Process Analysis

Work-In-Process Inventory

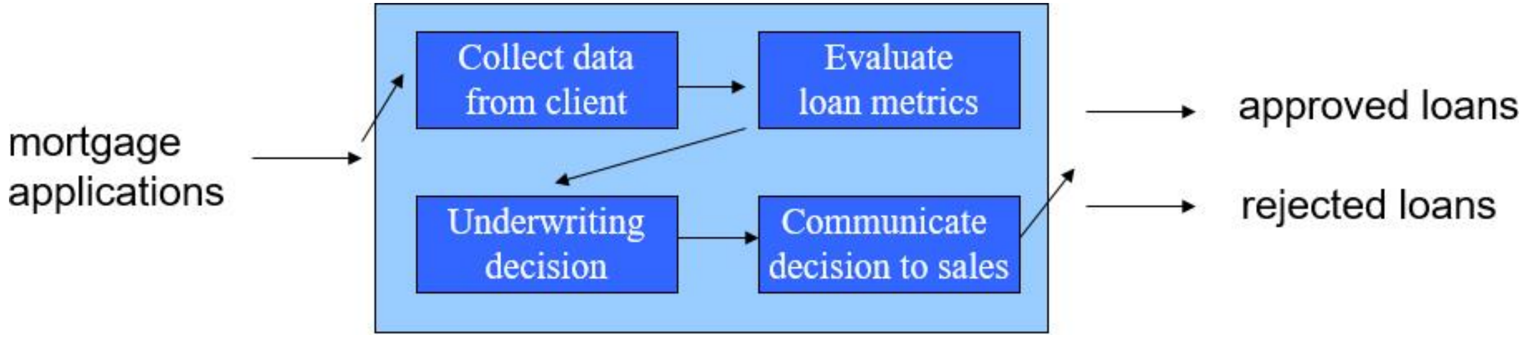
How is the process doing ?

How could I make it better?

Process: A process is a set of tasks to be performed in a defined sequence and uses inputs (such as labor, capital, knowledge, raw materials, purchased components and energy) to create outputs that are of create value to customers and therefore to the organization itself.

A process can be defined at an aggregate level:

A process can be defined at a micro level, with multiple sub-processes:



Defining a process’s flow unit / flow rate / flow time

Flow unit – single unit tracked through the process and generally defines the process output of interest.

Flow rate - measures the number of flow units that move through the process in a given unit of time.

Flow time - The amount of time a flow unit spends in a process from beginning to end, which includes the time it is worked on at various resources as well as any time it spends in inventory.

For Example: Processes	Flow unit	Flow rate	Flow Time
Income Call → Call center → Completed call	Phone call	On average 11 calls per minute	On average caller spends 2.5 minutes with the call center
Students → University → alumni	A student	180 students per year	18 months
Milk → Processing plant → milk powder	Pounds of milk powder	450 Kg	8 manual hours

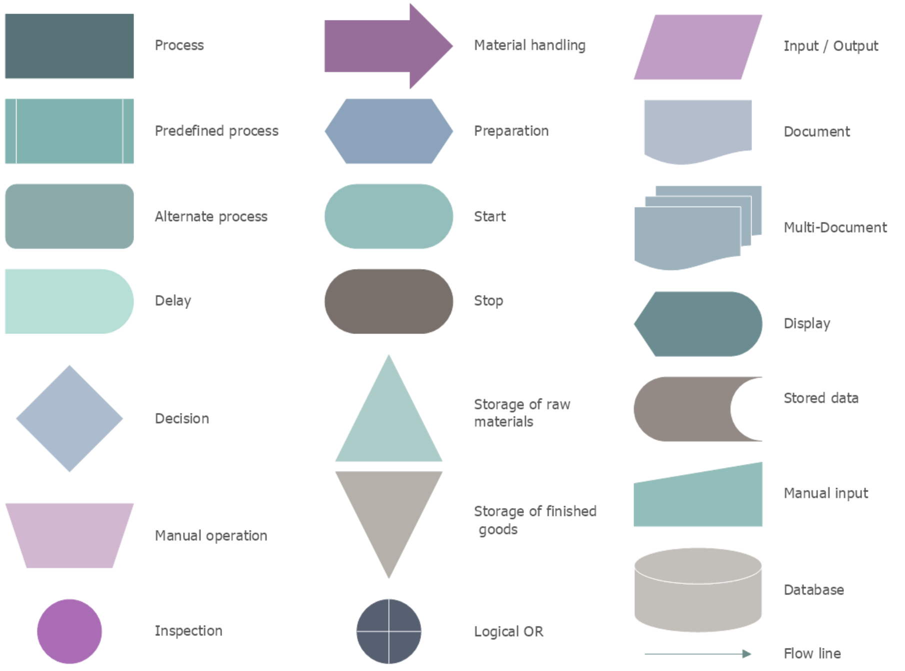
Process Flowchart or Flow Diagram

It maps resources and inventory and shows graphically how the flow unit travels through the process in its transformation from input to output

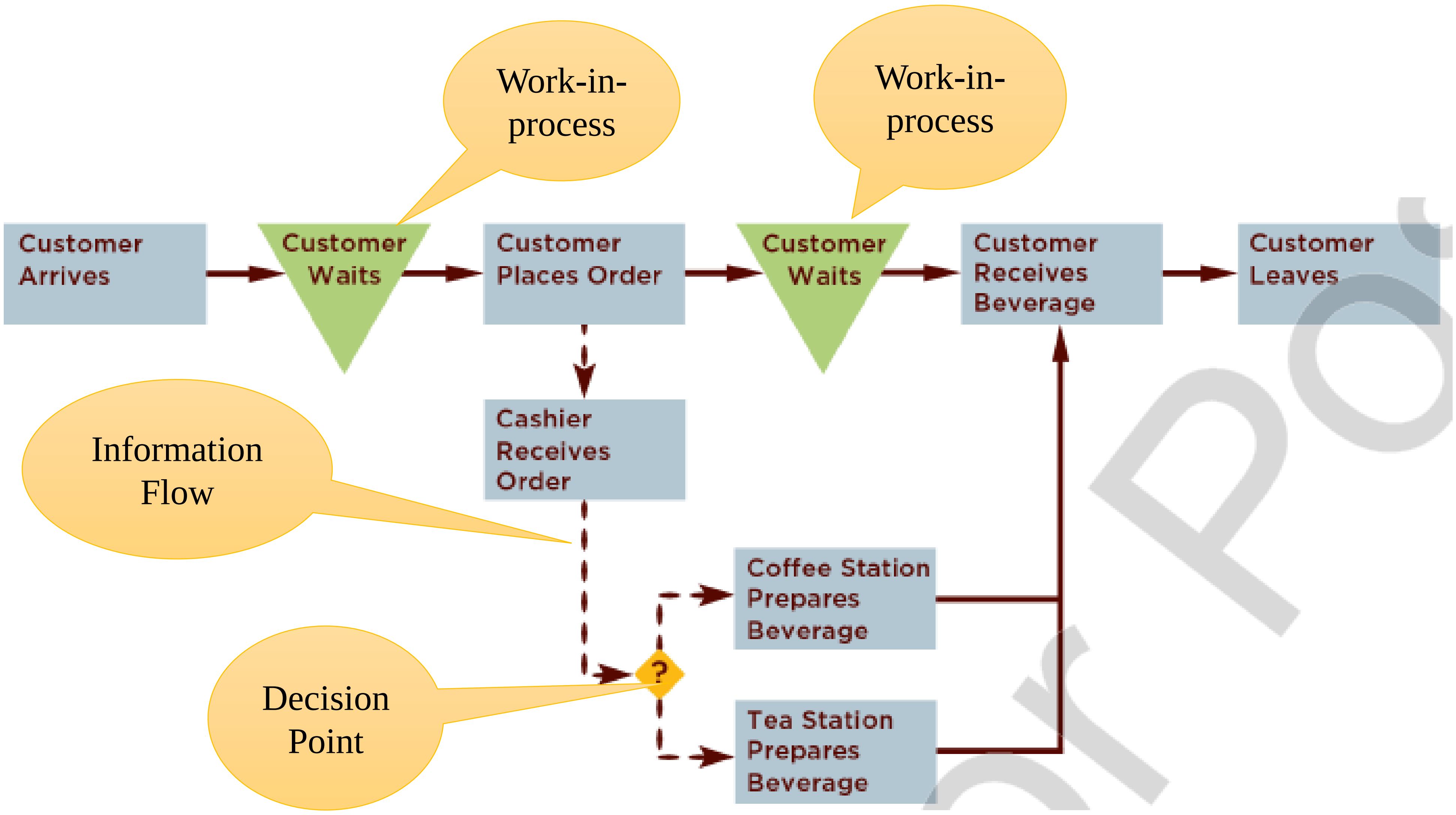
Process flow diagram used to present *the major elements of a process*

The basic elements can include tasks or operations, flows of materials or customers, decision points, and storage areas or queues

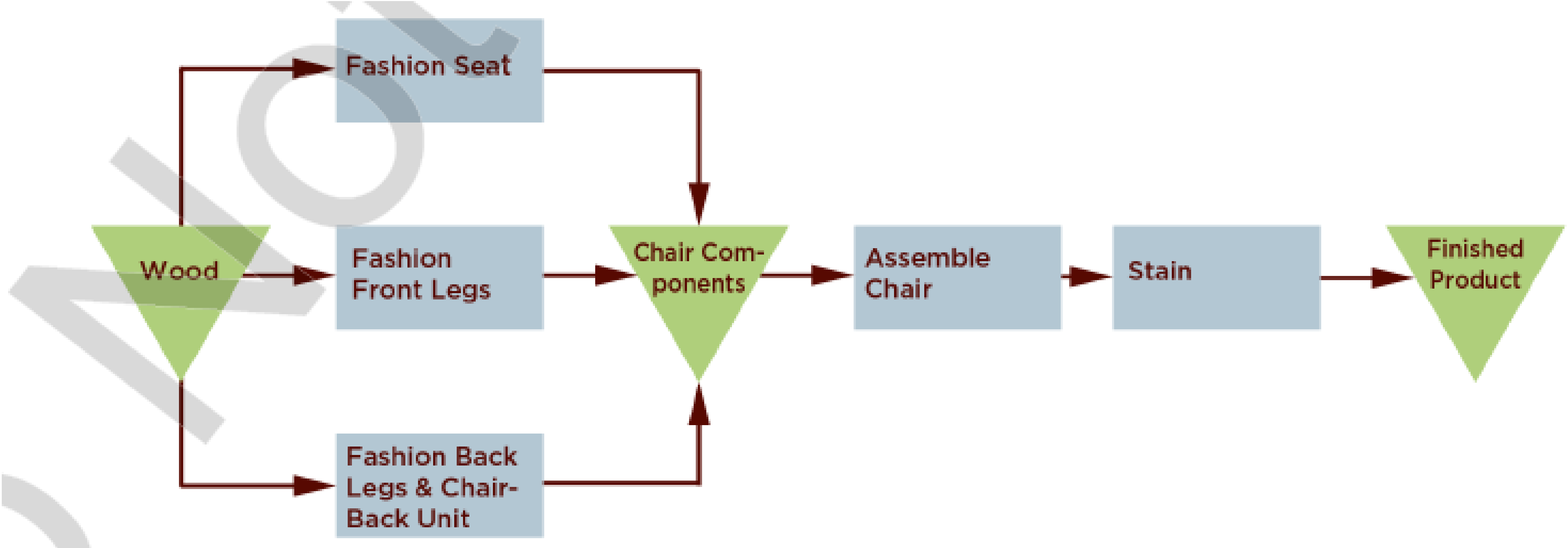
It is an ideal methodology to conduct process analysis



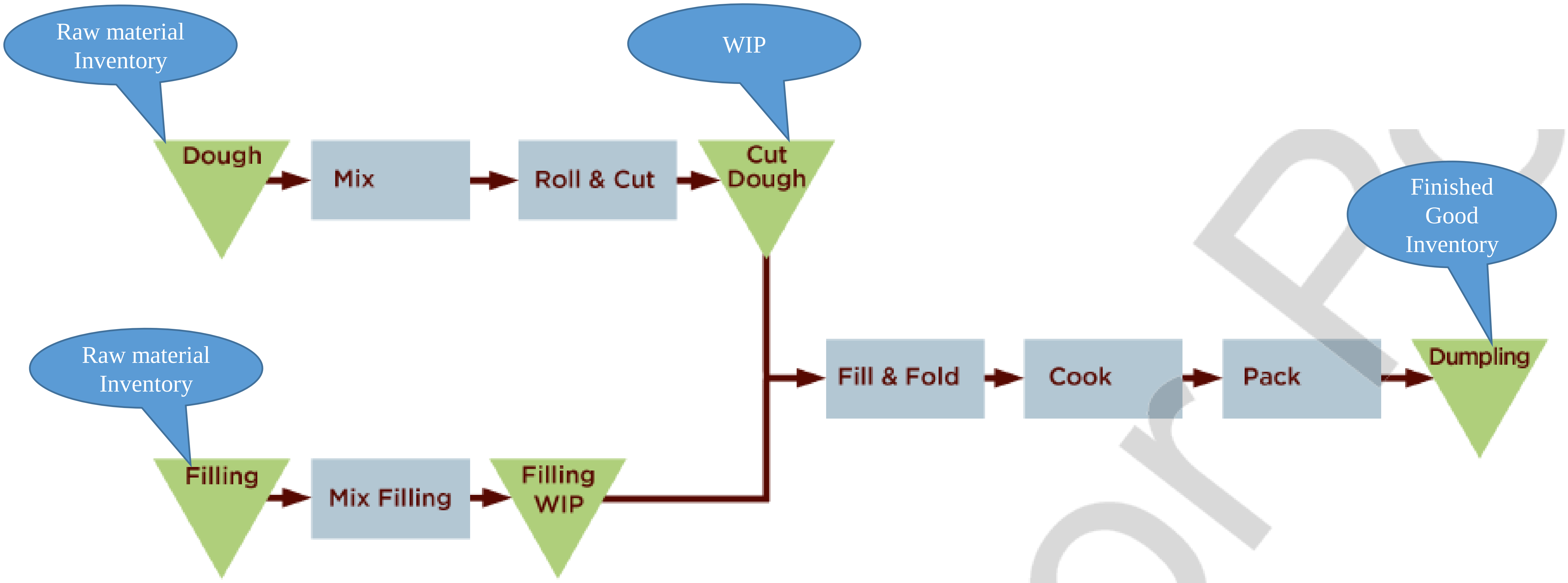
Process Flow Diagram: Café



Parallel Process Flow Diagram for Making Chair

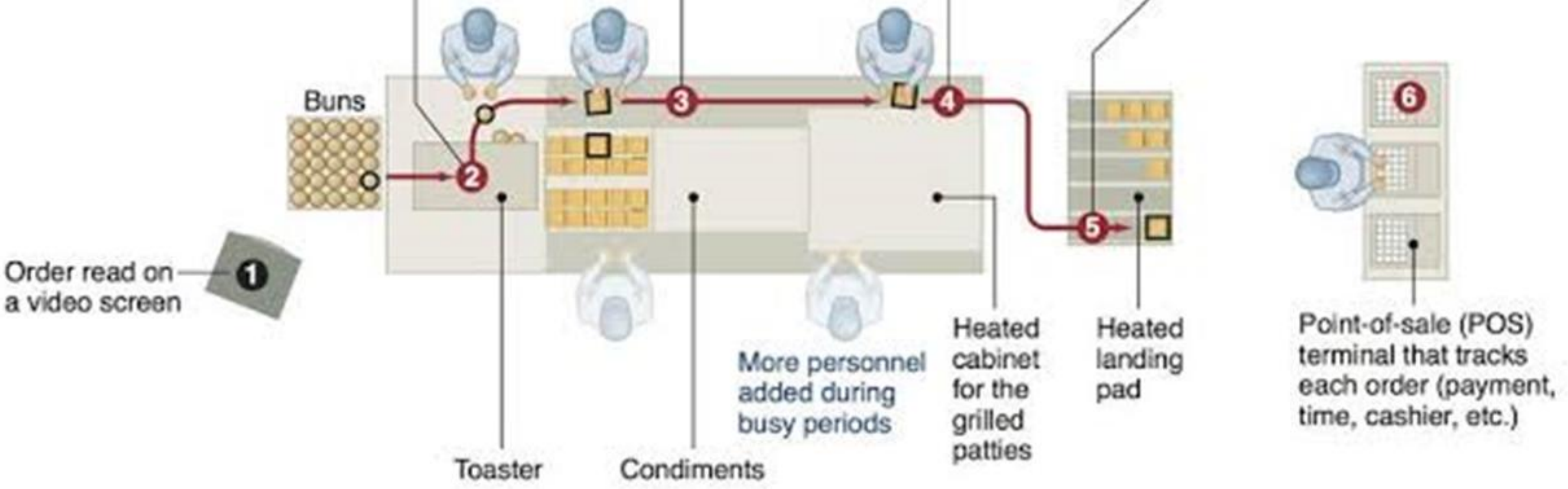


Batch and Parallel Process for Making Dumplings



McDonald’s Kitchen Process

Elapsed time	0:00	0:11	0:31	0:45		1:30
Task time (seconds)		11	20	14	0	45
Task	1. Order	2. Bun toasting	3. Assembly with condiments	4. Wrapping of patty with bun	5. Order picked up immediately to keep it fresh	6. Customer service (order and payment)



Process Analysis

- Do I have adequate number of resources to meet the demand?
  - *If I need to add some extra resources where should I add?*
- What is the utilization of my resources?
- If I need to increase the capacity of my system how should I modify the process?
  - *Should I add some more resources?*
  - *What will the cost of my operation?*
- One can find answers to the above questions by *process analysis*

Process Analysis - Performance Metrics

Setup Time: The time required to prepare a machine to produce a particular item.

Cycle time: The average time between completions of successive units in a process

Bottleneck: The task or resource that limit the capacity of the process (or) the bottleneck of any process is the task that causes all other tasks to have idle time.

Throughput Time: Start to Finish Time of a Process or (the elapsed time from the first stage of the process to the last stage of the process. It is also known as lead time)

Cycle Time

The cycle time is the maximum time allowed at each workstation (WS) to compete its set of tasks on a unit.

Example: Suppose that the work required to fabricate a certain product (like cutting, bending, assembling etc..) can be multiple workstation divided up into five tasks, with the task times and precedence relationships, as shown in the figure

-> Task A 0.1 min WS 1 -> Task B 0.7 min WS 2 -> Task C 1.0 min WS 3 -> Task D 0.5 min WS 4 -> Task E 0.2 min WS 5 ->

Highest task time is the cycle Time in the sequential process, which is 1.0 min in this case.

Assume that the line will operate for eight hours per day (480 minutes). With a cycle time of 1.0 minute, output would be

$$\text{Output Rate} = \frac{480 \text{ min } per\ day}{1.0 \text{ min } per\ unit} = 480\ units\ per\ day$$

Example: Suppose there is an fully automated car washing service and it is a single workstation with various task, and task times, as shown in the figure

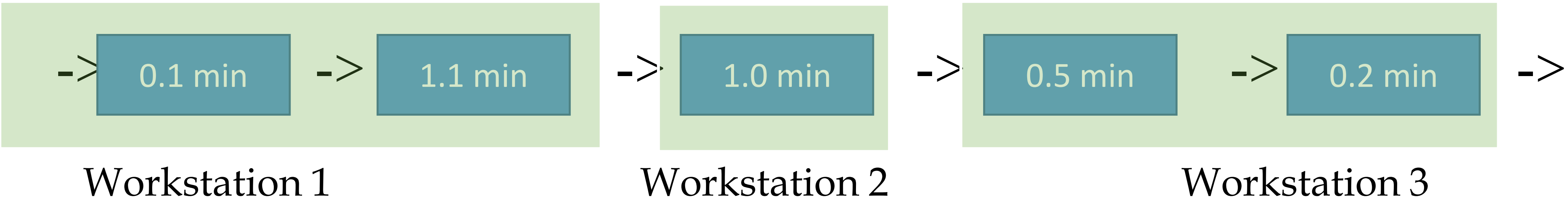
Single Workstation

-> 0.1 min -> 0.7 min -> 1.0 min -> 0.5 min -> 0.2 min ->

Assume that the line will operate for eight hours per day (480 minutes). With a cycle time of 2.5 minute, output would be

$$\text{Output Rate} = \frac{480 \text{ min } per\ day}{2.5 \text{ min } per\ unit} = 192\ units\ per\ day$$

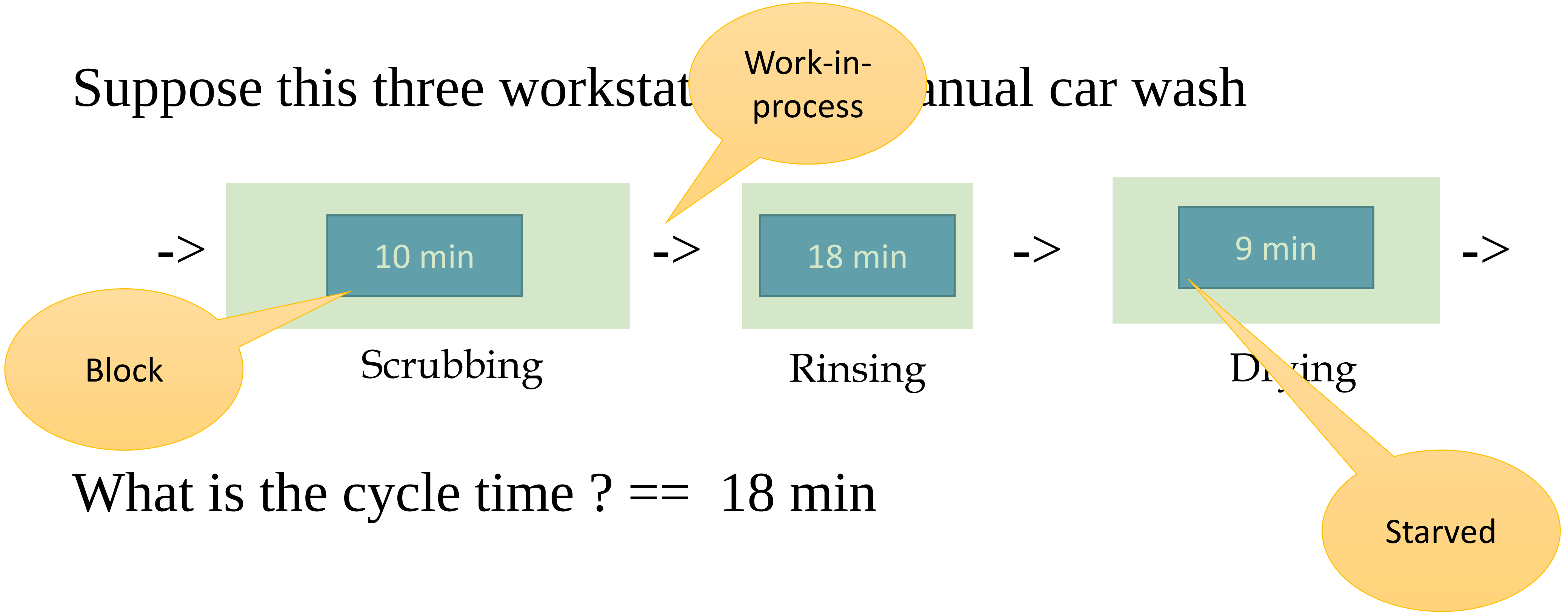
Suppose there are three workstation



What is the cycle time ? == 1.2 min

$$\text{Output Rate} = \frac{480 \text{ min } per\ day}{1.2 \text{ min } per\ unit} = 400\ units\ per\ day$$

Suppose this three workstat… anual car wash

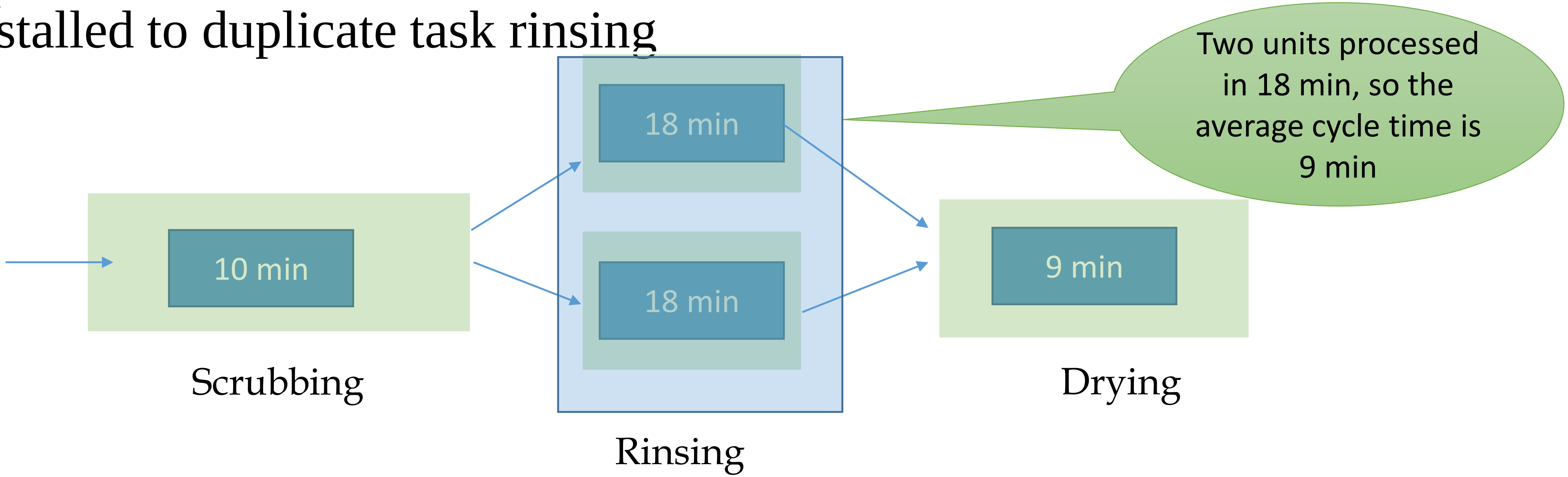


What is the cycle time ? == 18 min

$$\text{Output Rate} = \frac{480 \text{ min } per\ day}{18 \text{ min } per\ unit} = 26\ appro\ \ units\ per\ day$$

- https://s3.amazonaws.com/he-assets-prod/interactives/013_blocked_and_starved/Launch.html

Suppose this three workstation is a manual car wash. A second machine is installed to duplicate task rinsing



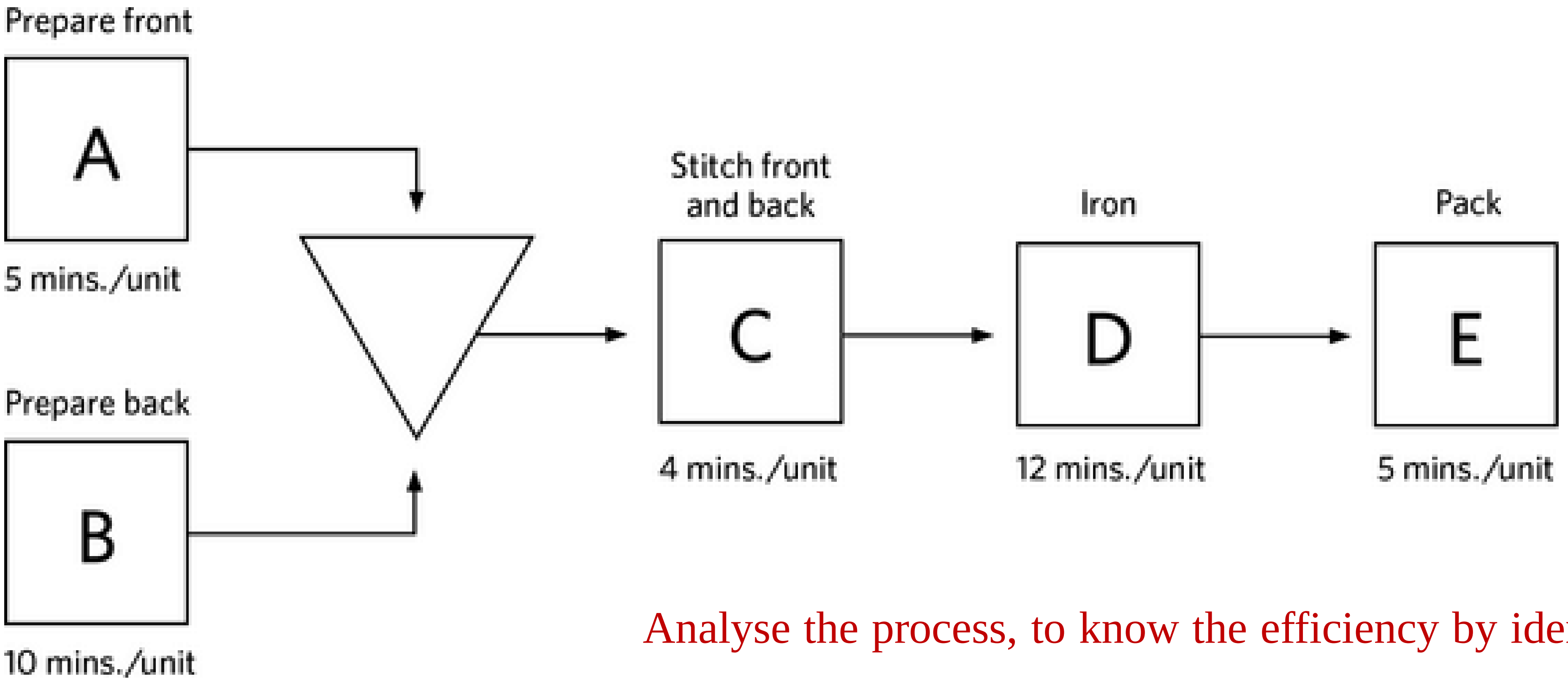
What is the cycle time ? == 10 min

Cycle time: The average time between completions of successive units in a process

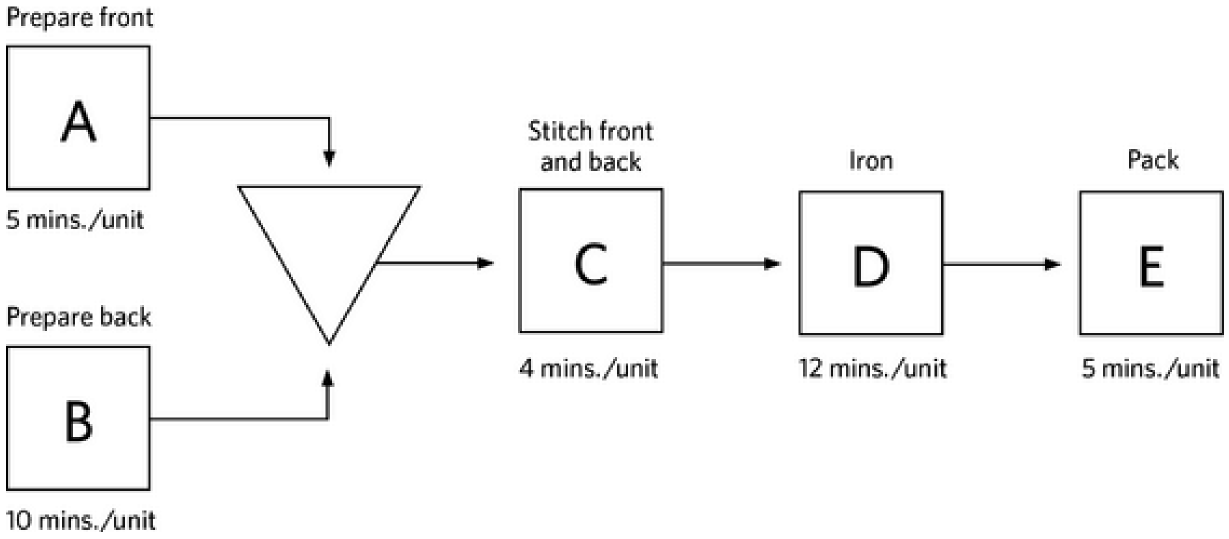
$$\text{Output Rate} = \frac{480 \text{ min } per\ day}{10 \text{ min } per\ unit} = 48\ appro\ \ units\ per\ day$$

https://s3.amazonaws.com/he-assets-prod/interactives/022_cycle_time_multiple_workers/Launch.html

Consider the following process flow diagram for making a shirt. All steps (A, B, C, D, and E) are necessary to create each finished unit (shirt). Each step employs a single worker. Exact task times, in minutes/unit, are shown at each step. For example, it takes exactly 4 minutes to stitch the front and back of the shirt.

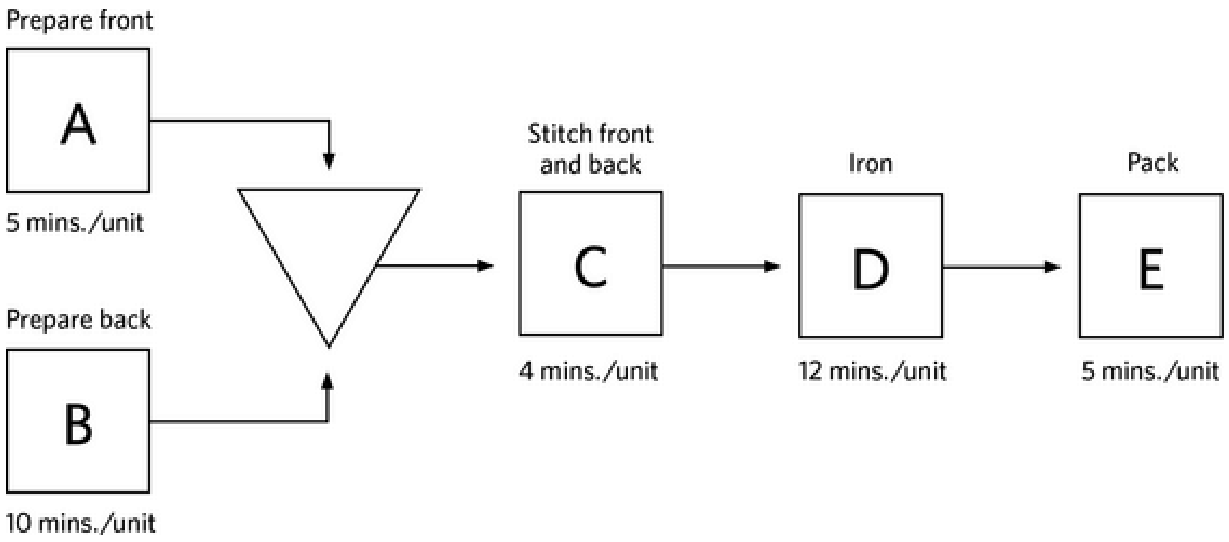


Analyse the process, to know the efficiency by identifying the cycle time, bottleneck, throughput time



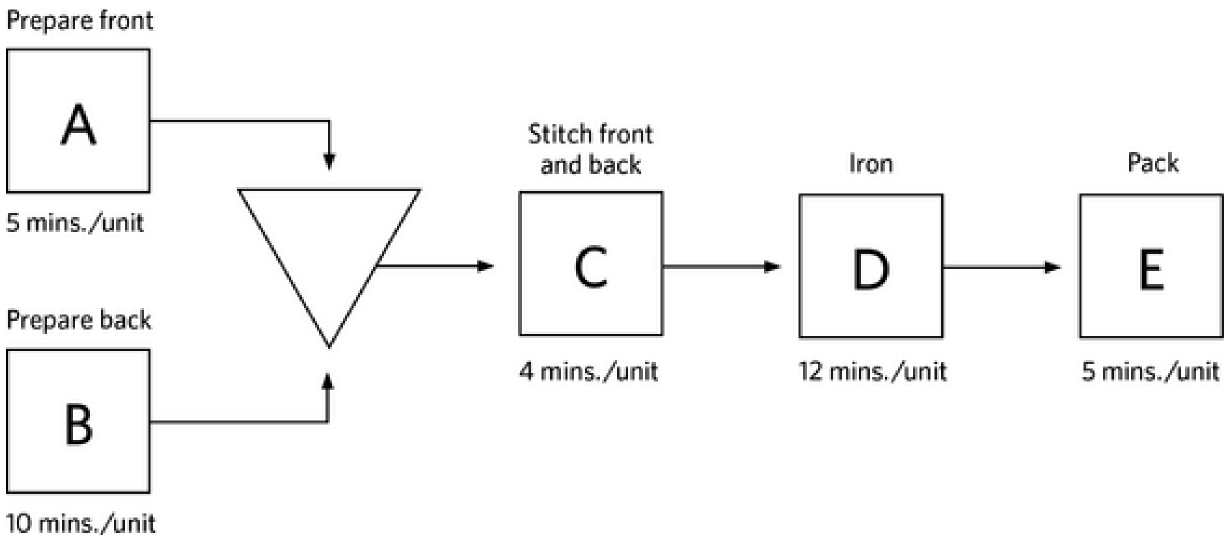
Consider only the task of preparing the front, task A, in isolation from the rest of the process. What is task A's cycle time?

If task A operated without interruption, its cycle time—the average time between successive units—would be 5 minutes. Therefore, the cycle time is 5 minutes/unit.



Consider the entire system (all steps). What is the entire system's cycle time?

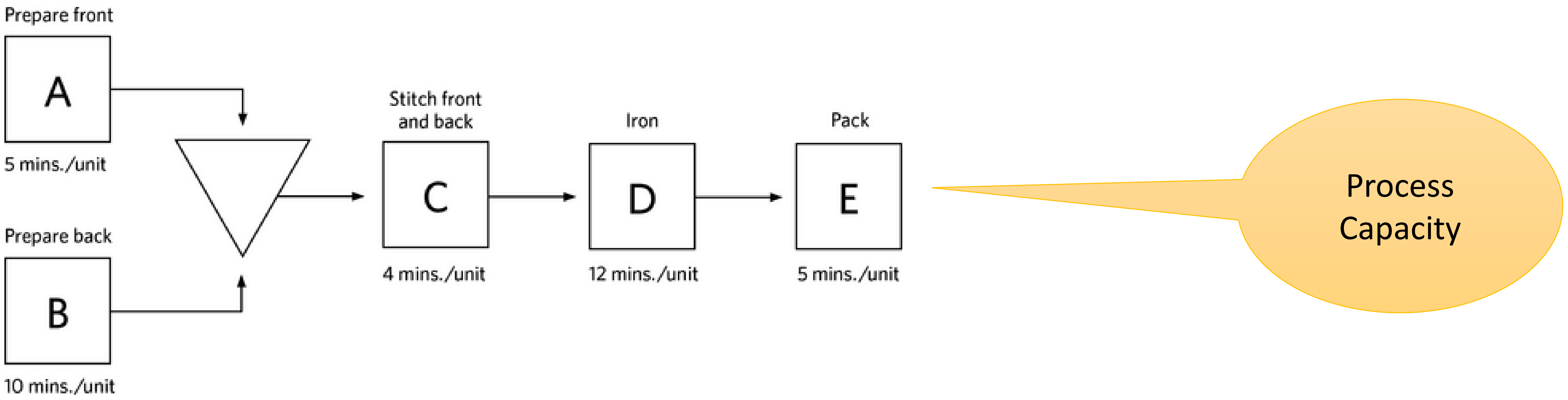
The entire process can run only as fast as its bottleneck. The bottleneck of the process is task D because it has the longest task time. Therefore, the cycle time for the entire process is 12 minutes/unit..



What is the throughput time, that is, the fastest a rush order for one unit can go through the process?

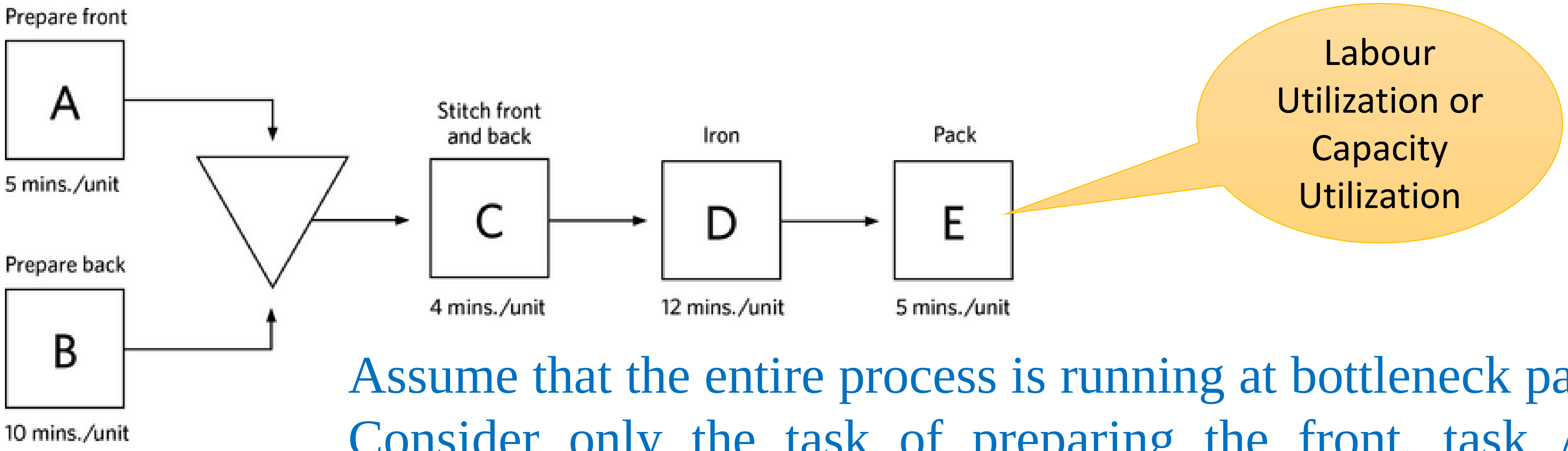
We assume for a one-unit rush order that it will never be “blocked” as it moves from process to process. Because the unit can move through step A faster than through the parallel step B, the front will have to wait for its companion back coming out of step B, so the fastest time for a rush order is:

10 + 4 + 12 + 5 = 31 minutes



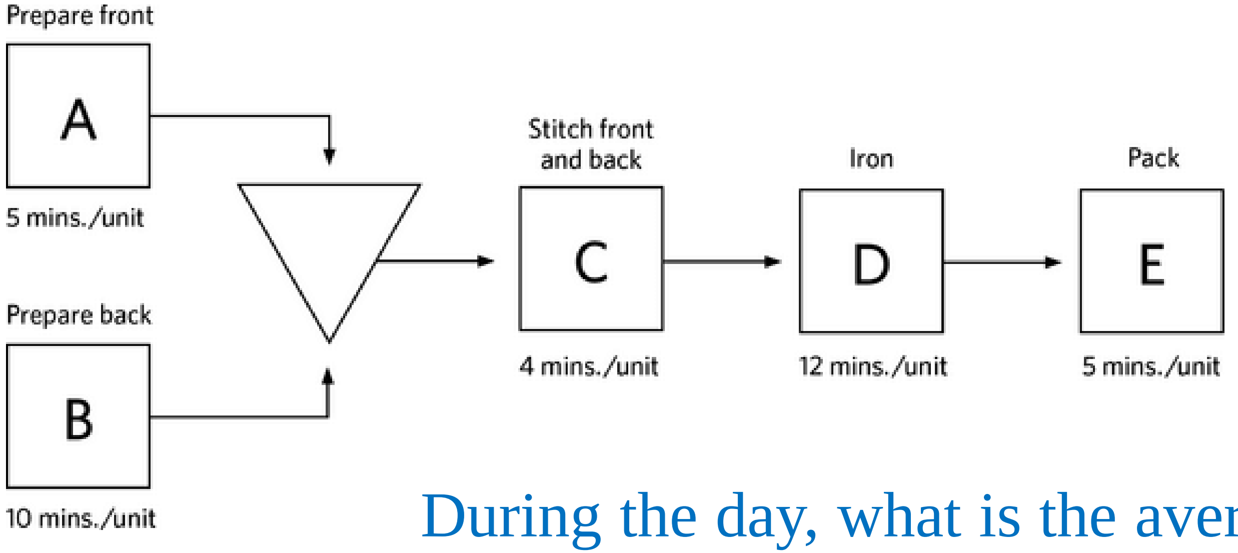
Assume that the process operates eight hours a day. What is its daily capacity, in units per day?

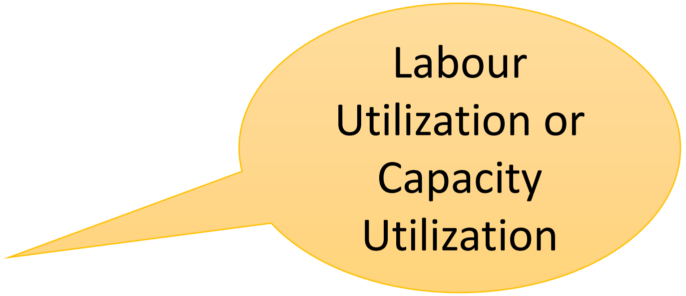
The longest cycle time and bottleneck of this process is 12 minutes/unit at process D. Therefore, the daily capacity of this process is: (8 hr/day)(60 min/hr)/(12 min/unit) = 40 units/day.



Assume that the entire process is running at bottleneck pacing. Consider only the task of preparing the front, task A, in isolation from the rest of the process. What is the approximate labor utilization at task A?

Labor utilization is the time during which the employee is actively working on the task divided by the time that the employee has available. Because the process is running at bottleneck pacing, the cycle time for the entire process is 12 minutes. The employee at task A is available for 12 minutes but is actually working on the task for 5 minutes. Thus, labor utilization at task A is 5 minutes/12 minutes = approximately 42%.





During the day, what is the average labor utilization of all five workers?

Average utilization for the five workers is labor time used to produce one unit divided by the labor time available to produce one unit. Labor time used (labor content) is the sum of the times of each of the process steps: 5 min + 10 min + 4 min + 12 min + 5 min = 36 min. Labor time available in a cycle is (the cycle time of the process) × (the number of workers) = 12 min × 5 = 60 min. Utilization is therefore 36/60 = 60%.

Capacity Utilization and Idle Time

Activity	**Cycle Time (min/units)**	
Task A	5	
Task B	10	
Task C	4	
Task D	12	
Task E	5	
Total		
Average		

Capacity Utilization and Idle Time

Activity	**Cycle Time (min/units)**	**Capacity (units/hr)**
Task A	5	12
Task B	10	6
Task C	4	15
Task D	12	5
Task E	5	12
Total		
Average		

Capacity Utilization and I

= Min Capacity / Actual Capacity

Activity	**Cycle Time (min/units)**	**Capacity (units/hr)**	**Capacity Utilization at Bottleneck Pacing**
Task A	5	12	41.66666667
Task B	10	6	83.33333333
Task C	4	15	33.33333333
Task D	12	5	100
Task E	5	12	41.66666667
Total			
Average			

Capacity Utilization and I

= Min Capacity / Actual Capacity

= cycle time X min Capacity

Activity	**Cycle Time (min/units)**	**Capacity (units/hr)**	**Capacity Utilization at Bottleneck Pacing**	**Work Time in min**		
Task A	5	12	41.66666667	25		
Task B	10	6	83.33333333	50		
Task C	4	15	33.33333333	20		
Task D	12	5	100	60		
Task E	5	12	41.66666667	25		
Total				180		
Average				36		

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Task A	5	12	41.66666667	25	35	60
Task B	10	6	83.33333333	50	10	60
Task C	4	15	33.33333333	20	40	60
Task D	12	5	100	60	0	60
Task E	5	12	41.66666667	25	35	60
Total				180	120	300
Average				36	24	

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Task D	12	5	100	60	0	60
Task E	5	12	41.66666667	25	35	60
Total				180	120	300
Average				36	24	
	Total capacity per shift	40				

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Total				180	120	300
Average				36	24	
	Total capacity per shift	40				
	Average Labour Work Time in min	36 /min				
	Average Idle Time in min	24 / min				

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Total				180	120	300
Average				36	24	
	Total capacity per shift	40				
	Average Labour Work Time in min	36 /min				
	Average Idle Time in min	24 / min				
	Idle Time	40				
	Capacity Utilization	60				

If you want to increase the capacity utilization and minimize the idle time ???

Thank you