Using Simulation to Increase OEE in the Pulp, Paper & Tissue Industry

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Trivial questions without trivial answers

The context

- Operational issues in a tissue converting plant result in an OEE (Overall Equipment Efficiency) lower than expected… repeatedly
- Several fixes have been tried in the past – none of them seemed to permanently solve the issues
  - And are we really sure we know what are the issues?
- Pressure is rising: need to find solutions… urgently!

The challenges

- There is no “universal” bottleneck… hell!
  - Acting on one outstanding (local) issue does not increase the OEE!
  - Varying the product mix on moves the bottleneck!
  - In other words: no clear indication of the “true” root causes
- Basic question: “What do we do?”
  - Where do we start from?
  - What should we really act on?
  - Tons of (unanalyzed) data: what could we learn?
- A global structured strategy is needed!

Discrete Events Simulation : what is that?

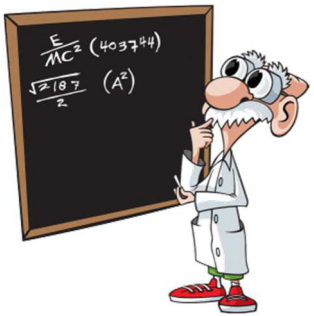
Oh no, theory...

Event-based modelling

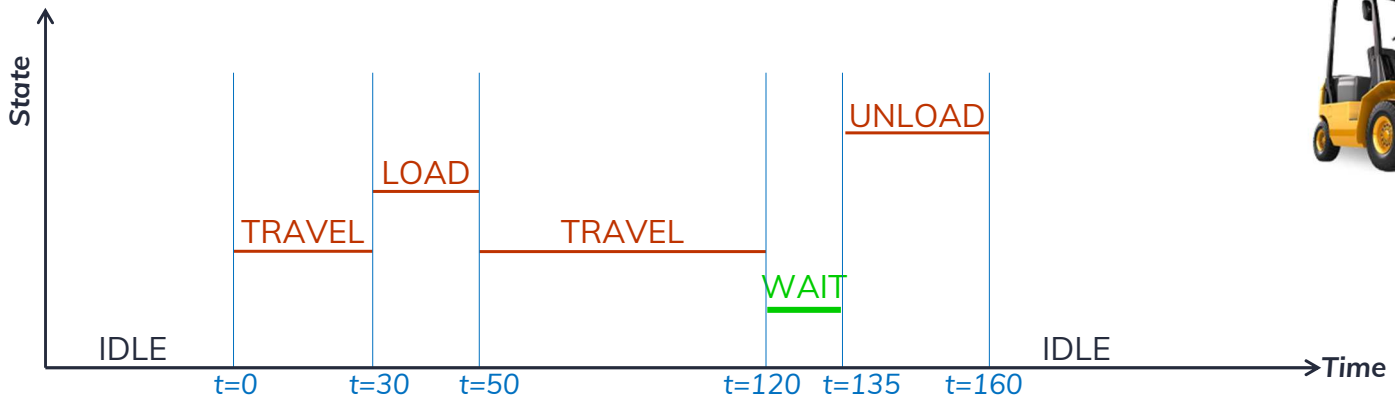
≡ Model of systems which change states at discrete points in time as a result of specific events:

Examples of **events**
- ~ Order/part arrivals
- ~ Product movement
- ~ Machine cycle start/finish
- ~ Machine breakdown/repair

Examples of **states**
- ~ Machines: idle, setup, processing, down
- ~ Queues: empty, full
- ~ Operators: on-shift, off-shift, utilized, idle
- ~ Transports: travelling, loading, unloading

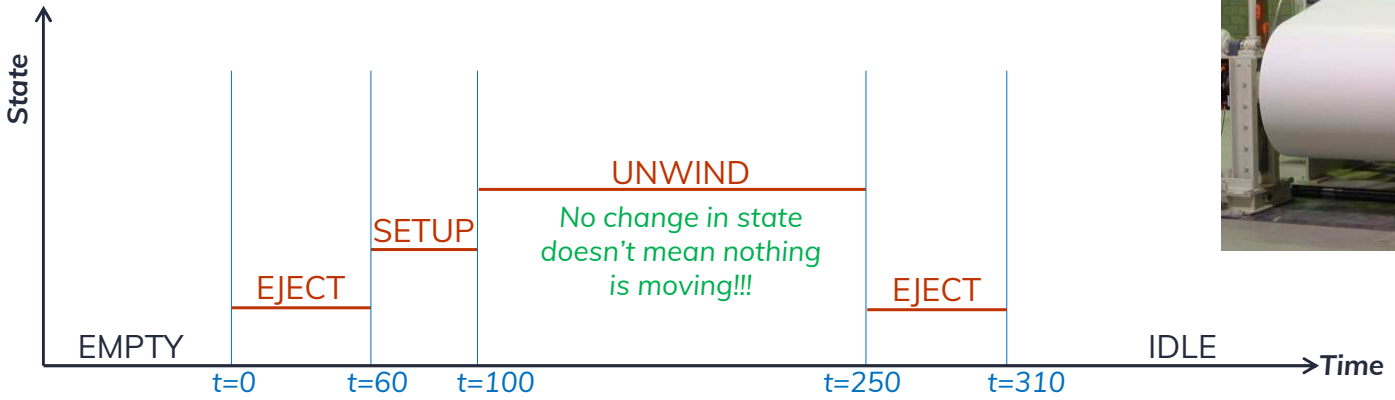


Example: moving a box (or two!)



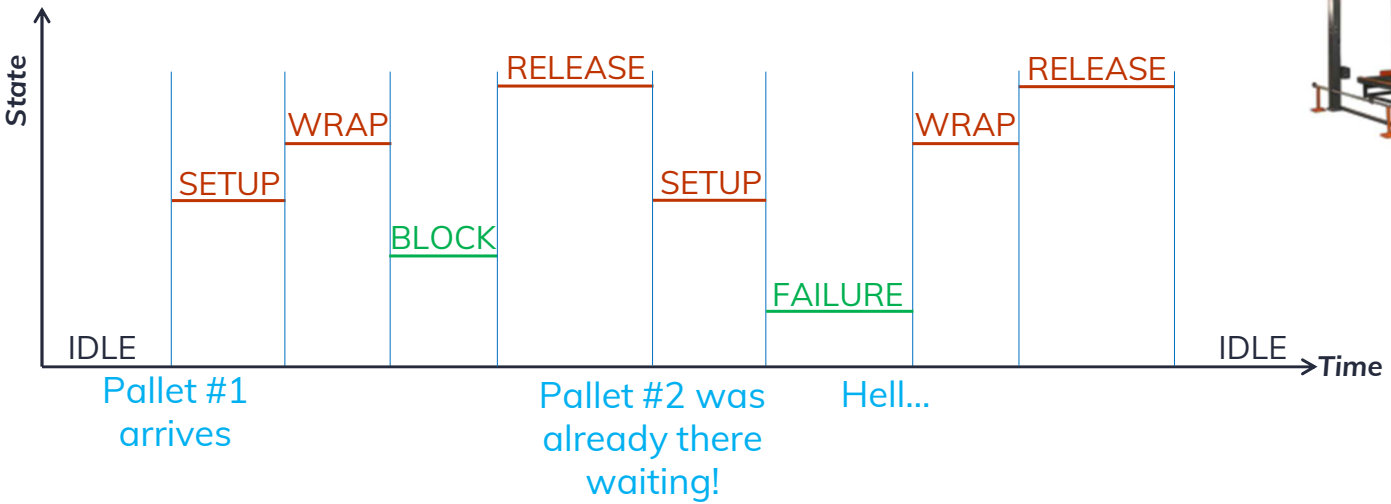
Box to be moved! → Call a forklift → Drop zone is overcrowded → Box delivered + Forklift freed

Example: unwinding a parent roll



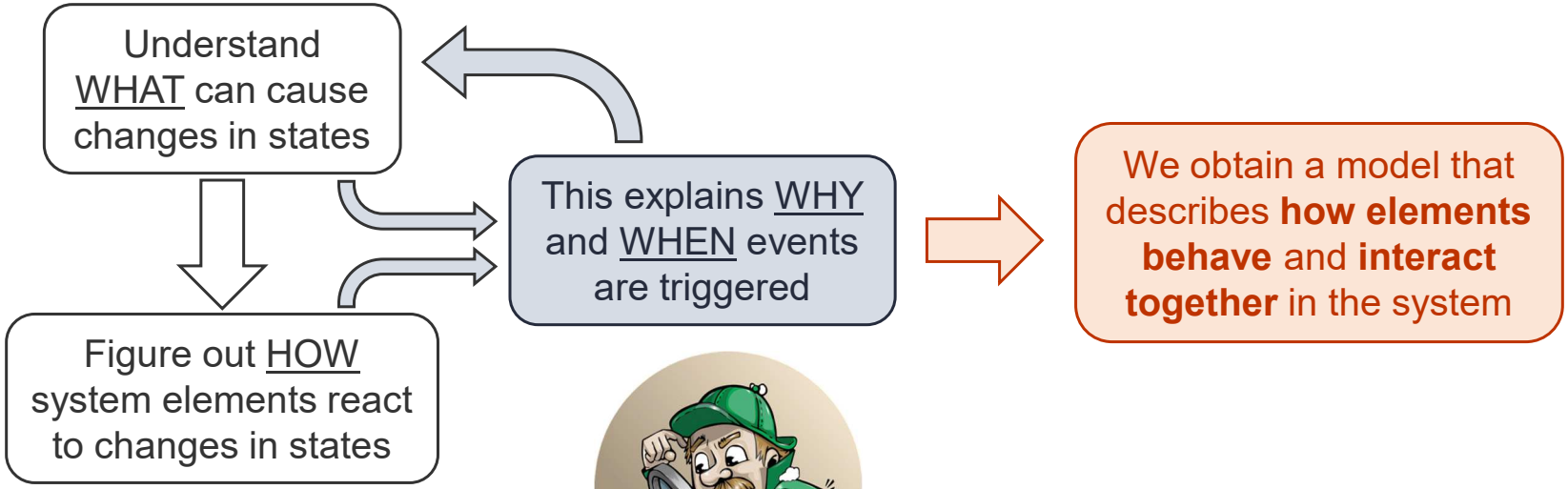
Parent roll to be changed! → Eject roll → Insert and thread sheet → Unwind at speed X → Eject roll → Ready for next!

Example: pallet stretch wrapper



Event-based modelling

≡ The mental exercise behind event-based modelling is:



Even without a computer implementation, investigating and developing this vision of a system is value added!

Event-based modelling

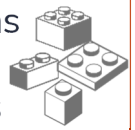
- It's much more advanced than spreadsheets! These models can include :
  - Wait queues and buffers
    - Waiting for… tools, operators, supervisors, an empty place
    - Wait while vehicle travel ends before unloading it
    - Wait for a free bay in the rack to unload the vehicle
  - Breaks/jams/failures/unplanned stops as a function of utilization
    - Randomly stop after X hours of service, X produced items, X travelled distance… depends of the evolution of the simulation!
  - Coordination/syncing between resources/agents
- In these models, decisions are made dynamically depending of the evolving states and conditions!

Models building blocks

≡ Discrete events models can be built using these blocks!

VARIABILITY

≡ Probability distributions
≡ Delays and rates
≡ Uncertainty tolerances



MANAGEMENT

≡ Scheduler
≡ Dispatcher/regulator
≡ Assets tracking
≡ Performance monitoring

DELAY

≡ Cycle time
≡ Time to failure
≡ Repair time

RATE

≡ Vehicle speed
≡ Bulk/liquid flow
≡ Items arrival

WAIT

≡ Queue (FIFO)
≡ Stack (LIFO)
≡ Priority pick

INVENTORY

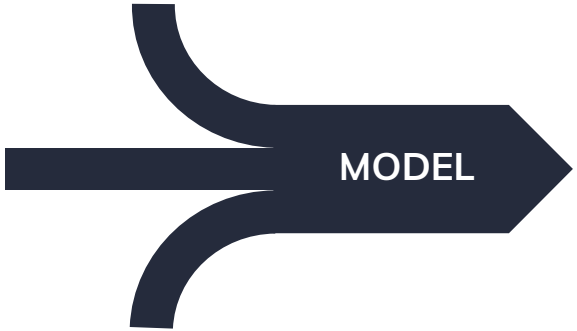
≡ Items storage
≡ Parts buffer
≡ Tank/silo

DES = Global structured vision

Layouts, routes, dimensions, stationary and mobile equipment characteristics, technical data

DESIGN SPECIFICATIONS
engineering

HISTORICAL PROCESS DATA
data science



OPERATIONS KNOWLEDGE
people

Cycle times, schedules, resources availability, logic, routing and operational constraints, reliability

Outputs:

- Performance diagnosis
- Effective and ultimate throughput
- Equipment utilization rates
- Meaningful and custom statistics
- Trend and pie charts, histograms

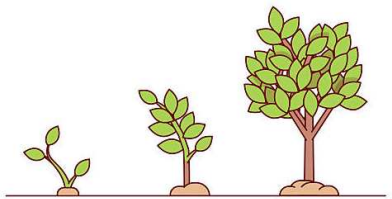
Experimentation
Optimization

Trials and errors for “free”!
No consequences!

DES in Pulp & Paper

DES in Pulp & Paper

- Examples of possible applications of DES in P&P:
  - Forestry
    - Modelling trucks and machinery movements to determine the right fleet sizes and wood production to match scheduled production
  - Inventory management and shipping
    - Modelling raw material stocks, production schedules and jumbo rolls flow to improve the efficiency of shipping and better control of inventories
  - Inter-mill delivery networks
    - Modelling inbound and outbound movements of items between several plants and distribution centers to optimize the truck fleet size and reduce internal shipping costs
  - Production schedule optimization
    - Efficiently assign production lots to lines and manage ordering of “vitals” to optimize inventories



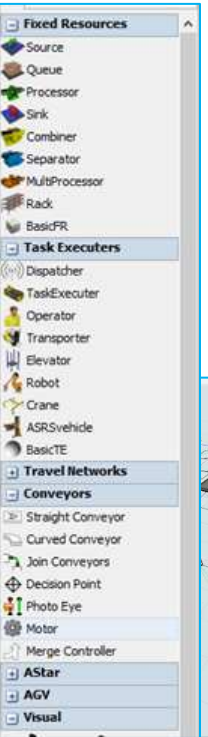
DES in Pulp & Paper

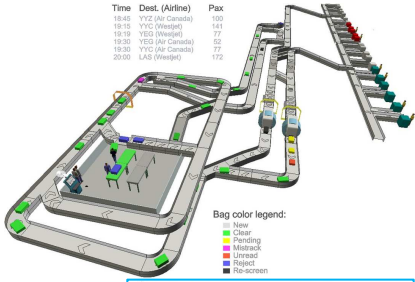
- Back to the tissue converting plant facing low OEE results
  - A Kaizen event was organized where the goal was to identify potential improvement projects that would result in a 2-digits increase in OEE
  - A lot of historical data were statistically analyzed and presented during the Kaizen event
  - From the data, a set of projects were identified
  - In parallel, a simulation model was built and used to validate the impact of those projects on the OEE

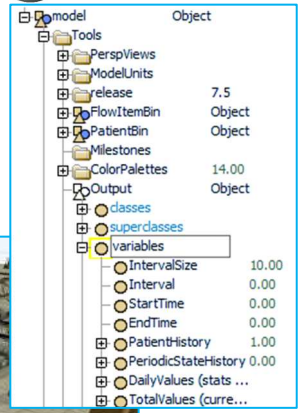
DES in Pulp & Paper

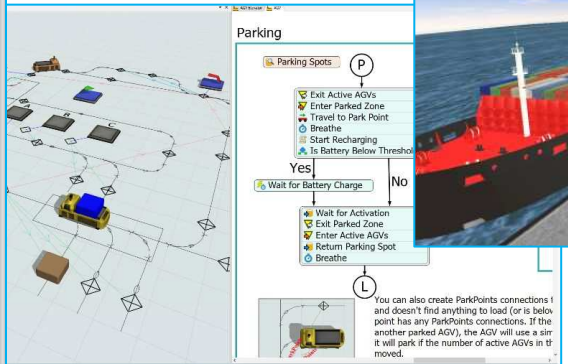
≡ Flexsim was the selected simulation platform:

- Powerful 3D interactive object-oriented environment
- Drag-drop objects, coding, process mapping… multiple ways of editing a model, chose your preferred one!
- Open architecture, interoperability with known technologies
- Complex systems can be quickly represented!









DES in Pulp & Paper

- The simulation input parameters included:
  - Fabrication “recipes”: SKUs, roll sizes, routes, packaging rules, …
  - Production schedule: actual or proposed
  - Accumulators and buffers capacities
  - Conveyor speeds and reliability (from historical data)
  - Machine cycle times and reliability (from historical data)
  - Changeover rules and durations
  - Operators duties and tasks durations
  - Daily operators schedule
- All of these items could be modified and the impact on the OEE could be assessed!

DES in Pulp & Paper

- The projects were evaluated and selected based on their expected benefits
- Thanks to the visuals, the simulation was very useful to convince people of the impact of significant changes
  - Visualizing in a 3D environment the impacts of changing a parameter “live” speaks a lot to everyone
  - Being able to visually determine where is the bottleneck and find out what is missing to resolve it is very helpful
- The model was programmed to output KPIs… projects selection becomes a quantitative exercise!

To conclude…

If you ask yourself…

- Can the system attain its designed throughput?
- How can I scale up my production capacity?
- Are conveying and/or storage capacities adequate?
- Are there sufficient cranes or vehicles?
- Can the supply chain respond to client requirements?
- Is the schedule of operations feasible?
- What will be the impact of breakdowns on throughput?
- What are the optimal spare parts inventory levels?
- ..

In conclusion…

- Discrete Events Simulation is a powerful technique to model flow of items, schedules, operators tasks, etc.; interactions between system elements can be captured and evaluated
  - Combining DES and Continuous Improvement :
    - The exercise of building the model in itself brings to daylight flaws and inefficiencies
    - Simulation results helps to confirm/validate root causes, select/prioritize potential solutions, and in general, assess the impact of changes before really changing the system
  - Team consensus is built around an analytical tool…
- Simulation was beneficial to select solutions having a global impact!

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