Conveyor Paths and routes agents
- Has at least one input and one output path
- Looks like a circle; Conveyor Paths are connected at arbitrary angles
- Passing a turntable does not change agent orientation
- Properties:
  - Rotation speed
  - Speed of passing through



Position On Conveyor [markup element]

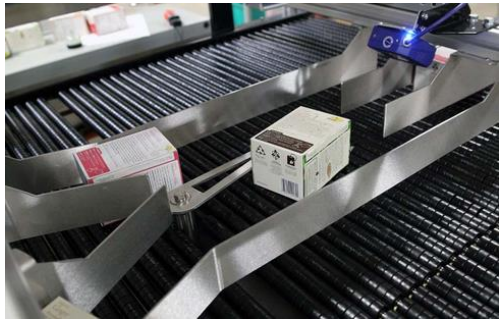
- Represents a certain point on conveyor
  - Unlike Photo-eye that watches an area
  - There can be multiple Position On Conveyor elements on a single path
- Use cases:
  - A photo-eye
  - Target location of agent's route through conveyor
  - Position where an agent is placed / picked from the conveyor
- Conveyed agent can be stopped (and conveyor possibly blocked) at a position





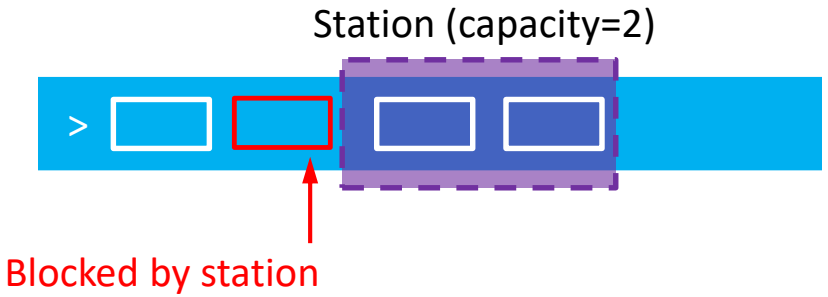
Area On Conveyor [markup element]

- Represents a certain area on conveyor that is being watched by e.g. a photo-eye, unlike Position On Conveyor that refers to a point
- Use cases:
  - A photo-eye watching a certain area
  - Estimation of conveyor line occupation
  - Getting the list of agents in the certain area
- Single or multiple photo-eyes can be placed at arbitrary positions of conveyor paths



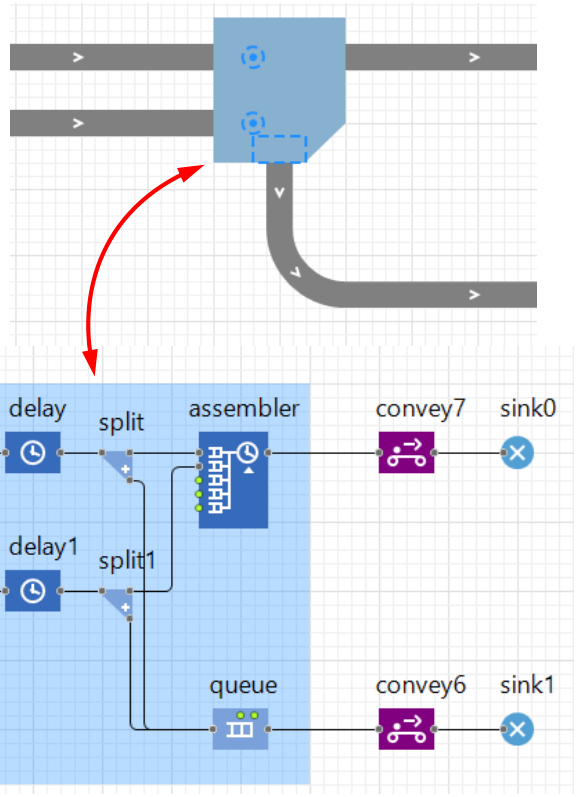
Station [markup element]

- Models a simple processing device or an operation/process
- While the agent travels through the Conveyor Network (being in a Convey block), it is processed by Stations it meets on the way
  - No need to add flowchart blocks to model simple operations
- Properties:
  - Delay time
  - Capacity
  - Optionally, resources needed to perform the operation
- Specific callbacks:
  - On process started
  - On process finished



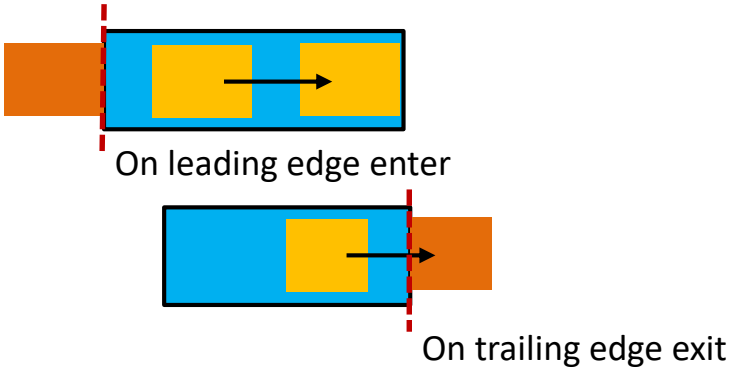
Custom Station [markup element]

- Models an operation/process with custom logic that cannot be described with capacity/delay/use resources parameters
- Looks like a polygon with conveyor paths connected to it
  - Custom Station can be set as a destination point of Convey block
  - Routes can not be built through a Custom Station due to custom logic!
- Operations are specified by a process flowchart
  - E.g. assembling process that combines agents of different types from several conveyors



general features of conveyor network markup

- Each element has callbacks:
  - On leading edge enter
  - On leading edge exit
  - On trailing edge exit
  - On trailing edge enter



- The user can define custom dynamic routing logic:
  - Dynamic priorities at a merge of conveyor paths
  - Dynamic routing depending on e.g. path occupancy/congestions
- Each element has
  - Statistics
  - Failure/maintenance profiles (MTTF, MTTR, MTBPM, MTTPM)
- You can create a conveyor network dynamically by reading the layout e.g. from a database or a spreadsheet

Conveyor Enter and Conveyor Exit [flowchart blocks]

conveyorEnter

- Places an agent in the Conveyor Network, but doesn't let it move
  - May block other agents
  - [Normally, you just use Convey block to place agents in]
- Use case:
  - A worker has placed a box on the conveyor belt, but needs to e.g. label it before it goes

conveyorExit

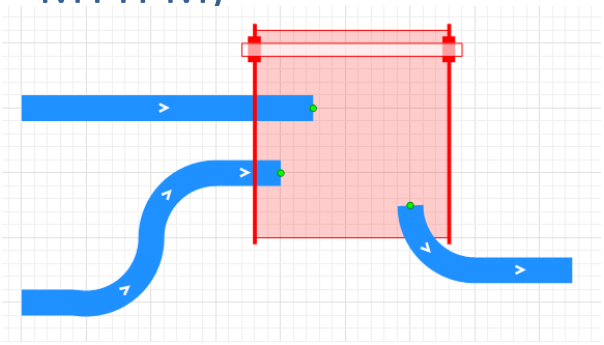
- Removes the agent that has finished its movement from the Conveyor Network
  - [Normally, you remove it by checking "Remove" in the Convey block]
- Use case:
  - The agent has reached its final destination in the network, but waits for e.g. some resource, and still blocks other agents

ASRS

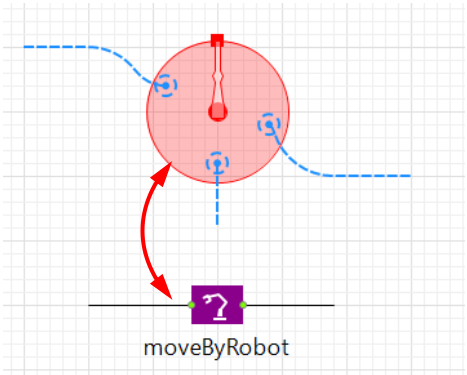
- ASRS can be connected to Conveyor networks
- Standard 3D shapes, animation of storing and retrieving from a rack
- Equipment statistics

robots, cranes, transfer cars

- Implemented as markup elements that can be:
  - A part of a Conveyor Network, or
  - Standalone, referenced by MoveBy… blocks
- Collision detection and auto management of bridge cranes and transfer cars sharing rails
- Each element has
  - Statistics
  - Failure/maintenance profiles (MTTF, MTTR, MTBPM, MTTPM)



Conveyors are connected to a bridge crane



Flowchart block refers to the Robot markup

Automated Guided Vehicles (AGVs)

- AGV movement is a combination of free space, lane-guided or grid-guided (KIVA) movement featuring:
  - Collision avoidance (sensing other AGVs, workers)
  - Deadlock detection and resolution (e.g. when sharing same aisle)
  - Auto routing around obstacles (walls, pillars, racks)
- AnyLogic already includes relevant technology in Pedestrian and Road Traffic libraries
- Optionally, tug trains

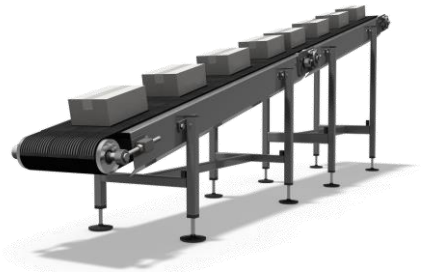


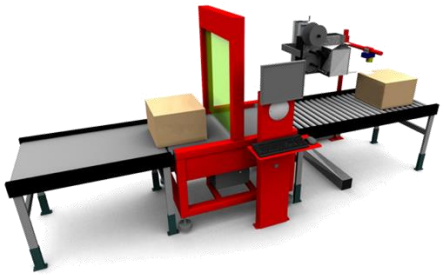

AGVs additional features

- Routing
  - Shortest path with minimum number of turns
  - Minimum turn radius considered
  - Zones with limited capacity
  - Optionally, priorities of AGV's tasks
- Movement
  - Acceleration/deceleration depending on turn radius
  - Speed reduction in case other objects detected in proximity
- AGV fleet management
  - Auto (depending on current task list)
  - Custom (user-controlled)
- Statistics:
  - Utilization, delivery time distribution, heat map

3D Animation

- Conveyor markup animation :
  - Multiple conveyor types
  - Supports
  - Any form of conveyor is supported
  - Turnplate, turntable, transfer table animation
- Photo-eyes, scanners, typical stations
- Workers
- Storage systems
- Robots, cranes
- Forklifts, trolleys, AGVs





thank you!

- Come to AnyLogic Conference 2018!