Little´s law basics

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Different times used in Little´s law

(used in different resources)

- Lead time (LT)
- Flow time (FT)
- Cycle time (CT) we will use only this time

It is **essential** to define precisely all mentioned times to better understand the principles of Little´s law- see time variables explanation in the following slides

WIP=TH x CT

Definitions – time variables

- **CT**=average time from when the job is released into the station (machine or line) to when it exits

Only explanations if you will use different literture

- **LT**=management **constant** indicating the time allotted (assigned) for production of a part on a given routing – used more often in planning
- **CT =FT** (in different publications they use **FT** instead of **CT**), where FT stands for=Flow Time
- **CT**=**Throughput Time** (in different publications they use Throughput Time instead of CT)

Other two variables of Little´s law

- **WIP**= Work in Process (Work in Progress)

- **TH**=Throughput=Throughput Rate = average output of the production process (machine, workstations) per unit time

Facilities -suitable for the application of the law

One example to be solved

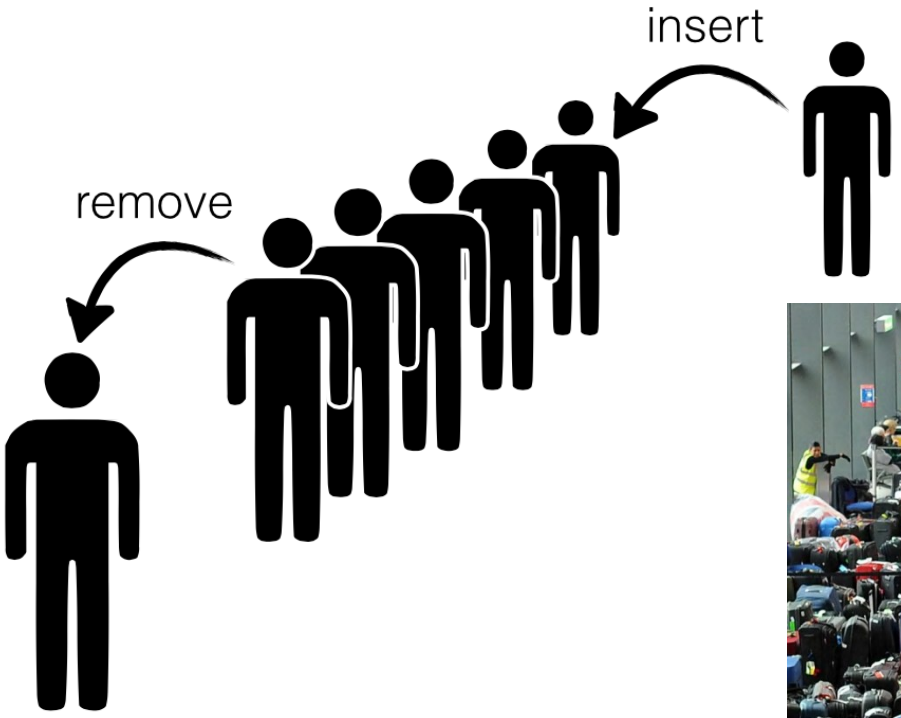
- **30** customers/hour – (max capacity of the facility). The **Facility** may be a hairdresser, fast food, bank counter, airport checking, massages and so on.
- 8 customers waiting in the queue (buffer) – **see next slide**
- **5** minutes take service of one customer

8 customers
waiting in the queue

5 minutes/service of **1** customer
at one serving point (run time)

- **You need to remove all times that do not add value to the process**
- **1 serving point** = **12** customers per hour -> (**60** minutes/**5** = **12**),
  for **30** customers/hour the needed **2.5** = **30**/12 of serving points

WIP=TH x CT



Buffering

A buffer is used to temporarily keep data (customers in our model) while it is being moved from one place to another. A buffer often adjusts timing by implementing a queue or **FIFO** algorithm in memory, simultaneously writing data into the queue at one rate and reading it at another rate.

Questions to be answered

- How long does the customer wait in the queue?
- How many people on an average can be served at once?
- How many customers are in the facility just in time (both pending and those served by facility staff)?
- What is the average time of the "flow" of the customer by the facility (wait and service)

Simplifying conditions :

"Input flow" (average) = "Output flow" (average)- **steady flow** (see video at the end of this PWP)

We do not consider fluctuation due to averaging (see flip a coin situation)

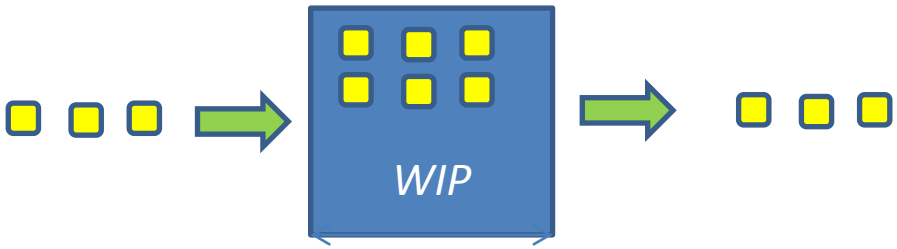
Key metrics and variables (completion of definitions)

- **CT** =Cycle Time (how long takes the whole process) = **5 minutes take the service of one customer**
- **Work In Progress** = **WIP** (how many units are in process at any moment = **W**ork **I**n **P**rogress)
- **Throughput** =**TH** (how many customers/time unit) – *e.g. In our case 30/hour = 30/60*

- These metrics are tied together by Little´s law **WIP=TH x CT**

- **Our example** : **TH=30 customers/hour** , service of one takes **5** minutes, **WIP**=(30/60) *(**5**/1)=(1/2)*5 =**2,5**

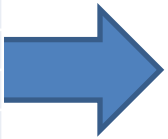
TH in minutes



Cycle Time

Solution (home study, C=Customer)

Proces	WIP	TH (Cust/hour)	CT
Buffer	8	30	
Service		30	**5**
Total		30	



Proces	WIP	TH (Cust/hour)	CT (min/Cust)	Time
Buffer	8	30	5	
Service		30	5	5
Total		30	5	

WIP =TH x CT

Proces	WIP	TH (C/h)	CT(min/C)	Time
Buffer	8	30	5	
Service	2,5	30	5	5
Total	**10,5**	30	5	

CT= WIP /TH (third column is only se see the units)

Proces	WIP	TH(C/h)	CT (/min/C)	Time
Buffer	8	30	5	16
Service	2,5	30	5	5
Total	**10,5**	30	5	**21**

Input data (from previous slides)

30 customers/hour - > (max **Capacity** of the facility) = Throughput = **TH**

8 customers are waiting in the queue = **WIP2** = buffer

5 minutes per customer service = **CT**

WIP1 = THxCT = ((30/60) * 5) = (3 * 5) / 6 = **2,5**, so how many customers can be served at the same time and total quantity of customers is after that **10.5** = **8.0** (queue) + **2.5** (WIP1+WIP2) and then:

CT = WIP2 / TH **= 8** / (30/60) = (**8** * 6) / 3 = 48/3 = **16** (as long as the customer waits in the queue=buffer) and finally for control **CT** = **5** = (2.5 / (3/6)) = 2.5 * 6/3 = 15/3 is the service time (already entered). So total time is 16+**5**=21

Questions

- How long does the customer wait in the queue? ->**16 minutes**
  - How many average people can be served at once? ->**2,5 customers**

  - How many customers are in the facility just in time (both pending and those just serve by facility staff)? **10,5 customers**
  - What is the average time of the "flow" of the customer by the facility (wait and service) -> **21 minutes**

Little´s law-2nd part

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Based on resource : Factory Physics (Hopp and Spearman)

Little´s law - definition (formula)

- Fundamental relationships among :
  - WIP (Work In Process)
  - Cycle Time (CT)
  - Throughput (T or sometimes TH)
- Formula

$$WIP = TH \times CT$$

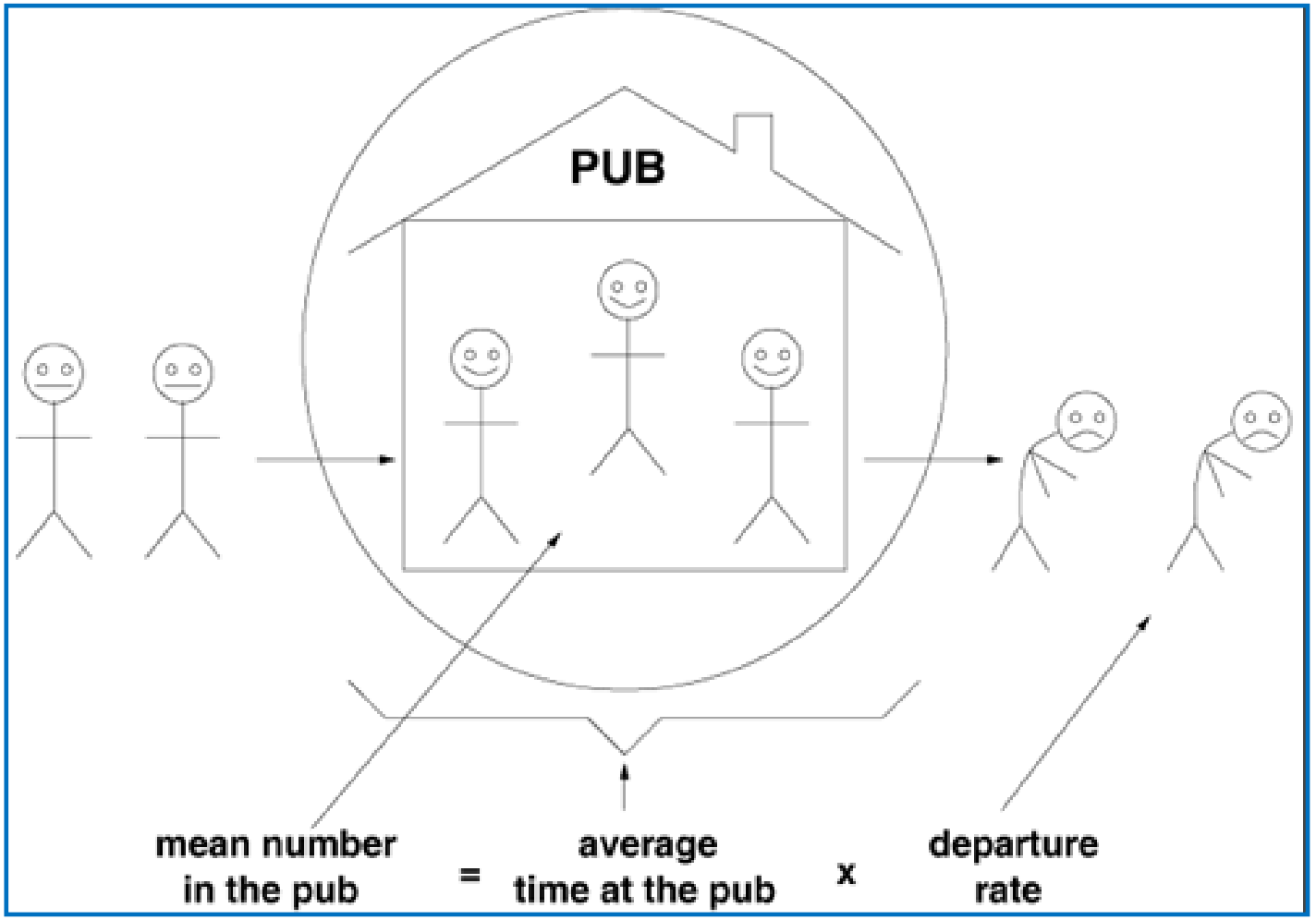
- Can be applied to :
  - Single machine station
  - Complex production line
  - Entire plant

Relationships among these variables will serve to se clearly precise (quantitative) description of behaviour of the single production line . It helps user to use a given scale to benchmark actual production systems

I finally figured it out !!!!

Avg.Lead Time =Cycle Time !!

Daily application of the law….



Definition of basic parameters (supplements)

- **Throughput (Throughput rate, TH)** : production per unit time that is sold (see TOC definition)
- If **TH** is measured in **cost dollars (not in customers/time)** , it is typically called :

Cost of good sold (COGS)

- **The upper limit** of **TH** in the **production process** is the **capacity**
- If you release more raw material above the capacity of the line (machine), the system becomes unstable –> WIP goes up !! See later …

Definition of basic parameters (supplements)

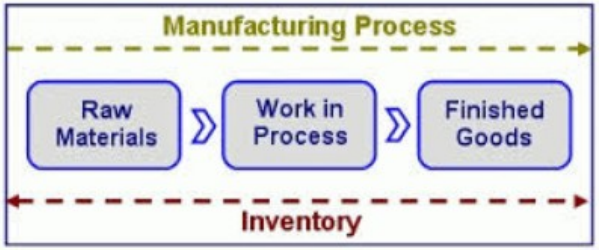
- **WIP (Work In Process)** : inventory between start and end points of the production routing

- **WIP** can be used as one parameter to calculate (measure) an **efficiency**

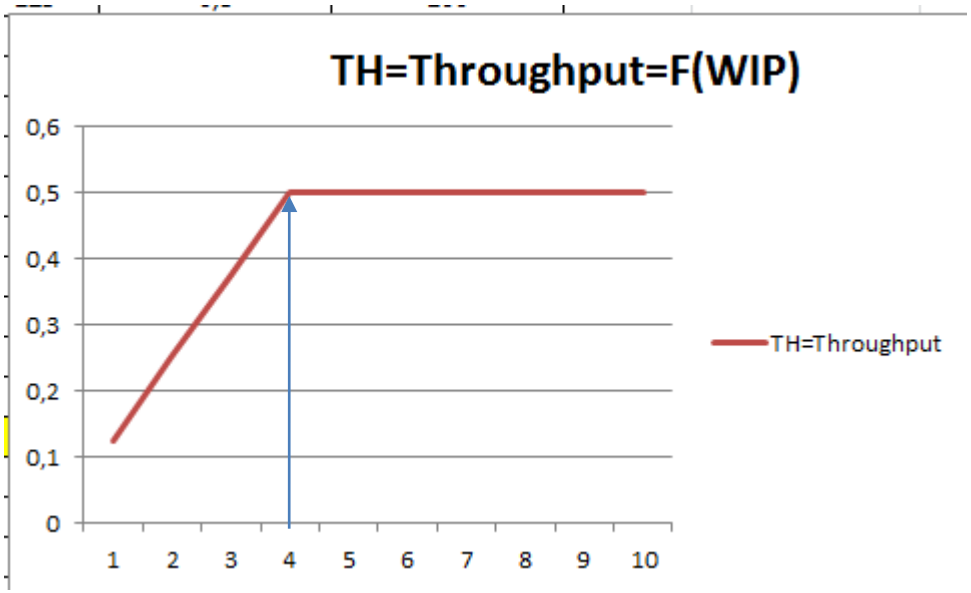
- **Efficiency** can be defined as **Turnover Ratio** = **TH**/**FGI** for warehouses or **TH**/(**FGI**+WIP) for production plants where **FGI**=Finished goods inventory

- **WIP** : inventory still in line

- **FGI** : inventory waiting for dispatch (shipping)



Best case performance



Resources

- **WIP=TH * CT**
- *Source : Factory Physiscs, Wallace J Hopp and Mark L. Spearman ; ISBN 13: 978-1-57766-739-1 or ISBN 10 :1-57766-739-5*

  http://www.factoryphysics.com/principle/littleslaw.htm

Example 1 (home study)

- **Estimating Waiting Times:** If are in a grocery queue behind 10 persons and estimate that the clerk is taking around 5 minutes/per customer, we can calculate that it will take us 50 minutes (10 persons x 5 minutes/person) to start service.
- This is essentially **Little's law.** We take the number of persons in the **queue** (10) as the "**inventory**".
- The inverse of the average time per customer (1/5 customers/minute) provides us the rate of service or the Throughput.
- Finally, we obtain the waiting time as equal to number of persons in the queue divided by the processing rate 10/(1/5) = 50 minutes).

Example 2 (home study)

- **Planned Inventory Time:** Suppose a product is scheduled so that we expect it to wait for 2 days in finished goods inventory before shipping to the customer. This two days is called **planned inventory time** and is sometimes used as protection against system variability to ensure high delivery service. Using Little's law the total size of inventory in finished goods can be computed as :
- **FGI = throughput × planned inventory time**

Youtube examples (6 minutes)

- http://www.youtube.com/watch?v=VU8TUSnQ-vw
- http://www.youtube.com/watch?v=rtGihR-bm-U