Planning and Scheduling

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Artificial Intelligence

Planning and Scheduling 规划与调度

□ **The previous chapter introduced the most basic concepts, representations, and algorithms for planning.**
上一章我们介绍了规划最基本的概念、表示、以及算法。

□ **The planning and scheduling in the real world are more complex, e.g.,**
现实世界中的规划和调度更为复杂，例如

■ **spacecraft, factories, and military campaigns.**
航天器、工厂、以及军事行动。

□ **They should extend both** 它们需要扩展

■ **the representation language, and**
表示语言，以及

■ **the way the planner interacts with the environment.**
规划者与外部环境交互的方式。

Classical Planning and Its Limitation 经典规划及其局限性

☐ **Classical planning can represent:**

经典规划可以表示：

- ■ *what to do,*

  做什么

- ■ in *what order*.

  按什么顺序

☐ **Classical planning cannot represent:**

经典规划无法表示：

- ■ *how long* an action takes,

  动作持续多长时间

- ■ *when* it occurs.

  什么时候发生

Plan First and Schedule Later 先规划后调度

☐ Divide problem into planning phase and scheduling phase.

将问题分为规划阶段和调度阶段

■ Planning phase 规划阶段

➢ select actions with some ordering constraints,

选择具有某种有序约束的动作，

➢ to meet the goals of the problem.

去满足问题的目标。

■ Scheduling phase 调度阶段

➢ add temporal information to the plan,

在规划中增加时间信息，

➢ to meet resource and deadline constraints.

去满足资源和期限的约束。

Representing Temporal and Resource Constraints 表征时间和资源约束

☐ A scheduling problem, consists of a set of jobs, each of which consists a collection of actions with ordering constraints.

调度问题包含一系列作业，每个作业包含一组具有顺序约束的动作。

☐ Each action has a duration and a set of resource constraints.

每个动作有一段持续时间和一组资源约束。

☐ Each resource constraint specifies: type, number, consumable or reusable.

每个资源约束指定：类型、数量、可消费或可重用。

☐ Actions can produce resources, including manufacturing, growing, and resupply.

动作可以产生资源，包括制造、增产、以及供给动作。

☐ A solution must specify the start times for each action, and must satisfy all the temporal ordering constraints and resource constraints.

解决方案需要对每个动作指定起始时间，并且要满足所有的时间顺序约束和资源约束。

Example: A job-shop scheduling 车间作业调度

Jobs({*AddEngine*1 ≺ *AddWheels*1 ≺ *Inspect*1 },

    {*AddEngine*2 ≺ *AddWheels*2 ≺ *Inspect*2 })

A ≺ B ---- action A must precede B
动作A必须领先于B

Resources(*EngineHoists*(1), *WheelStations*(1), *Inspectors*(2), *LugNuts*(500))

Action(*AddEngine*1 , DURATION: 30, USE: *EngineHoists*(1))

Action(*AddEngine*2 , DURATION: 60, USE: *EngineHoists*(1))

Action(*AddWheels*1 , DURATION: 30,
    CONSUME: *LugNuts*(20), USE: *WheelStations*(1))

Action(*AddWheels*2 , DURATION: 15,
    CONSUME: *LugNuts*(20), USE: *WheelStations*(1))

Action(*Inspect$_i$*, DURATION: 10, USE: *Inspectors*(1))

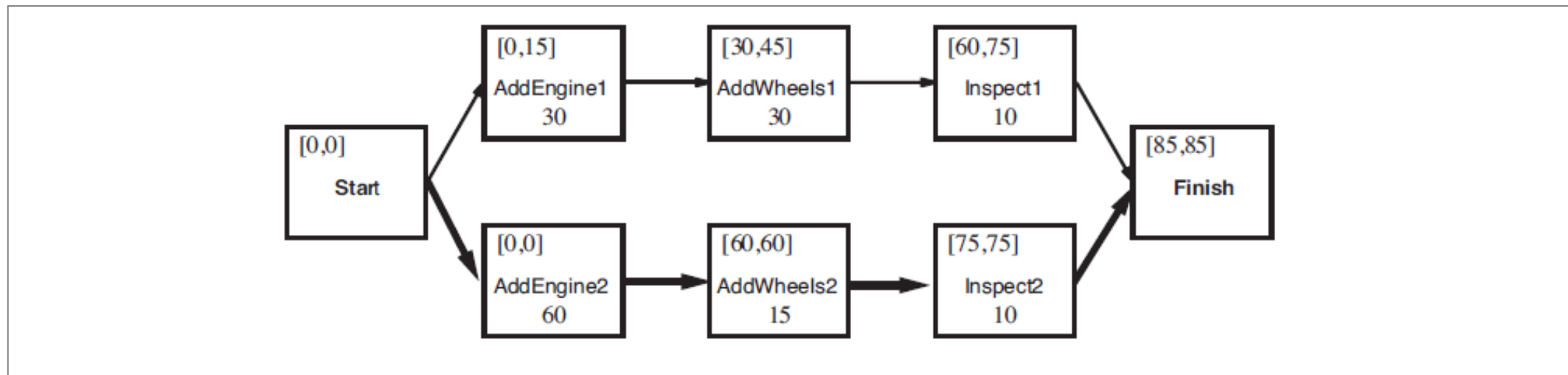A job-shop scheduling for assembling two cars
组装两辆汽车的车间作业调度

Solving Scheduling Problems 求解调度问题

□ To minimize plan duration, must find the earliest start times for all the actions consistent with the ordering constraints.

　　要使规划持续时间最短，必须找到与排序约束一致的所有动作的最早开始时间。

□ To view these ordering constraints as a directed graph.

　　将这些排序约束视为一个有向图。

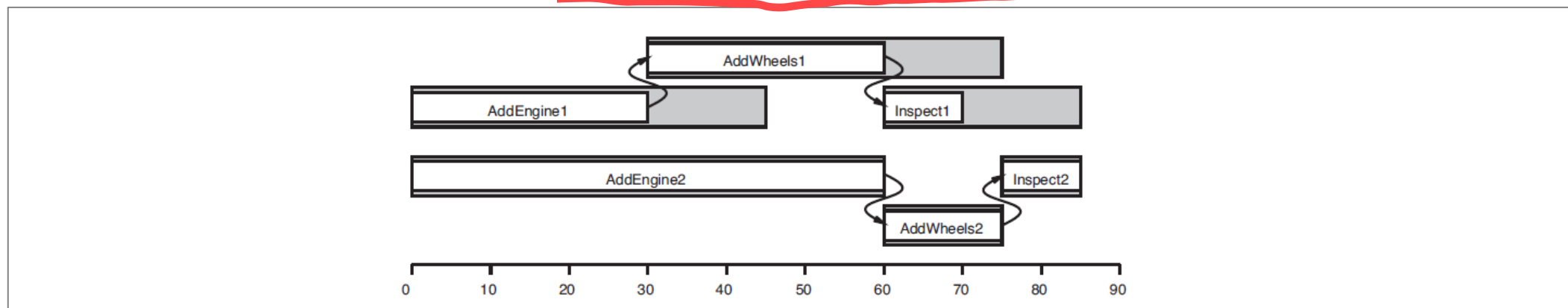A directed graph of temporal constraints for job-shop scheduling problem

一个车间调度问题的时间约束有向图

Solving Scheduling Problems 求解调度问题

☐ Can apply the critical path method (CPM) to this graph to determine the possible start and end times of each action.

  可以将关键路径法 (CPM) 用于该图，来确定每个动作可能的开始与结束时间。

☐ A path through a graph representing a partial-order plan is a linearly ordered sequence of actions.
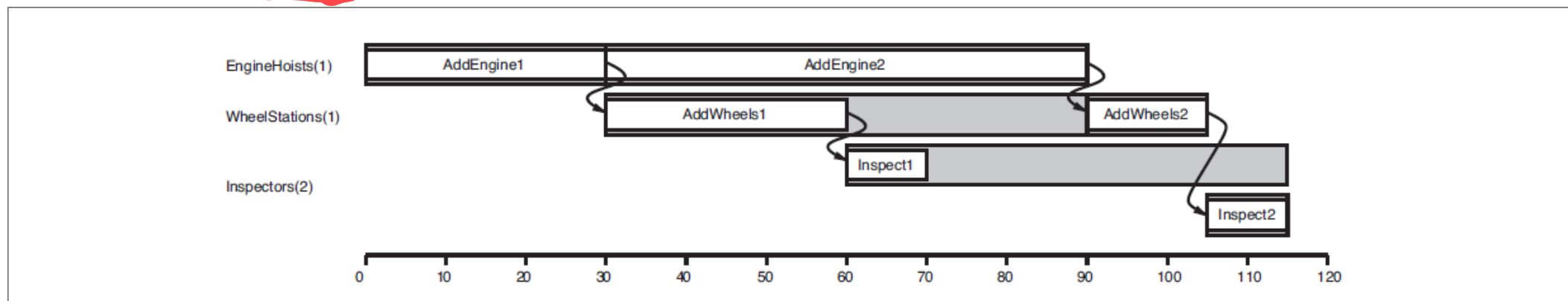
  一个表示偏序计划的图的路径是一个线性排序的动作序列。

A timeline of temporal constraints for job-shop scheduling problem
一个车间作业调度问题的时间约束的时间表

Solving Scheduling Problems 求解调度问题

☐ If we introduce resource constraints, the resulting constraints on start and end times become more complicated.

如果我们引入资源约束，所导致的开始和结束时间的约束变得更加复杂。

A timeline of resource constraints for job-shop scheduling problem
一个车间作业调度问题的资源约束的时间表

☐ The left-hand margin lists the three reusable resources, and actions are shown aligned horizontally with the resources they use.

左边列出了三个可重用资源，并且，动作与它们所使用的资源水平对齐显示。

Thank you for your attention !

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