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Planning as a State-Space Search

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→ There are two approaches to planning

1) State-Space Planning
2) Plan-Space planning

→ What we intend to do in both the cases is to find a plan.

→ A State-Space planning is the one that works at the States and the operators.

→ This is also called planning as a State-Space Search.

→ Here in state-space planning, the Search takes place in both the directions - forward and backward.

→ In case of plane-space planning, the Search is carried out through the space of plans.

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* Planning with State-Space tree :→

→ The planning can be ① from the initial State to the goal State or ② in reverse way.

→ The first one called as forward State-Space Search. or Progression planning.

→ The second one is called as backward State-Space Search, or Regression planning.

* Progression planning

→ This planning starts with the intial State and proceeds with search.

→ It follows the effects of the possible actions.

→ So the sequence of actions is considered till we are able to build or form a sequence to reach the goal.

Ex The forward search for a case in which a robot is in room1, and the tea and guest are in room2 and room3.

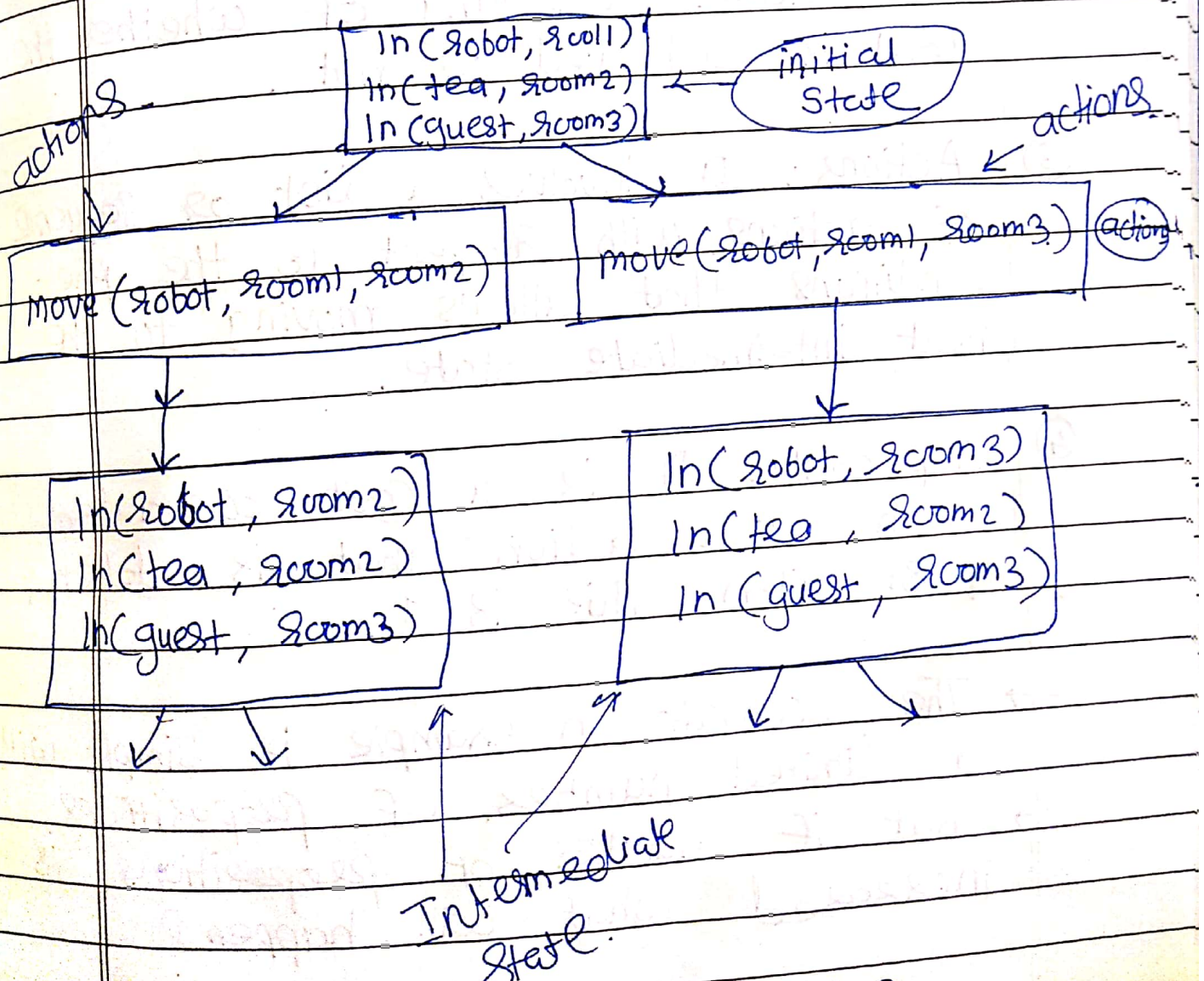

Fig Progression planning.

The problem is formulated as below:

① Start State: It is initial State of the problem befor any action applied to it.
- It assumes that the things not mentioned are not true.

② Goal State: Cheeking of whether the goal is achieved or not.

③ Actions: It involves a list or sequence of actions with respect to the pre-conditions that allows moving to the next intermediate state.

④ Step cost: It is a cost associated with every action that is taken, most often, this is 1.

→ The scenario in example is simple with a limited numbes of propasitions.
→ But if number of propasitions is increased what will happen?

→ Similary, we have Considered actions in planning are all the possible actions.
→ These ~~are~~ is a possibility that irrelevent actions not leading to the goal are carried out.
→ Here, heuristic Comes in picture.

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* Regression Planning

→ In case of regression planning, the reverse process is applied.

→ To plan, the search is started from the goal state to the initial state.

→ That is, we move towards the intermediate (pre-states) states.

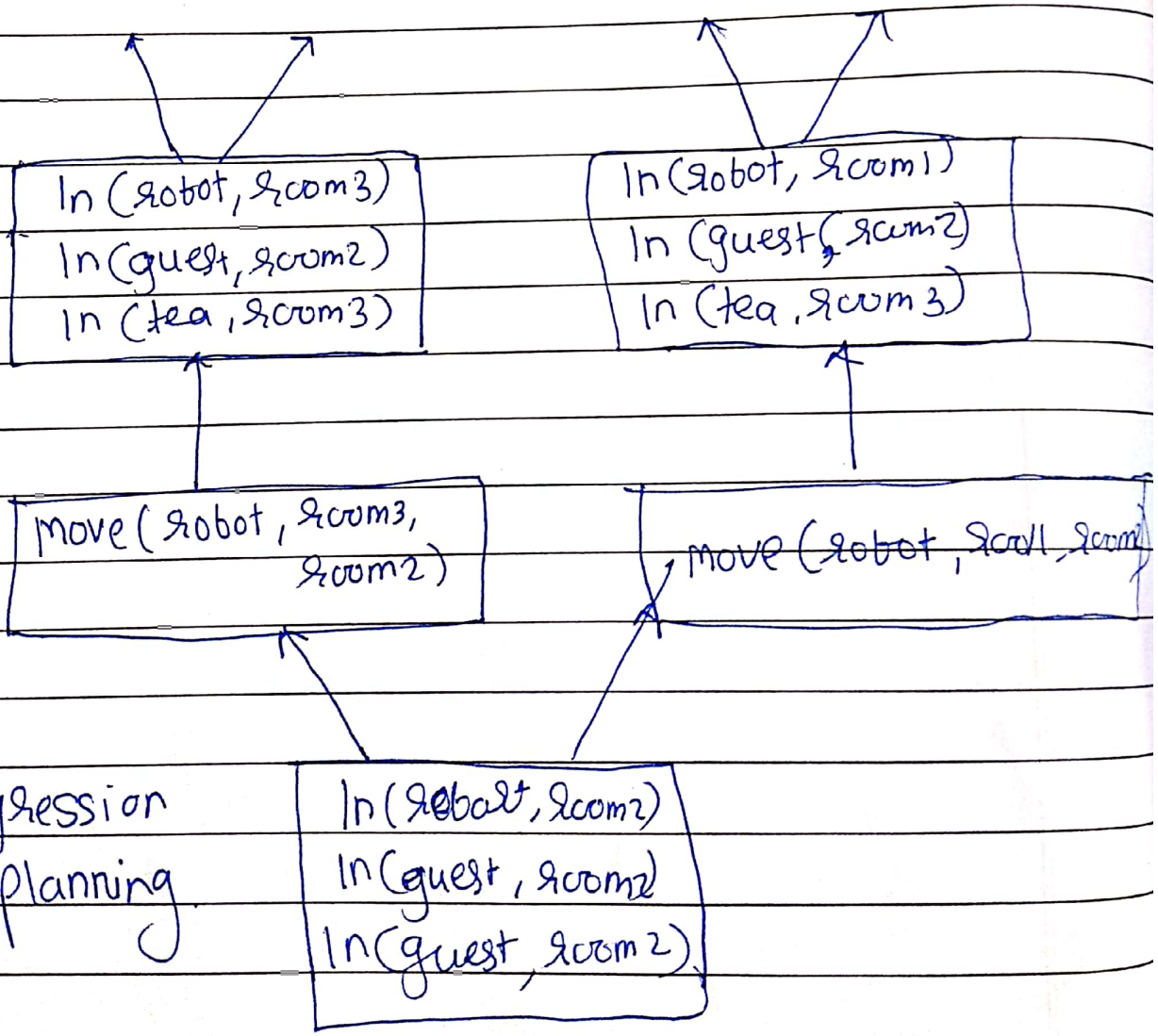

Fig. Regression planning

Let see how algorithm works,

1. Selection of an action that satisfies all or some of the propositions in the goal state.

2. Reforming a new goal.

Step 1 and 2 are repeated till the initial state or the start state is reached.

→ The main advantage of backward search is that the relevant actions are considered.

→ Any of the search strategy can be made use of in the process of planning.

Role of Heuristics in Progression and Regression planning :-

→ The methods discussed above i.e. progression and regression planning can be made efficient with the use of heuristics.

→ This comes to a NP-hard problem.

→ Still some solutions to it are discussed here.

We need to find an admissible heuristic. This is done in the following way.

1. By converting the problem into a relaxed one (by removing all pre-conditions)

2. By assuming that sub-goals are independ

To summarize,

→ The progressive and regressive plann actions are dependent on the sequen

→ There is a need to have planners th can consider sub-goals, solve them independently and then the final plan c be a combinations of the sub-results obta Thus, we will discuss partial order planning n

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Partial Orders Planning

→ The Concept of total orders planner states that any planner that maintains the solution as a totally ordered steps it has identified so far. forms a linear planner.

→ Whereas, if partially we are able to put up the ordering constraints (temporal), it is refereed to as a partial order planning.

Note → [The progressive and regressive planning that are linear in nature and are often refereed as totally ordered.]

Example → Consider a case where you have to latch the door. With the use of lock and keys, the total orders plan and partial order plan (POP) are shown in figure below.

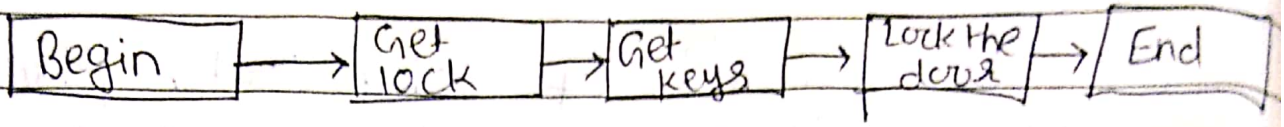

Fig (a) Total order planning

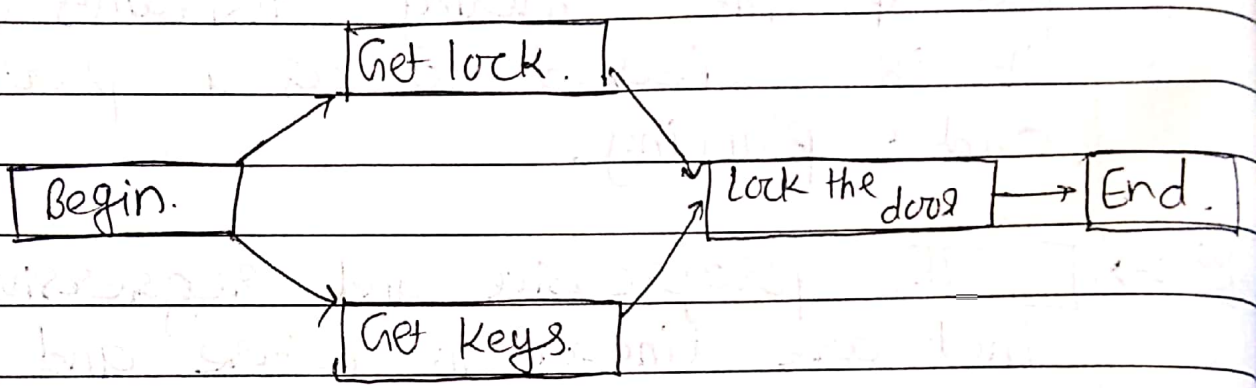

Fig Partial order planning.

→ There is a notion of least Commitment Strategy in POP.

→ Least Commitment Strategy, is a policy where the decisions or the choices are delayed.

→ It says that, "Do not make any decision unless required."

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→ One advantage of using this is that it avoids the re-work.
→ The task might have to be undone.
→ The partial order plans are created by making a search through plan spaces.
→ The partial orders plans are represented using graphs.

→ The graph structure for the POP comprises temporal constraints. (for ex. State x is before State y).

* POP Representation

Ex: Consides the case of 4 states with temporal constraints.
State 1 < State 2
State 1 < State 3
State 2 < State 3
State 3 < State 4

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- The plan is represented as follows.

1. Set of plan steps. The operators are mapped into steps.

2. It also has 'ordering constraints' for the steps. This is represented as $S < S'$, where S occurs before S' step.

3. Binding on variable are also added. of the form $Var = x$, where var is variable and x could be referring to another variable on some constant.

4. The caused links are also established. It is represented as $S \rightarrow c_1 ; S'$, this means, the precondition 'c_1' for step S' is satisfied by S.

- The partial order plan algorithm comprise

ex. 1. Begin with initial plan
+Fig 13 This plan consist of only start and finish step
here 2. Till a sol^n plan is achieved.
a) Select an unachieved pre-condition and achieve it.
b) Resolve threats by applying promotion or demotion

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Multi-agent Planning

→ The multi-agent planning involves use of multiple agents to carry out the planning tasks.

→ The background behind this is that a teamwork can prove to be better when an individual cannot accomplish the task.

→ If the task is extended to multiple agents, it would be easier.

→ It is of two types ie: by and for mutiple agents.

→ These should be proper Communication between agents.

→ The multi-agent planning is most commonly used in the industries. Co-ordination and assembling of components, associated with electronic devices or vehicle assembling and not to forgot, the gaming para as well.

* The task involved in multi-agent planning are given below.

1) Setting goals and assigning to individual agents.
2) Refining the goals and further de-composing them into sub-goals.
3) Converting sub-goals into achievable tasks
4) Scheduling the tasks. (This includes resource allocation to agents and timining deadlines, if applicable, for the task.
5) Co-ordinating and communicating to avoid conflicts.
6) Executing the plan.

Job Shop Scheduling Problem

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→ It is a problem that needs to handle the time constraints, the scheduling, perform check on availability of resources.

→ The job shop problem consist of jobs j1 to jn that are to be completed.

→ To complete them, machines m1 to mn are used.

→ For the jobs to complete, there is a sequence of actions say a1 to an that is required to take place on the machines.

→ Every action has a specific duration and it might make use of some resources also.

→ The problem is to minimize the time required for the completion of the jobs, and at the same time, handle the resource constraints, if any.

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The job shop scheduling problem occurs in cases of the production scheduling.

ex

In this example the scheduling is occur for two vehicles to assemble the engin assembly, frame assembly and the chassis.

Below is pop diagram.

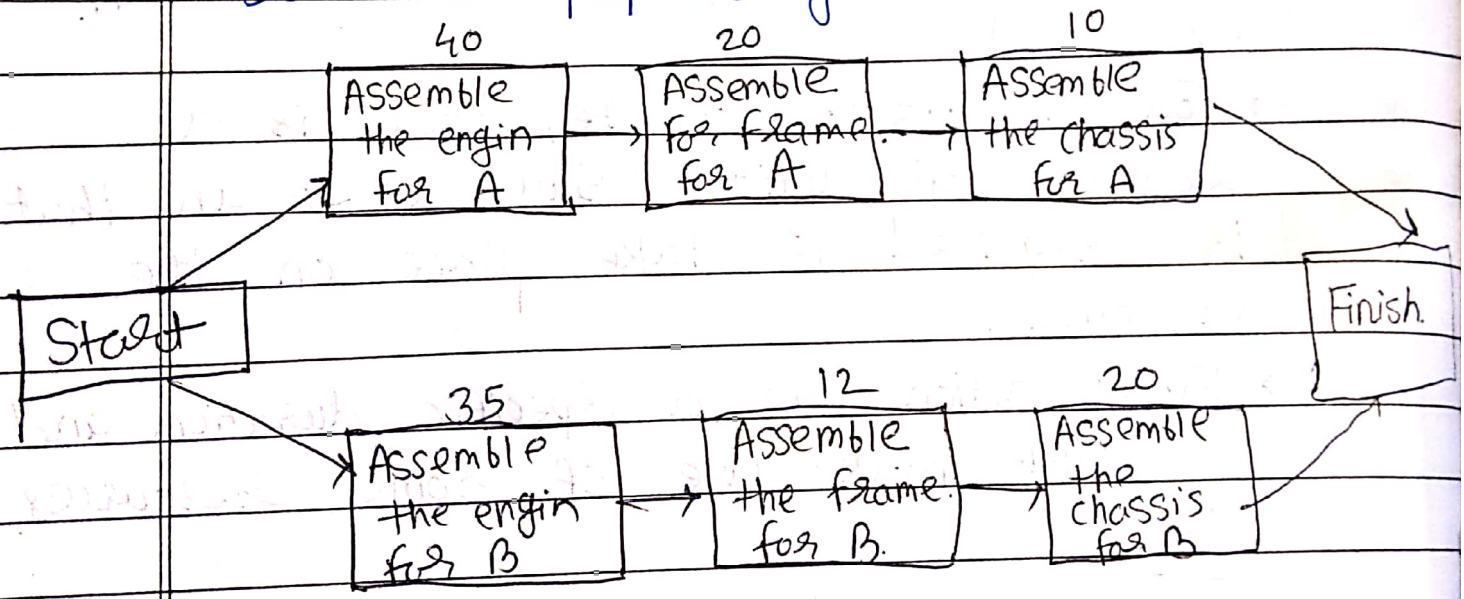

Fig. A partial order plan for the problem.

→ The numbers above each of the action indicate the time it need to execute.

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→ Suppose for each of the action, there is a resouree person, who actually - evaluates and monitors whether the things have been assembled in a ~~way~~ proper way or not and then, there is Constraint added to it.

→ Now assum that these are six different people to carry out the task, the Constraints are nil.

→ But if only three persons are available to carry out the fixed tasks like one working as engine cheeking manages, one as a frame cheeking manages and one as a chassis cheeking manages, things would get very much complicated.

→ There is a need to have a proper plan for this, where in these resouree person should be used in the planning process with the Constraints that exist.

→ The soln to this is shown below. Time required here comes to 107.

an NP-hard problem.

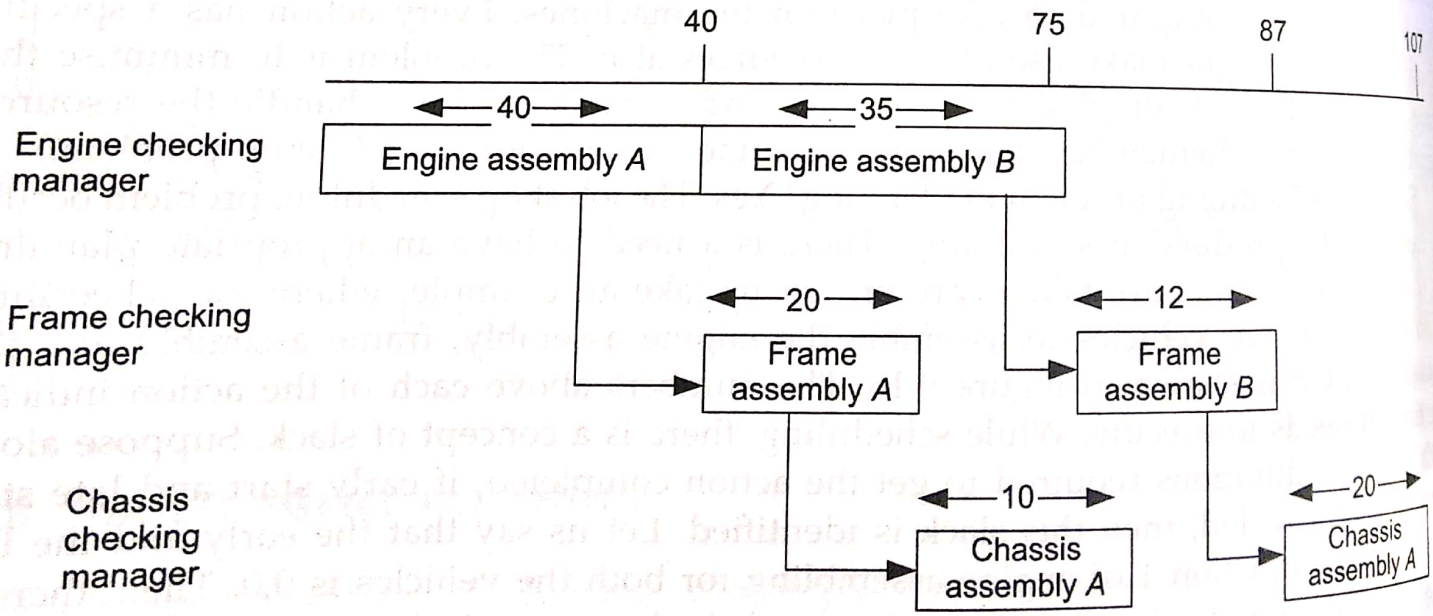

Figure 9.17 Possible solution for the problem with the resource constraint.