Dynamic models and strategies to control warehouse processes

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Model development

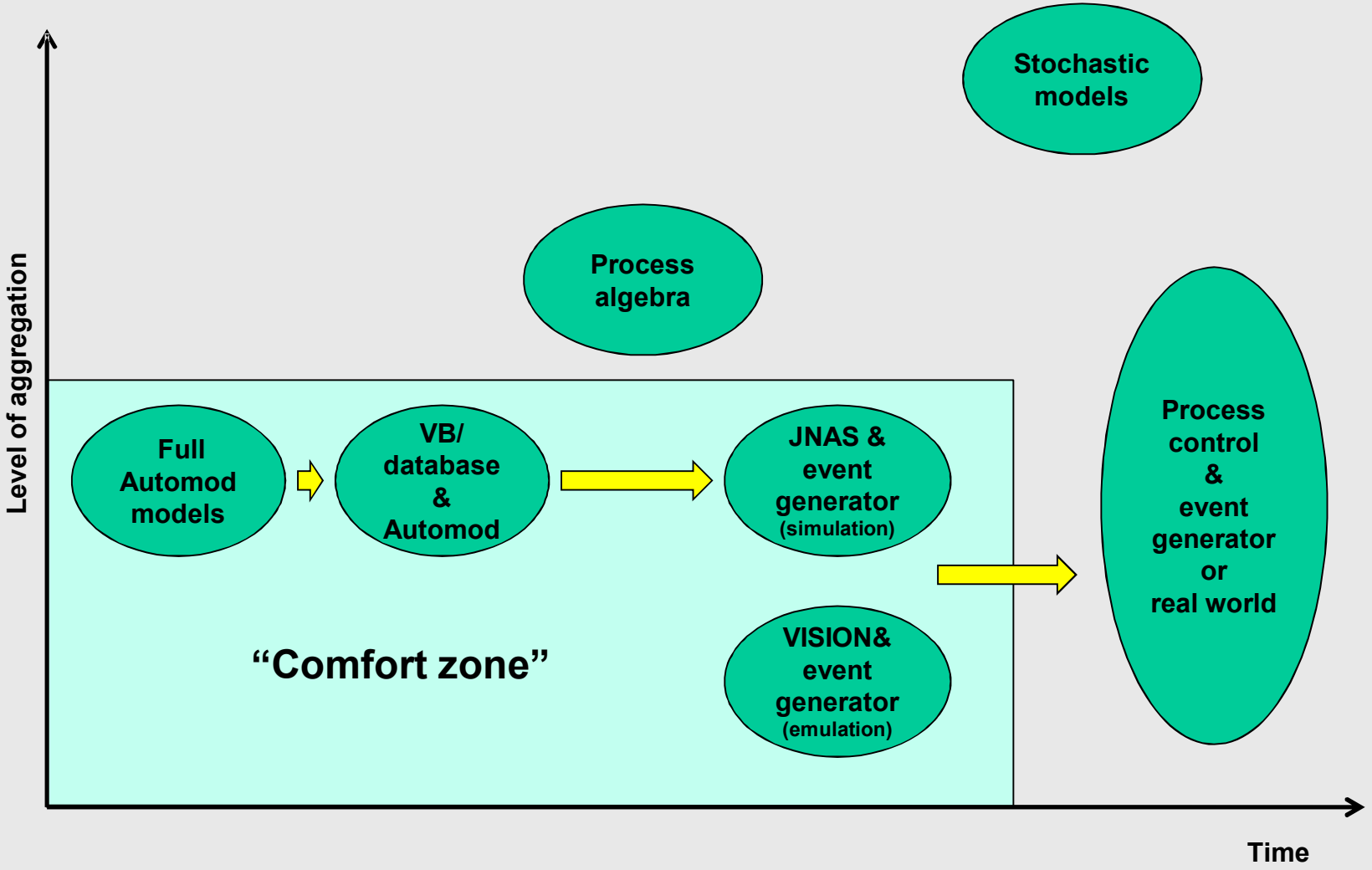
from tools & methods to methods & tools

Process control architecture

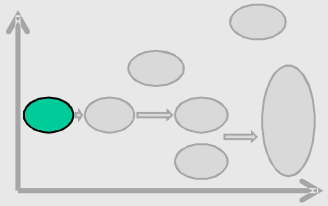
our pivotal model

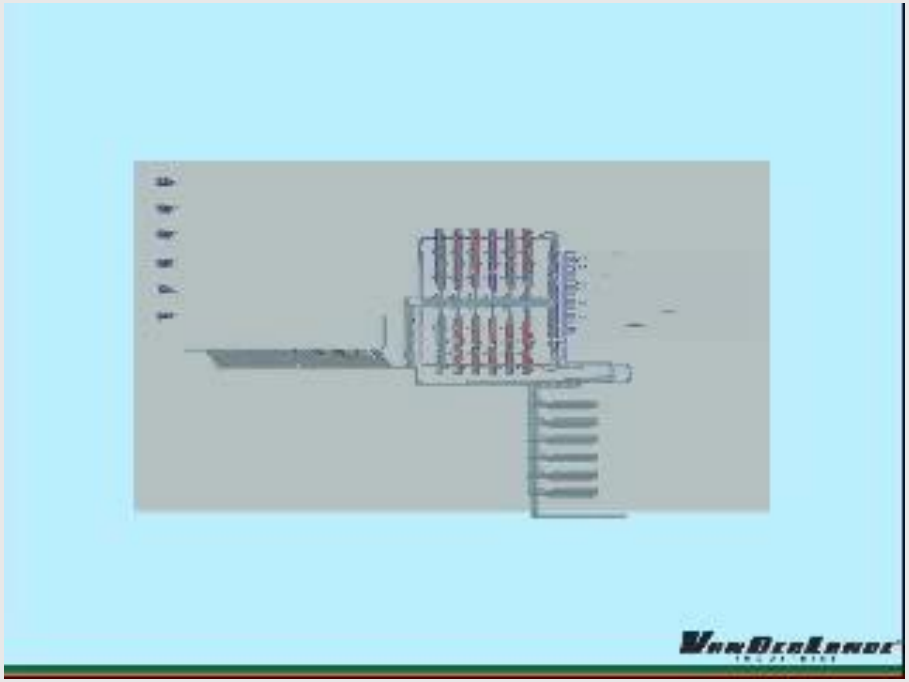
How to expand our range of methods and tools?

Model development overview



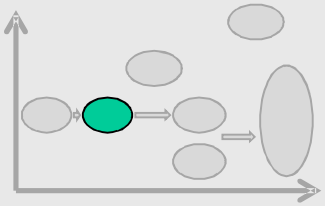
Full Automod models

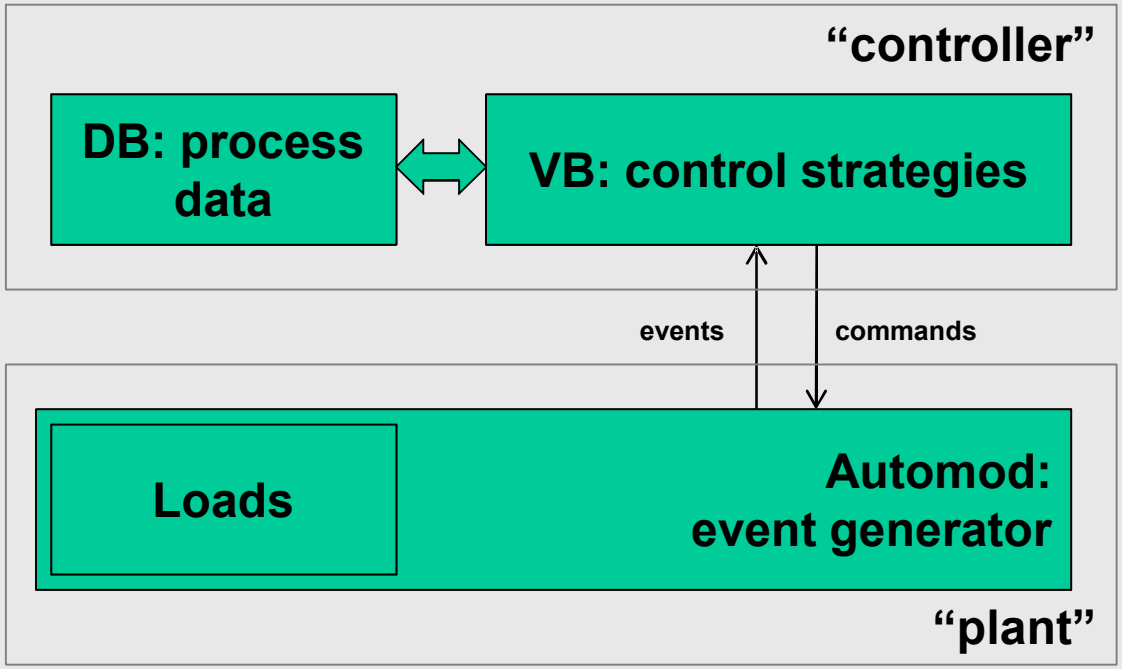




- System architecture is determined by simulation tool architecture: Automod language is procedural, no local variables
- Ad hoc strategies triggered by system behaviour as perceived through the animation
- Optimisation strategies focus on input fed to the simulation model: poor robustness with respect to changes in business

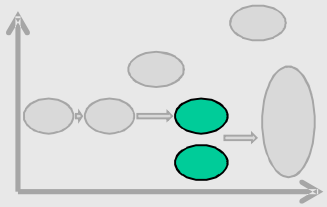
Visual Basic / database & Automod

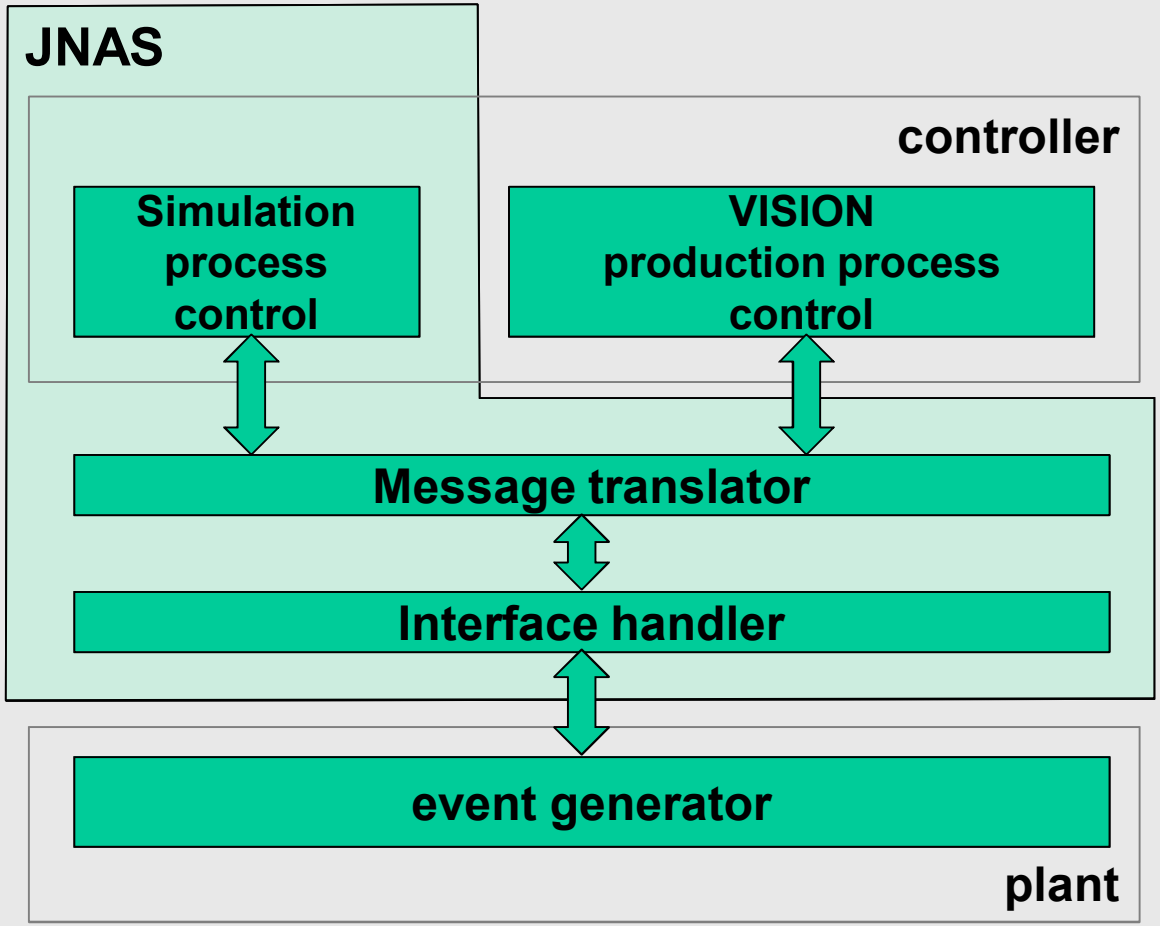




- Development is tool-driven: VB syntax and database to handle large amounts of data typical for W&D systems.
- Plant-controller interface not formalized: plant does not support emulation
- No evolution in system modeling / system design

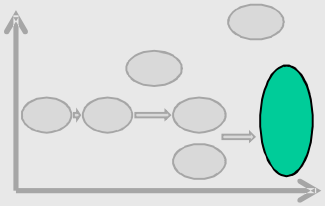
Java New Architecture Simulation / VISION & event generator

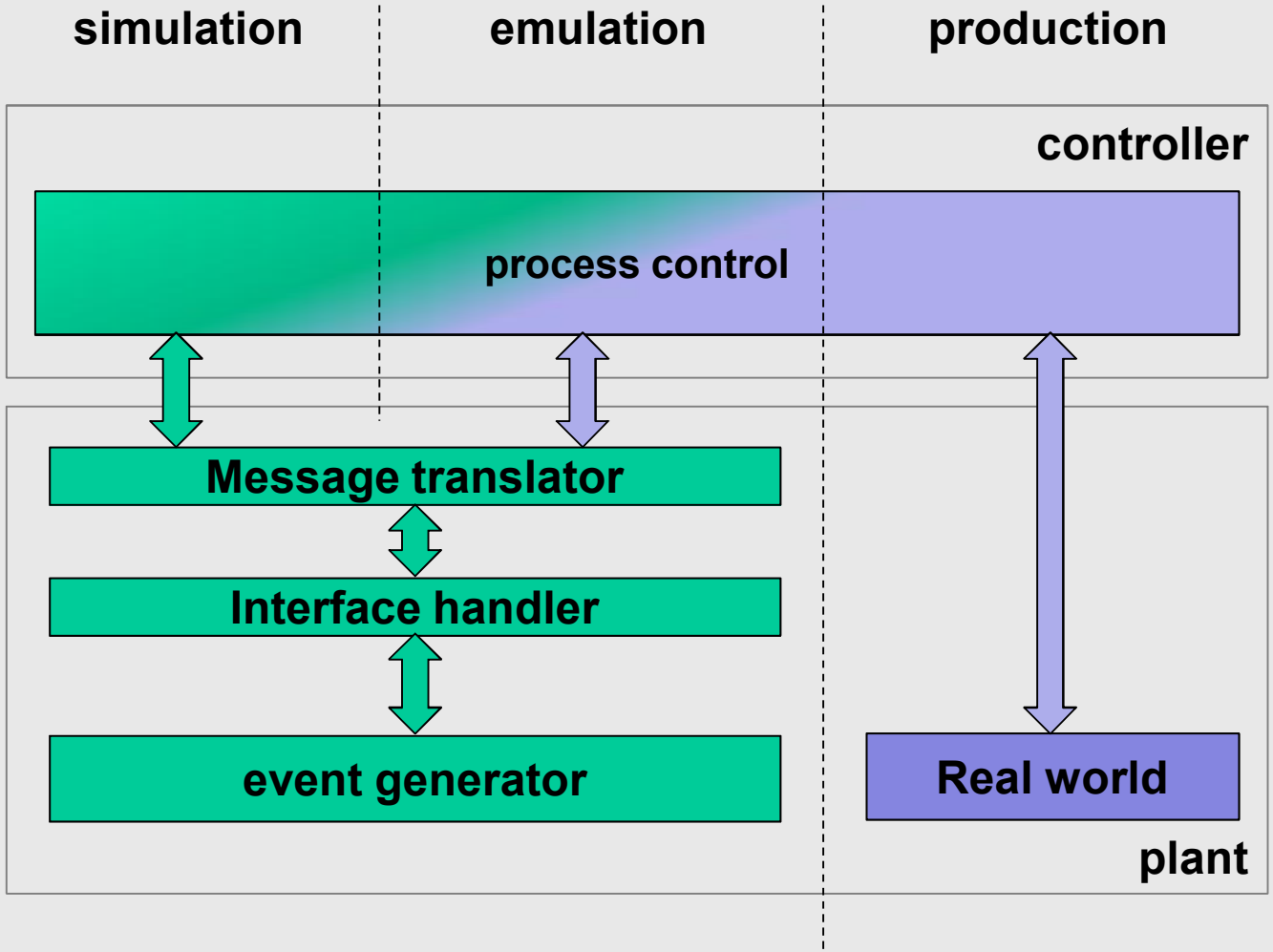




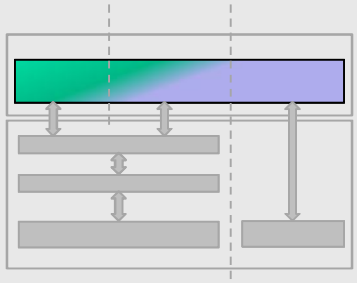
- **Plant-controller interface formalized: supports Model Based Design**

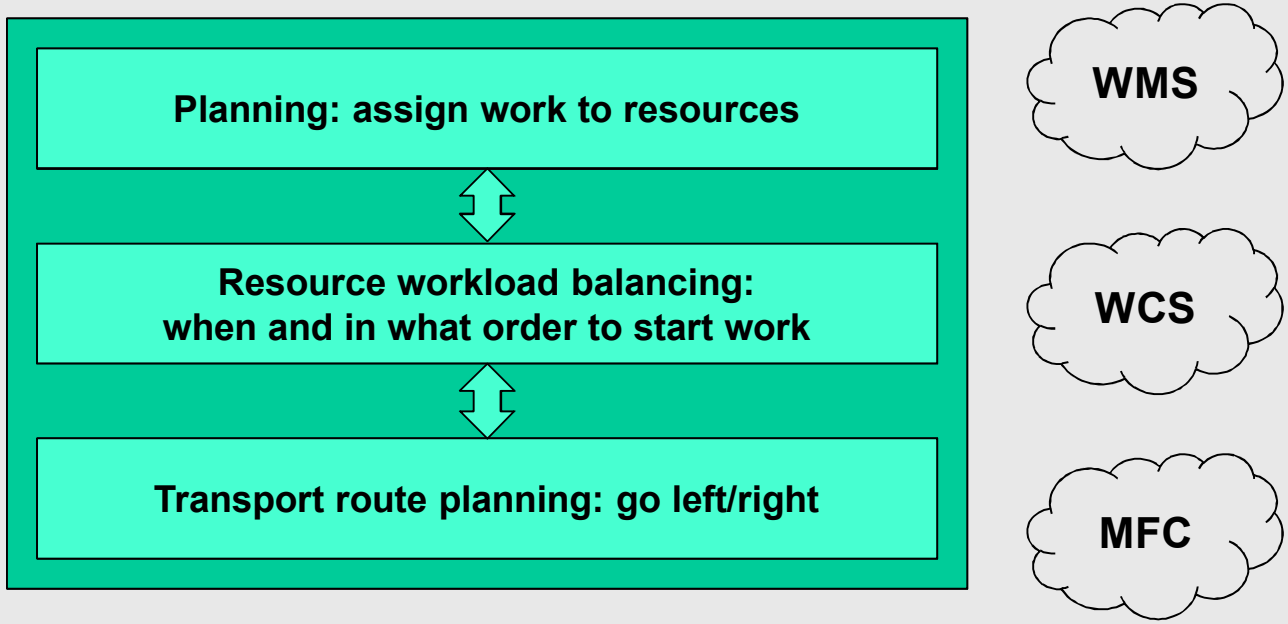
Unified process control





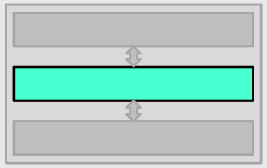
Process control architecture: layered functionality

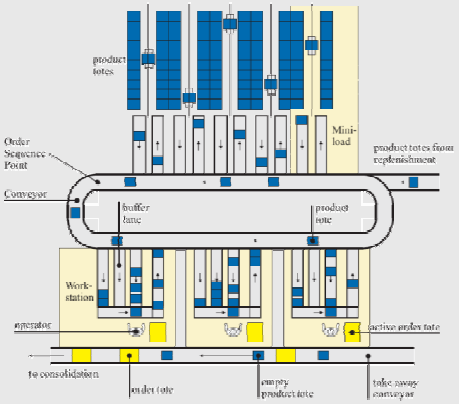


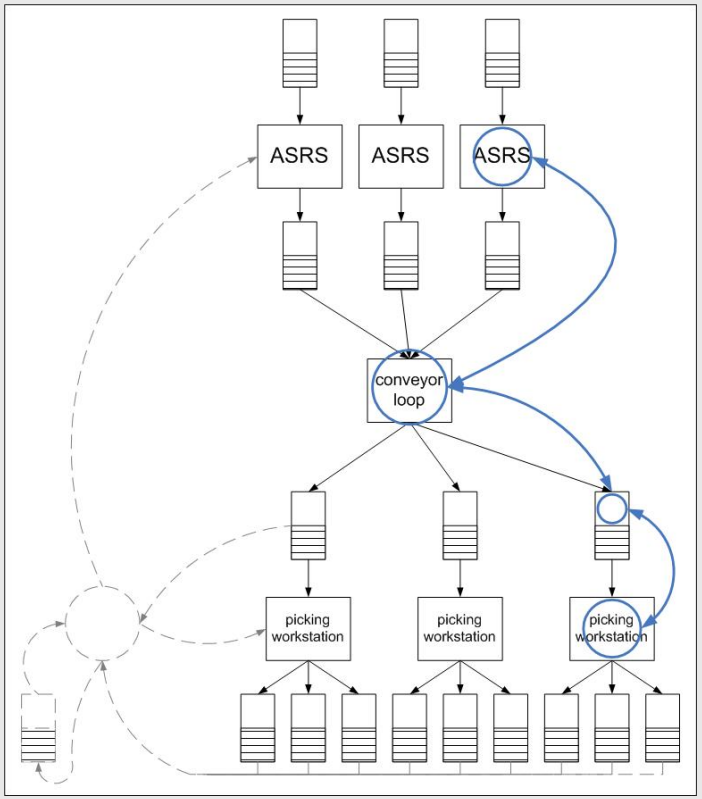


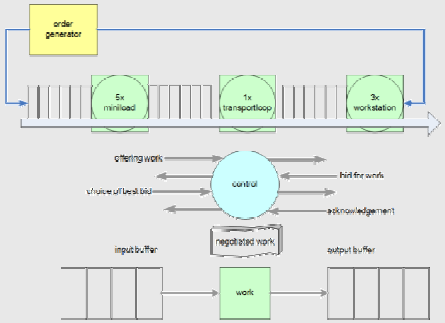
- Model based design
- Layered functionality: connectivity to ERP/WMS
- Model driven & service oriented architecture:
  - platform-independent model described in a domain specific language
  - hierarchically organized components
- Operations Research driven optimization algorithms

Resource workload balancing



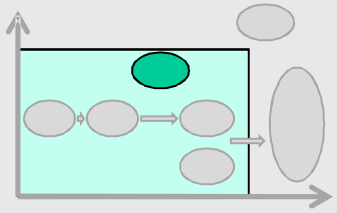






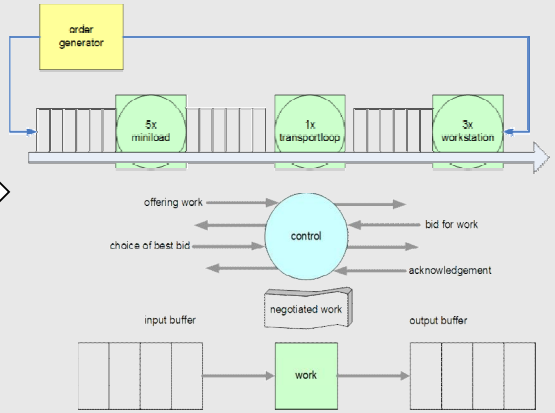
- **Model driven & service oriented architecture:**
  - **platform-independent model described in a domain specific language**
  - **hierarchically organized components**
- **Operations Research driven optimization algorithms**

Process Algebra

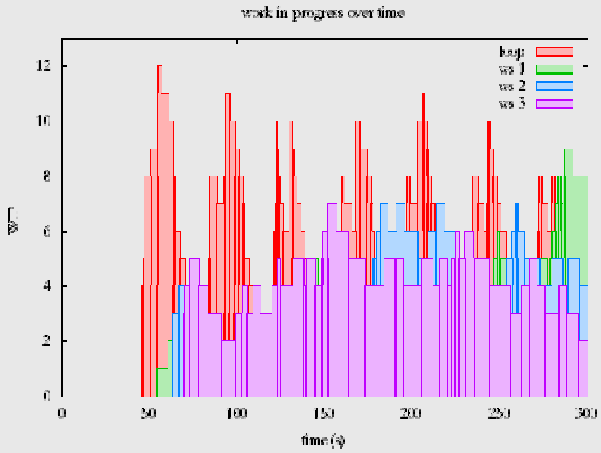


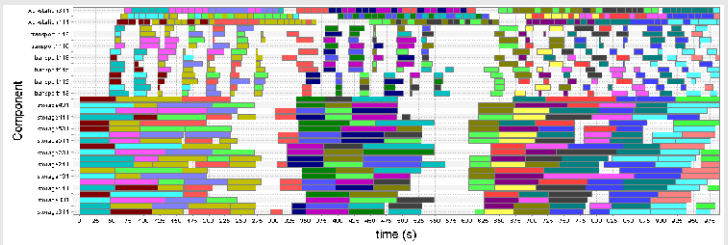
component	para	average	[confidence]	accur	[min, max]
storage1	Thru	195.3	[192.5, 198.0]	1.4%	[180.3, 208.3]
	flow	92.9	[88.3, 97.5]	5.2%	[28.7, 271.2]
	WIP	5.0	[4.7, 5.4]	6.8%	[0.0, 14.0]
Transport1	Thru	977.0	[960.9, 993.1]	1.7%	[793.2,1175.5]
	flow	16.6	[16.4, 16.8]	1.2%	[3.0, 57.8]
	WIP	4.5	[4.3, 4.7]	4.1%	[0.0, 12.0]
workstation1	Thru	328.4	[322.2, 334.6]	1.9%	[295.8, 359.4]
	flow	65.5	[61.9, 69.0]	5.7%	[6.8, 400.9]
	WIP	6.0	[5.5, 6.5]	8.8%	[0.0, 17.0]

input with “sales worldview”



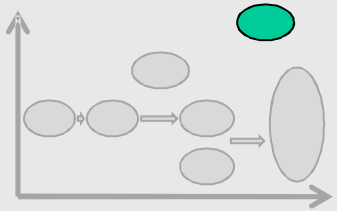
output with “sales worldview”

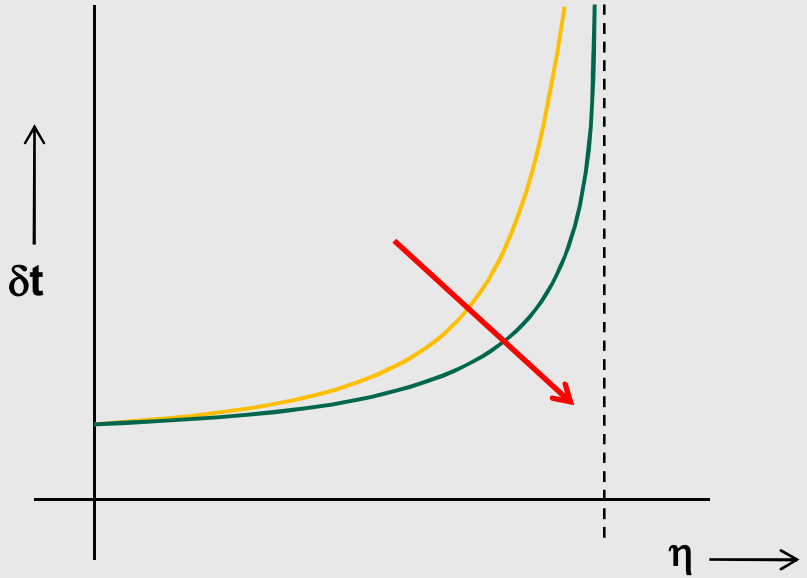




Stochastic models

$$\mathbb{E}(W_q) \approx \left(\frac{\rho}{1-\rho}\right)\left(\frac{c_a^2 + c_s^2}{2}\right)\tau$$





Challenges:

What do we “lose” in terms of system performance when we do not model optimization algorithms?
Alternatively, how to model these optimization algorithms in stochastic models?

Can a solution be validated using stochastic models only?

How to expand our comfort zone to stochastic models?