CONWIP

(A pull alternative to kanban principle)

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Diagrams, modifications, structures and editing (J.Skorkovský,KPH)

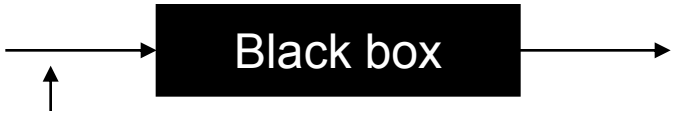
Methodologies used for effective production control

- Based on PULL principle
  - JIT
  - kanban
  - zero inventory

  → greatly reduced inventory levels and production lead times
    - kanban (mostly used for repetitive manufacturing)
- Based on PUSH principle
  - MRP (MRP-II)
- Based on both principles (push and pull)
  - CONWIP (Constant Work In Progress)

PUSH and PULL

- **PUSH :** production jobs (production orders) are scheduled (MRP nad MRP-II)
  - often not feasible plans are generated and problems are often detected too late
  - used fixed lead times=LT (see next slide) do not depend on capacity utilization
  - Having in mind , that production is random process, LT is very pessimistic



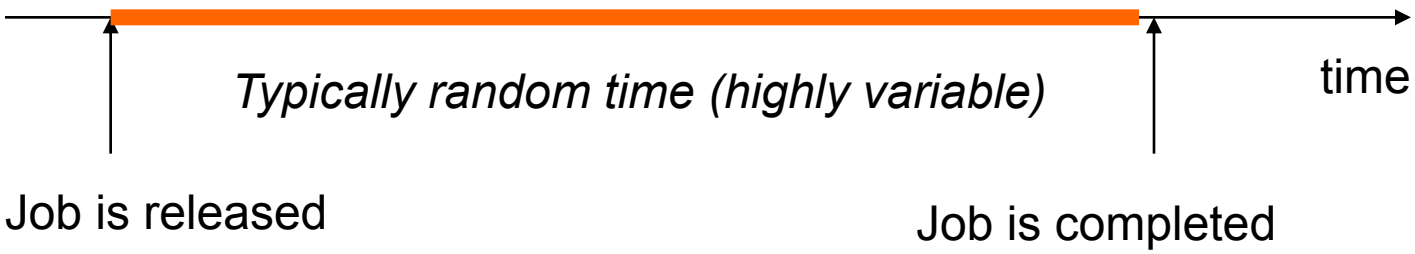
t=start of the job

t+LT=end time of the job (where LT=constant)

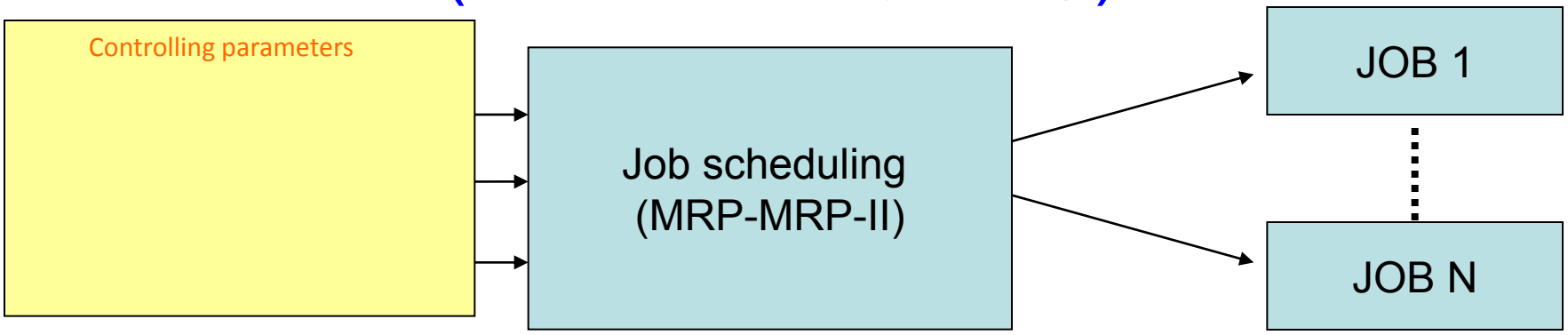
- **PULL :** production jobs (production orders) starts are triggered by completion of another job

Flow time and Lead time

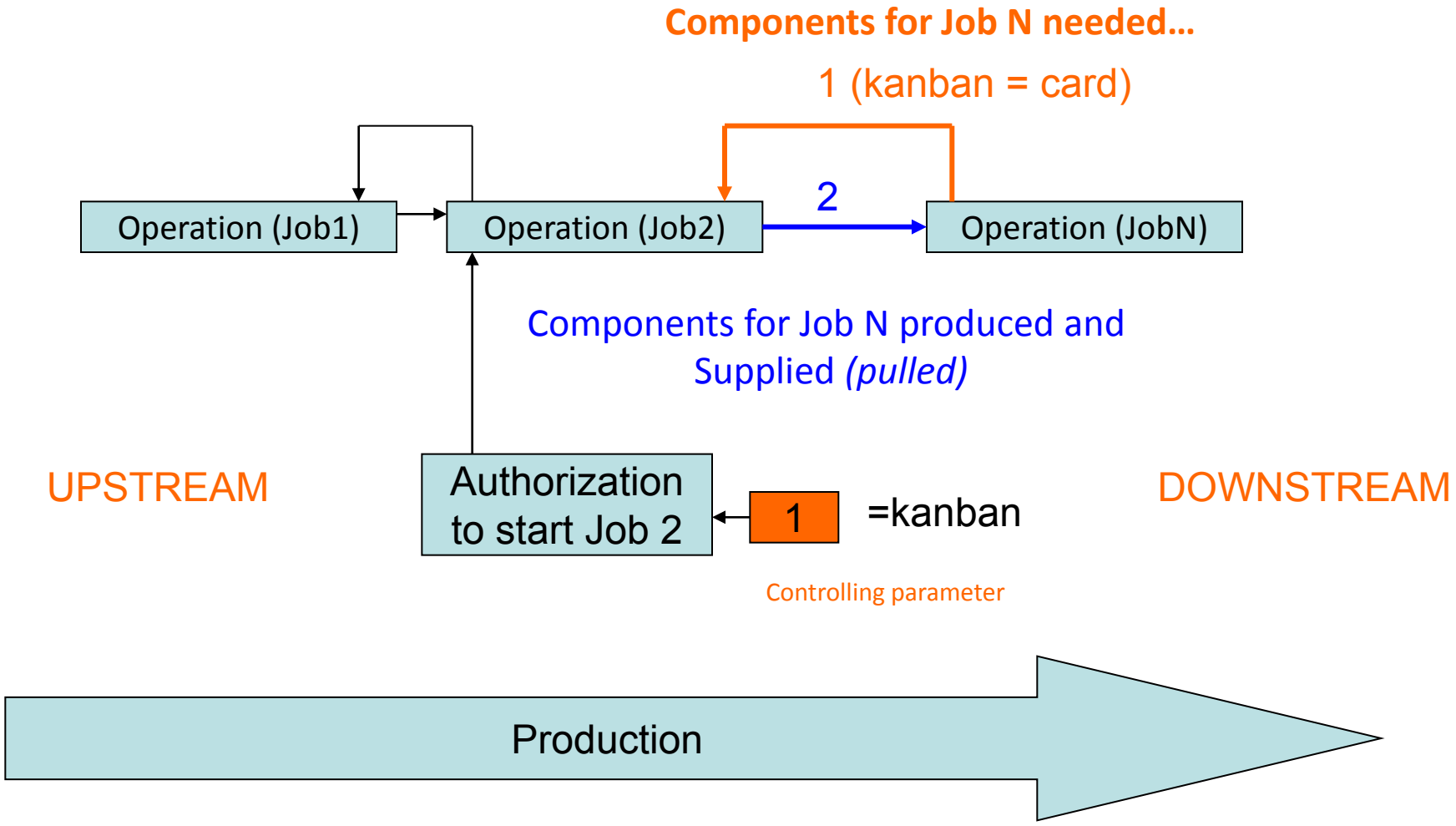
- Flow time (known also as a „cycle time“)



- Lead time (constant used for planning)



FGI – finished good inventory



The number of cards in the system determines the WIP levels in the plant

JIT

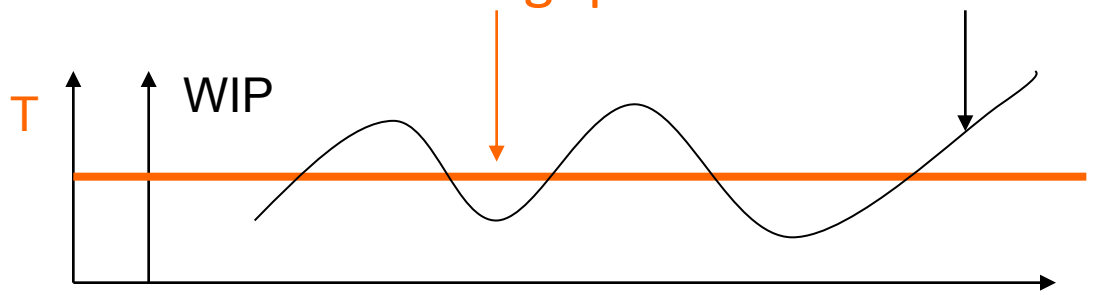
- Kanban is not JIT (manufacturing philosophy)
- JIT encompasses：
  - kanban
  - total quality control (TQM) – e.g. scrap loss not tolerated….
  - setup reduction
  - worker participation
  - lean production (low level of waste)
- Advantages of JIT philosophy：
  - reduced WIP
  - shorter flow times
  - lower production costs
  - greater customer responsiveness

PUSH and **PULL** are not mutually exclusive approaches and other statements…

- **Push** and **Pull** can be combined
- MRP is considered to be more applicable than kanban
- MRP is in almost any discrete part production
- Kanban(JIT,pull) – superior results if applicable
- Kanban(JIT,pull) – is difficult to use if :
  - Jobs with short production runs
  - Significant setup times
  - Remarkable Scrap losses
  - Unpredictable fluctuation in demand

PUSH and **PULL** and the types of the queueing networks

- **Push :** open queueing network
- **Pull** : closed queueing network
- **Push :** schedule Throughput and measure WIP



- **PULL :** setup WIP and measure Throughput

Advantage of **PULL** over **PUSH**

- **PUSH** : WIP and Throughput fluctuations – result in violation of the assumption, that Flow Times (**FT**) and therefore Lead Times (**LT**) are constant !
- WIP is easier to optimize than Throughput (**T**)
- **Little´s low :**

  Average **FT**=Average **WIP**/Average **T** – meaning that **FT** cannot be constant but vary with **WIP** and **T** - ***Little´s low see later in this PWP presentation !!***

- **Pull is easy to manage :** why ? -> **WIP** is easier to control than capacity needed to appropriately release work in **push** system must be estimated

CONstant Work In Process = CONWIP

- System having benefits of a PULL and can be used in variety of manufacturing environment
- CONWIP : generalized form of Kanban
- CONWIP relies on signals (electronic, paper cards…)

CONstant Work In Process = CONWIP

- **Kanban:** card is used to signal production of a specific part

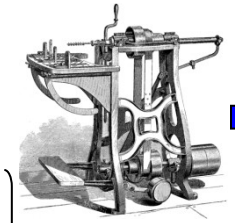
- **CONWIP :** card is assigned to production line and are not part number specific

CONWIP

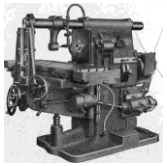
cards

Container C

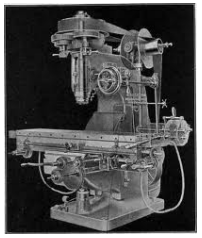
Container B



parts



parts



Queue (First in system first served=FSFS)

Container A

Container A

Container A

Container A

Baglog list

1 : 6 pc
2 : 6 pc
3 : 8 pc
4 : 8 pc
6 : 0 pc
5 : 0 pc
7 : 0 pc

SET=8:00

Baglog list

1 : 6 pc
2 : 6 pc
3 : 0 pc
4 : 0 pc
6 : 4 pc
5 : 0 pc
7 : 0 pc

SET=10:00

Baglog list

1 : 0 pc
2 : 0 pc
3 : 0 pc
4 : 0 pc
6 : 4 pc
5 : 2 ks
7 : 0 ks

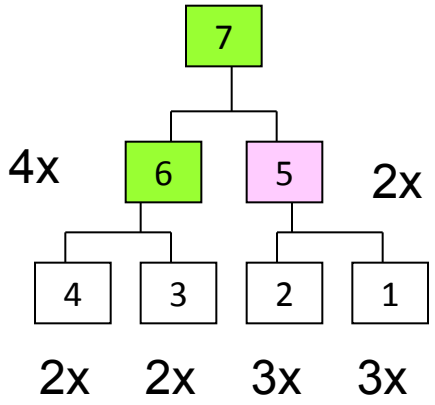
SET=12:00

Baglog list

1 : 0 pc
2 : 0 pc
3 : 0 pc
4 : 0 pc
6 : 0 pc
5 : 0 ks
7 : 1 ks

SET=14:00

BOM of the final product (7)



System Entry Time=SET

maintaining of BLL is responsibility of inventory control staff

CONWIP parameters

- The card count (it determines the max WIP level for the line) **=m**
- Production quota (target production quantity/period) **=q**
- Maximum work ahead amount =n (if q+n is produced during a period, the line is stopped until the start of the next period)

CONWIP-air traffic control

Originating airport

Destination airport
(air above airport)

If heavy air traffic, departing planes should be held on the ground at the originating airport rather than control flying aircrafts in the air above destination airport as a holding pattern

The results : greater safety and lower fuel consumption

CONWIP-Theory of Constraints

- Balance the flow and not the capacity
- Operation of the CONWIP line is regulated by the bottleneck resource
- If we have sufficient demand, the correct number of the cards will maintain just enough WIP to keep bottleneck busy

Děkuji za pozornost

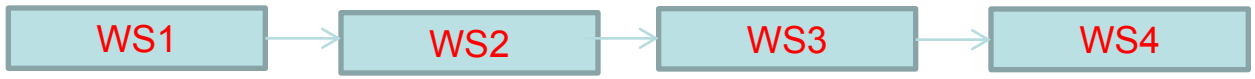
(pozor, další snímky budou částečně použity v prezentaci Littl´s law)

Utilization, Bottleneck rate and Raw process time (cycle time)

- Arrival rate to the machine (working centre) = AR
- Effective Production Rate (maximum average rate at which workstation can process parts, considering effects of failures, setups and other detractors that are relevant over the planning period) =EPR
- Utilization = AR/EPR = U
- $r_b = parts\ per\ time\ unit\ of\ the\ workstationwith\ highest$ long-term utilization (U)
- T_0 = raw process time of the line = $\sum_1^N PT_i$,where N= number of workstations
- **Critical WIP** =$W_0 = r_b \times T_0$,where T_0 =minimum cycle time and r_b= maximum throughput

Example

- Capacity of 4 machines is equal
- Thus every machine is bottleneck
- Line is balanced
- r_b=0,5 product/hour
- Daily line produces 12 products = 0,5 x24
- T_0 =8 hours=2 hours (product on one machine) x 4 machines in the line
- **Critical WIP** =W_0= $r_b \times T_0$ =0,5 x 8 =4 product
- S



Little´s Law

- WIP=TH x CT ,where TH=throughput and CT=cycle time

Little´s Law

WIP	CT	TH
1	8	0,125
2	8	0,250
3	8	0,375
4	8	0,500
5	10	0,500
6	12	0,500
7	14	0,500
8	16	0,500
9	18	0,500
10	20	0,500
11	22	0,500
12	24	0,500