Tutorial 7 Part 1
Analysing Business Processes

Objectives:

- **Describe the relationship between these operational variables using Little's Law**
- **Analyse cycle time and capacity**

1. Describe the terms work-in-process, throughput and cycle time. Using Little's law to define the general relationship between them.

Suggestion:

Briefly describe each element, and the general relationship between work-in-process, throughput and cycle time.

WIP = Average number of jobs in the system
λ = The throughput rate (=arrival rate)
CT = The average cycle time = the average time a job spends in the system

Little's Formula: WIP = $\lambda \cdot$CT
The formula states that the average number of jobs in the process is proportional to the average time that a job spends in the process, where the factor of proportionality is the average arrival rate.

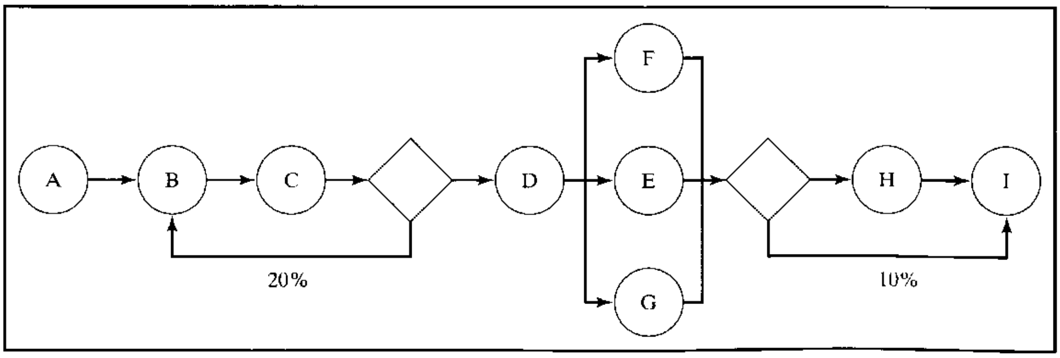
2. A fast-food restaurant processes on average 1,200 customers per day (over the course of 15 hours). At any given time, 60 customers are in the store. Customers may be waiting to place order, placing an order, waiting for the order to be ready, eating, and so on. What is the average time that a customer spends in the store?

Suggestion:

WIP = Average number of customers in the system = 60 customers
λ = The throughput rate (=arrival rate) = 1200/15 = 80 customers per hour
CT = The average cycle time = the average time a customer spends in the system

Using Little's formula it is easy to determine CT:
CT = WIP/λ = 60/80 =3/4 hours = 45 minutes

3. Consider the process flowchart in figure below.



The estimated waiting time and processing time for each activity in the process are shown in table below. All times are given in minutes.

Activity	*Waiting Time (in min.)*	*Processing Time (in min.)*
A	7	3
B	5	8
C	4	2
D	10	5
E	7	2
F	0	3
G	2	5
H	8	9
I	2	8

a) Calculate the average cycle time for this process.
b) Calculate the cycle time efficiency.

Suggestion:
Assuming a job is never reworked more than once in the same rework loop.

a. Calculate the average cycle time for this process.

$CT = T_A+(1+0.2)(T_B+T_C)+T_D+\max\{T_E, T_F, T_G\}+0.9(T_H)+T_I$

The activity time = Processing time + Waiting time

$\Rightarrow$ CT = 10+1.2(13+6)+15+max{9, 3, 7}+0.9(17)+10 = 82.1 minutes

b. Calculate the cycle time efficiency.

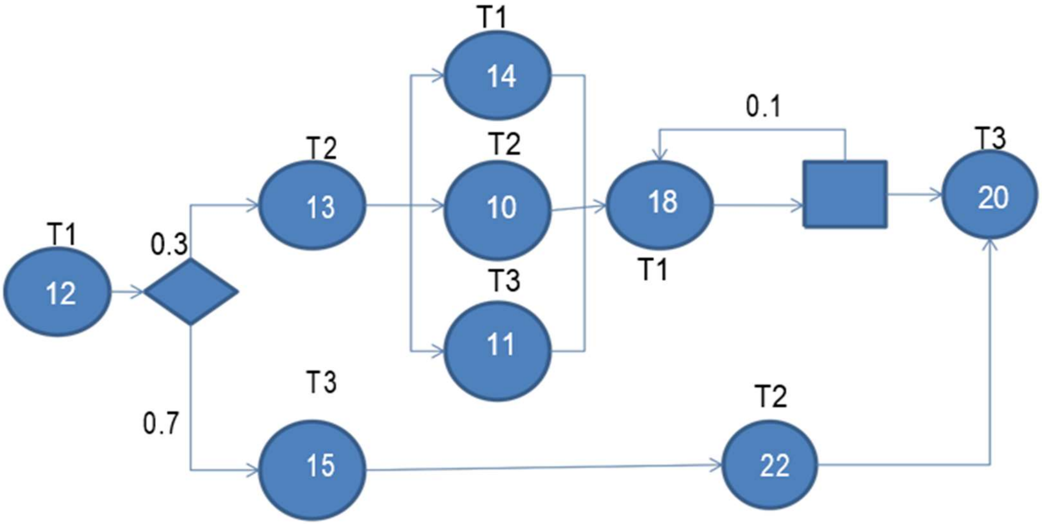
Cycle time efficiency = $\dfrac{Theoretical\ \text{Pr}ocess\ Cycle\ Time}{Actual\ Cycle\ Time} = \dfrac{CT^*}{CT}$

The theoretical cycle time (CT^*) is obtained by using the processing times instead of the activity times (i.e., by disregarding the waiting time).

CT^* = 3+1.2(8+2)+5+ max{2, 3, 5}+0.9(9)+8 = 41.1 minutes

$\Rightarrow$ The Cycle Time Efficiency = $\dfrac{41.1}{82.1} \approx 50.1\%$

4. 3 teams T1, T2 and T3 work in the process depicted in the figure below, where the numbers in each activity indicate processing times in minutes. Calculate the capacity utilization of the process assuming that the throughput is one job per hour.



Resource	Unit load (minutes per job)	Resource units	Capacity (jobs per minute)
T1	12+0.3*(14+1.1*18) = 22.14	1	1/22.14 = 0.0452
T2	0.3*(13+10)+0.7*22 = 22.3	1	1/22.3 = 0.0448
T3	0.3*11+0.7*15+20 = 33.8	1	1/33.8 = 0.0296

The bottleneck is resource T3 with capacity 0.0296 jobs/minute

The theoretical capacity = the capacity of the bottleneck = 60*0.0296 jobs/hour = 1,775 jobs/hour

Actual capacity or throughput = 1 job/hour
The capacity utilization = Actual capacity/Theoretical capacity = 1/1.775 ≈ 56%