Models for warehouse design and control: simulation, analytic or both?

29-11-12
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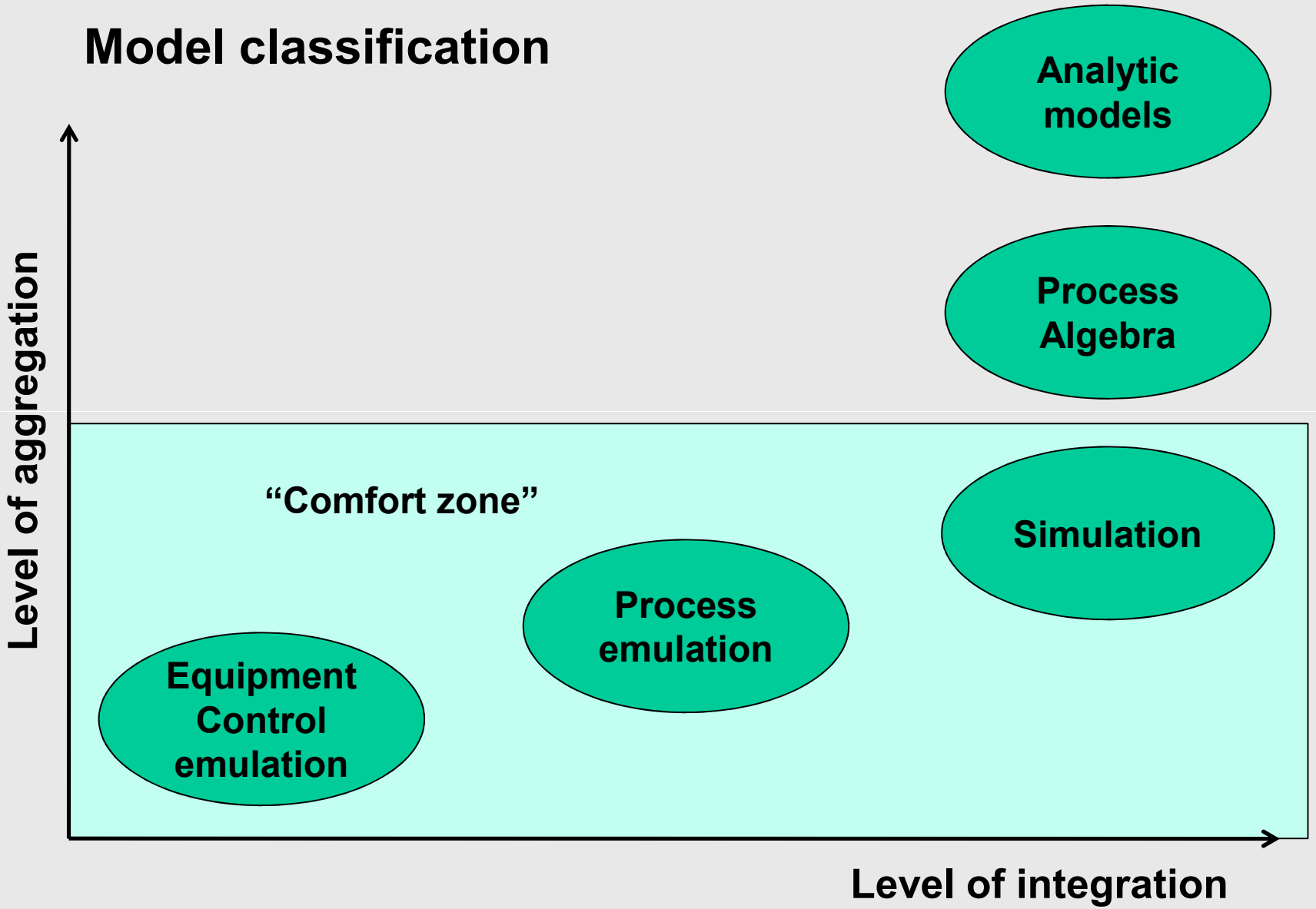
Vanderlande Industries

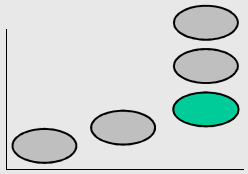
Vanderlande Industries

- Design and Implement material handling systems
  - Bagage handling (Schiphol, Heathrow)
  - Warehouse mechanisation (Tesco, Lidl)
  - Parcel sortation (UPS, DHL, DPD)
- Global presence (2400 employees)
  - Veghel headquarters (1500 employees)
- Annual turnover of 700 M Eur

Model classification



Simulation



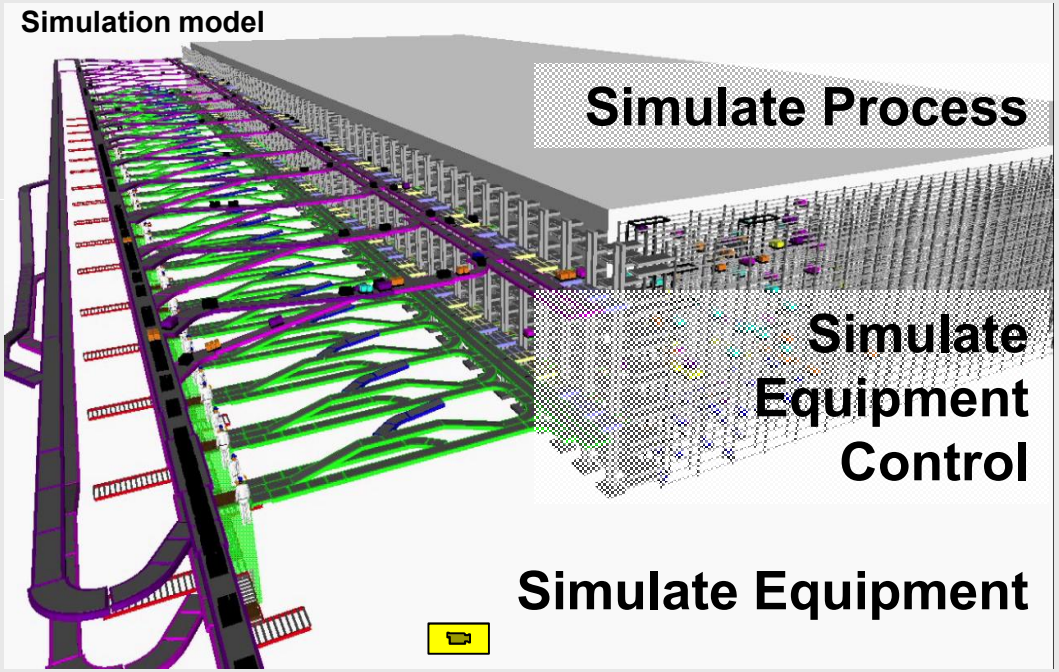
Real World

Process Control

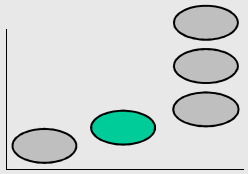
Equipment Control

Field Equipment

Simulation model



Process emulation



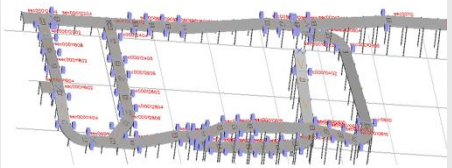
Real Situation

Process Control

Equipment Control

Field Equipment

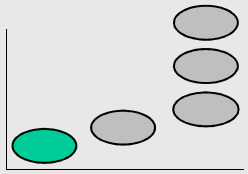
Process emulation model



Simulate Equipment Control

Simulate Equipment

Equipment Control emulation



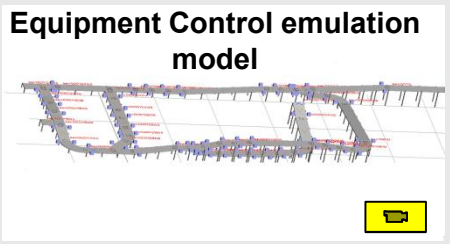
Real Situation

Process Control

Equipment Control

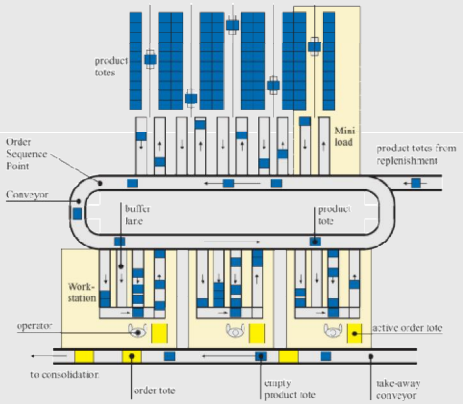
Field Equipment

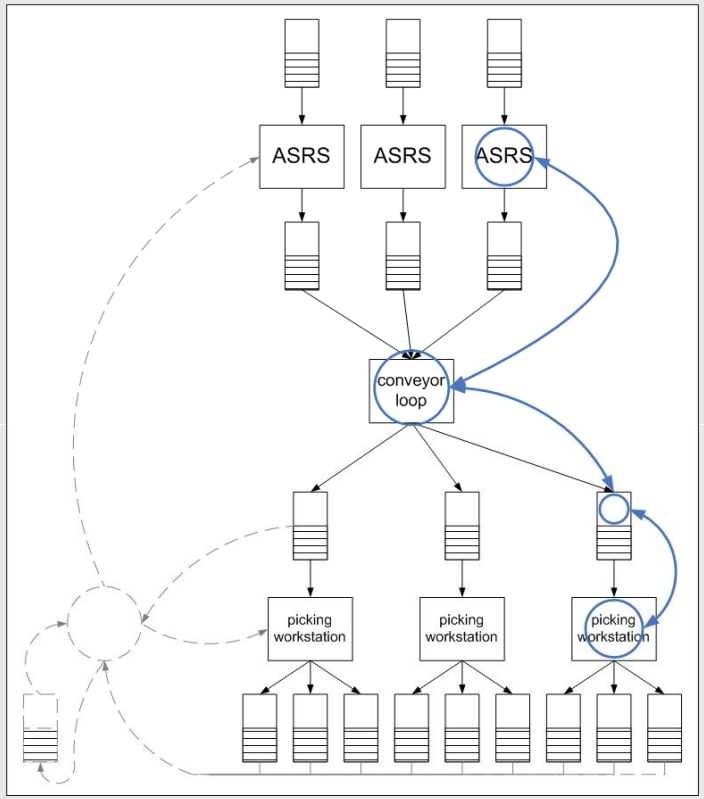
Equipment Control emulation model

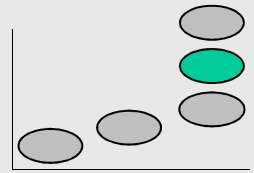


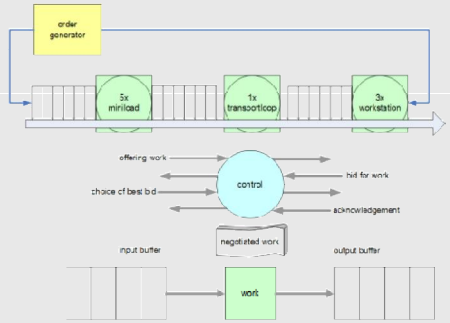
Simulate Equipment

Process Algebra

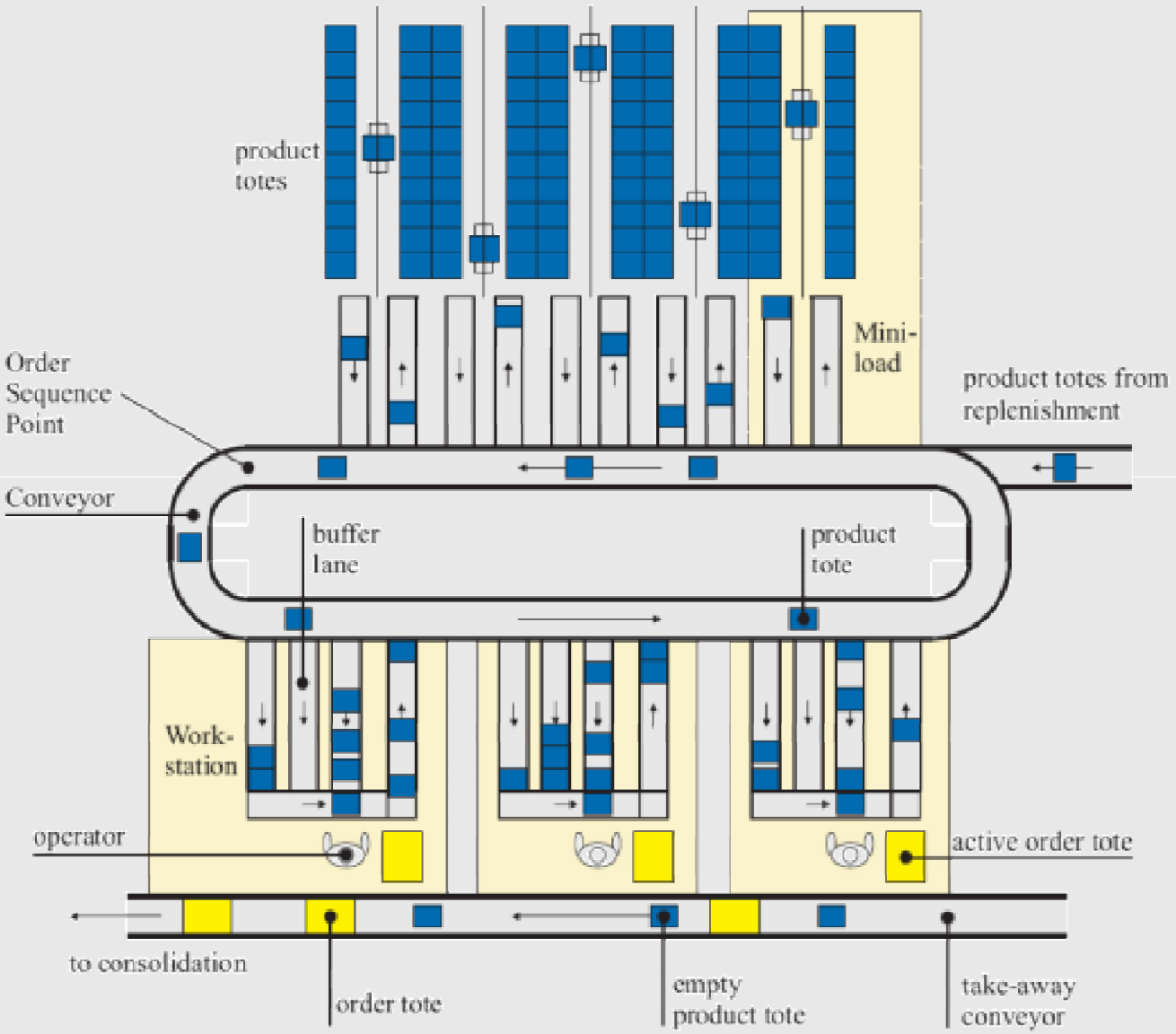




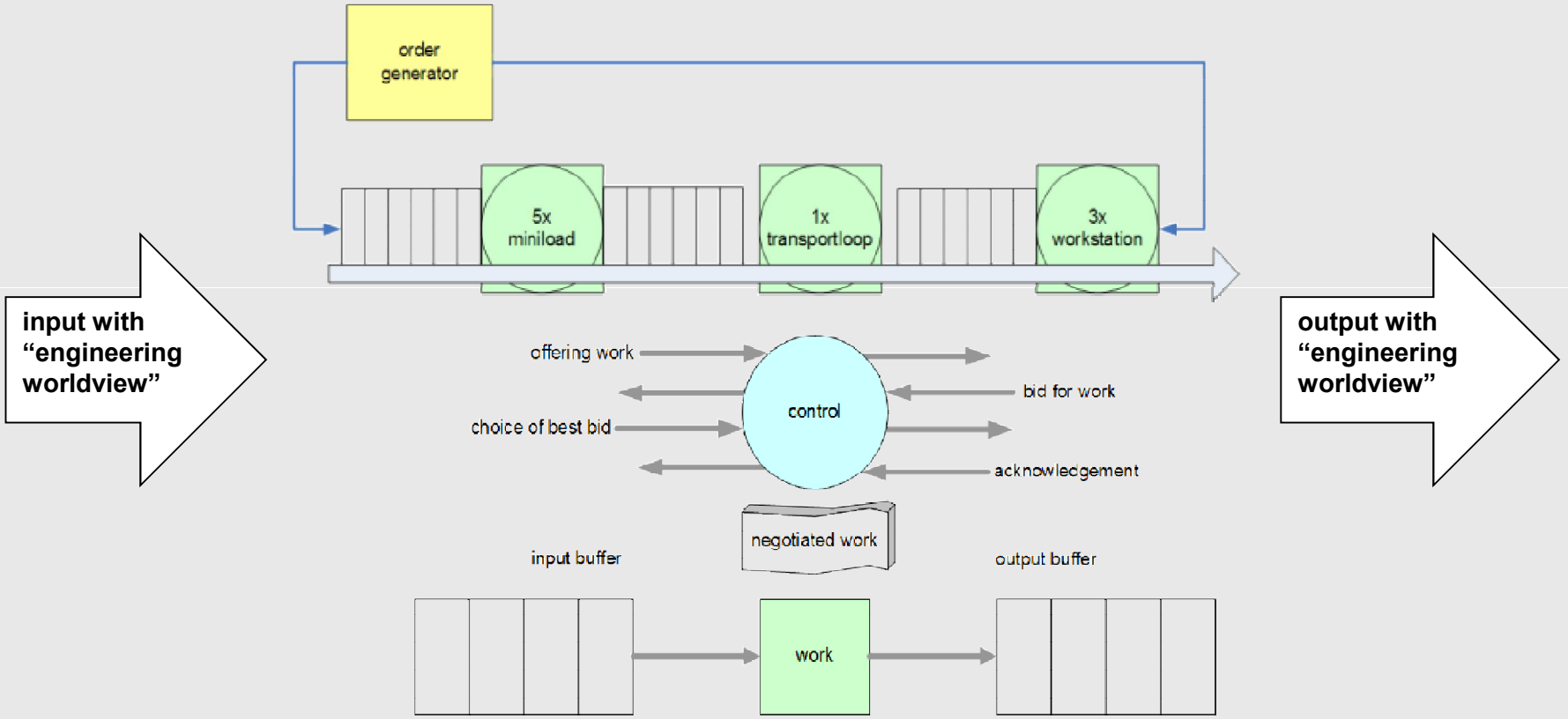




- **Model is a set of interconnected machines and buffers**
- **“Plant” – “Controller” model architecture, controller executes performance optimising algorithms**


product totes
Mini-load
Order Sequence Point
product totes from replenishment
Conveyor
buffer lane
product tote
Work-station
operator
active order tote
to consolidation
order tote
empty product tote
take-away conveyor

Process Algebra model

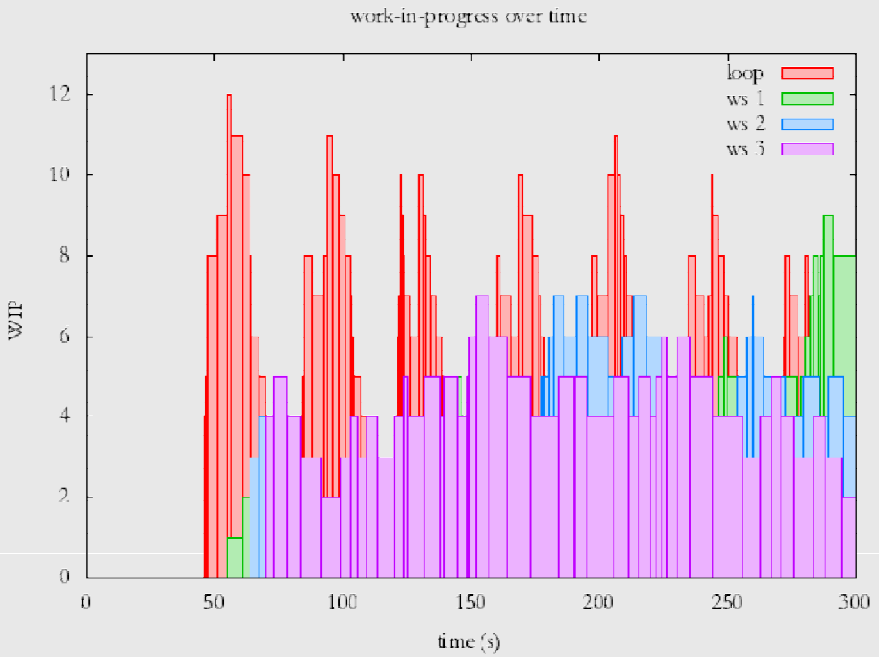


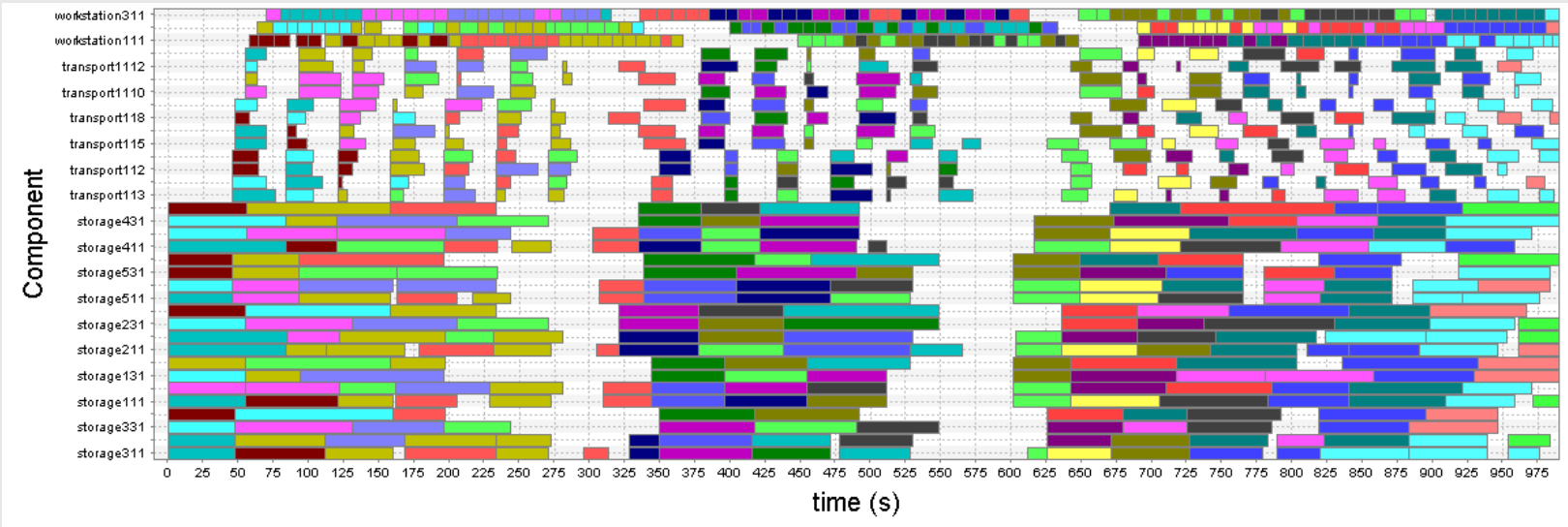
Process Algebra input

	A	B	C	D	E	F
1	**Miniloads**	MiniLoads	**Transport loop**		**Workstations**	
2						
3	number of cranes	4	total length of the loop (m)	35.0	number of workstations	2
4	load handling devices (#)	4	speed (m/minute)	50.0	design capacity (totes/hour)	345.0
5	output buffer size (incl. deposit) (totes)	8	design capacity (totes/hour)	1500	variation in process time (%)	20.0
6	design capacity (totes/hour)	185.0	distance last ASRS and first workstation (m)	10.0	number of assigned orders	4
7	variation process time (%)	15.0	distance between ASRSs (m)	2.5	number of pick-to locations	4
8			distance between workstations (m)	4.0	product tote input buffer type	FIFO
9			loop buffering (totes/workstation)	0	product tote input buffer size (totes)	12
10						
11						
12						
13	**order size distribution**		**Maximum simulated time (hours)**	5		
14	size	weight			number of positions on the loop	18
15	1	30			estimated window length (m)	1.9
16	2	10			corrected total cycle time (s)	43.2
17	3	4			return distance (m)	13.5
18	4	1			system design capacity (totes/hour)	690
19	5	1				
20					average order size	1.5
21					assigned orders * average order size	6.2
22						
23					average travel time ASRS (s)	13.8
24					(based on constant tote handling time = 16 s)	
25					shortest possible ASRS cycle (s)	18.2
26						
27						
28						
29						
30						
31			Save XLS copy		Simulate	Visualize
32						
33						
34						

Process Algebra output

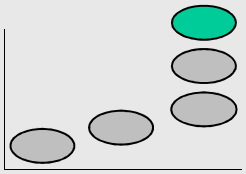
component	para	average	[confidence]	accur	[min, max]
storage1	Thru	195.3	[192.5, 198.0]	1.4%	[180.3, 208.3]
	flow	92.9	[88.3, 97.5]	5.2%	[28.7, 271.2]
	WIP	5.0	[4.7, 5.4]	6.8%	[0.0, 14.0]
Transport1	Thru	977.0	[960.9, 993.1]	1.7%	[793.2,1175.5]
	flow	16.6	[16.4, 16.8]	1.2%	[3.0, 57.8]
	WIP	4.5	[4.3, 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]

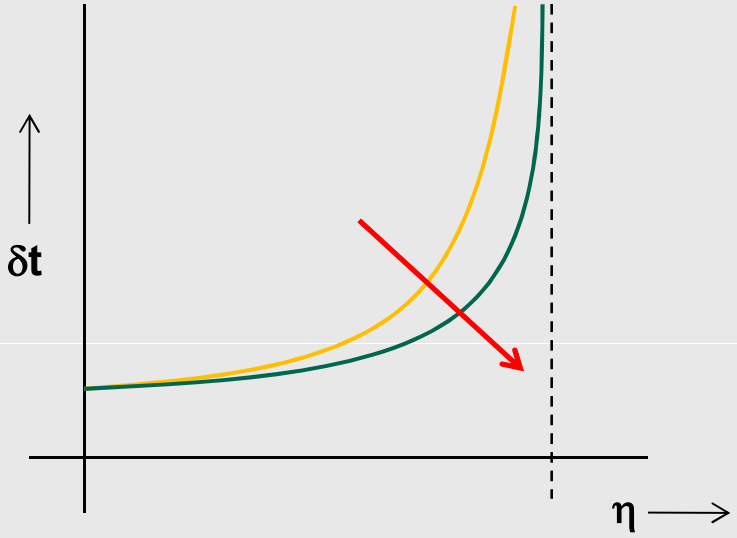




Analytic models

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





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 analytic models?

Can a solution be validated using analytic models only?

How to expand our comfort zone to analytic models?