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Multi-Agent Path Finding Under Time Uncertainty

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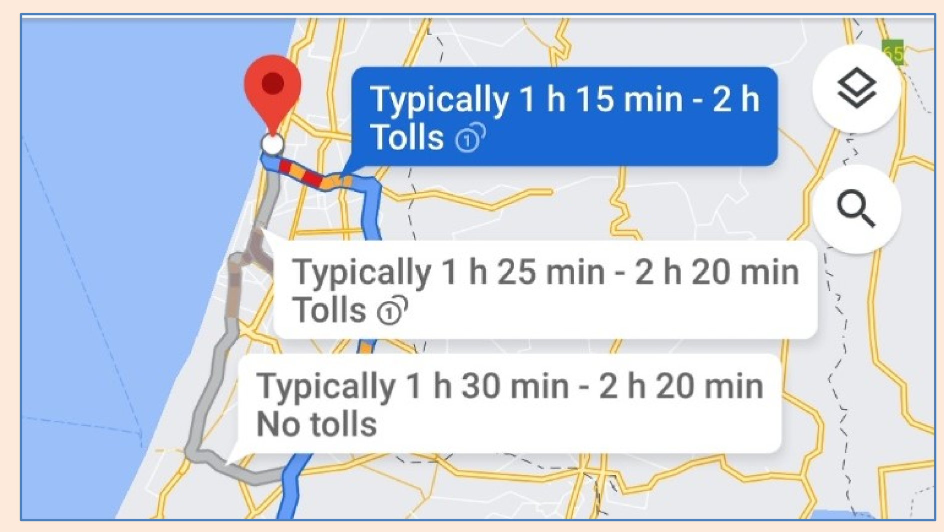
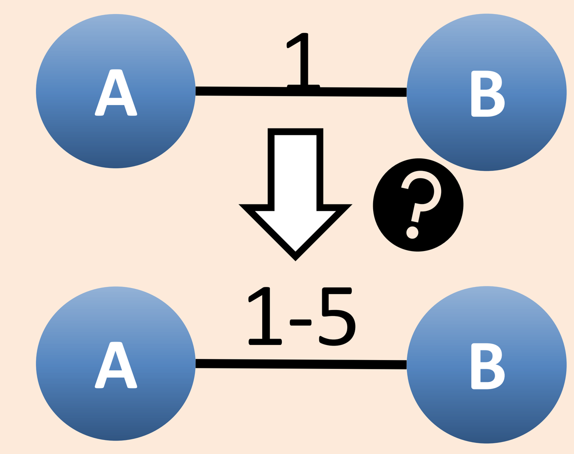
1. Motivation

Background

- Multi-Agent Pathfinding (MAPF) is needed when **multiple** agents travel **simultaneously.**
- **MAPF has applications** in domains such as video games or warehouse robots.
- Classic MAPF assumed move durations are **fixed**
- May real life MAPF scenarios contain **time uncertainty**



Fixed Duration



Uncertain Duration

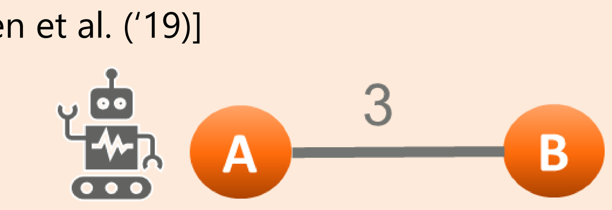
MAPF under Time Uncertainty (MAPF-TU): move durations are bounded but non-deterministic

2. Contributions

- Definition of MAPF-TU, safety, and different optimality criteria
- Safe and Optimal MAPF-TU algorithms: A*+ODTU , CBSTU
- Online replanning algorithms for cases where
  - Agents can sense their location and replan
  - Agents can also communicate with each other
- Experimental Evaluation
- Learning technique to obtain duration ranges from data

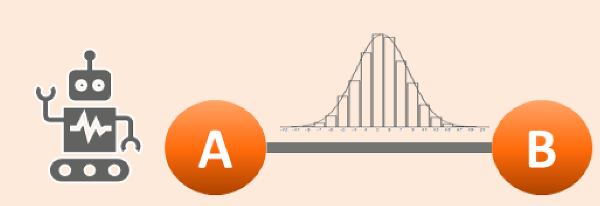
3. Related Works

MAPF_R [Walker et al. ('18, '20), Andreychuk et al. ('19, '21)]
MAMP [Cohen et al. ('19)]



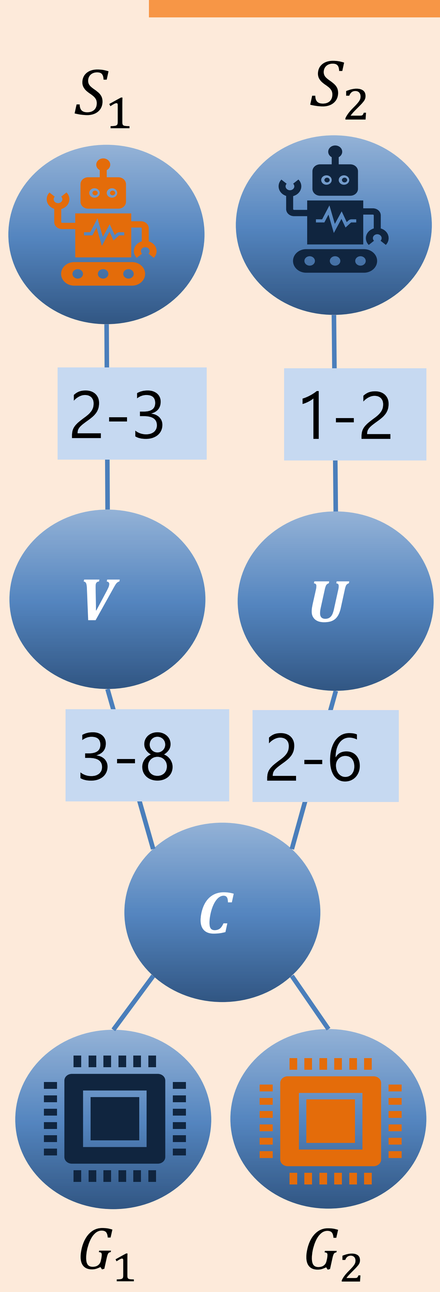
Fixed Duration

MAPF-DP [Ma et al. '17, Wagner & Choset '17, Atzmon et al. '20]



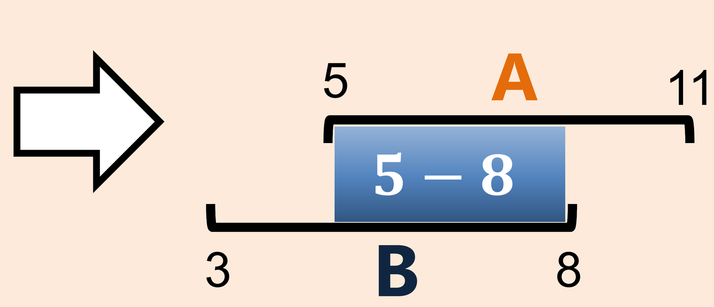
Stochastic Duration

4. Safety and Optimality



Safety

- A plan is **safe** if no collision occurs in any possible execution
- **Potential Presence:** the time ranges in which an agent *might* be at a certain vertex.
- Here: the *Potential Presence* of agents **A** and **B** at vertex **C** is $[5-11]$ and $[3-8]$, accordingly.
- Overlaps in a potential presence indicates an **unsafe plan**.

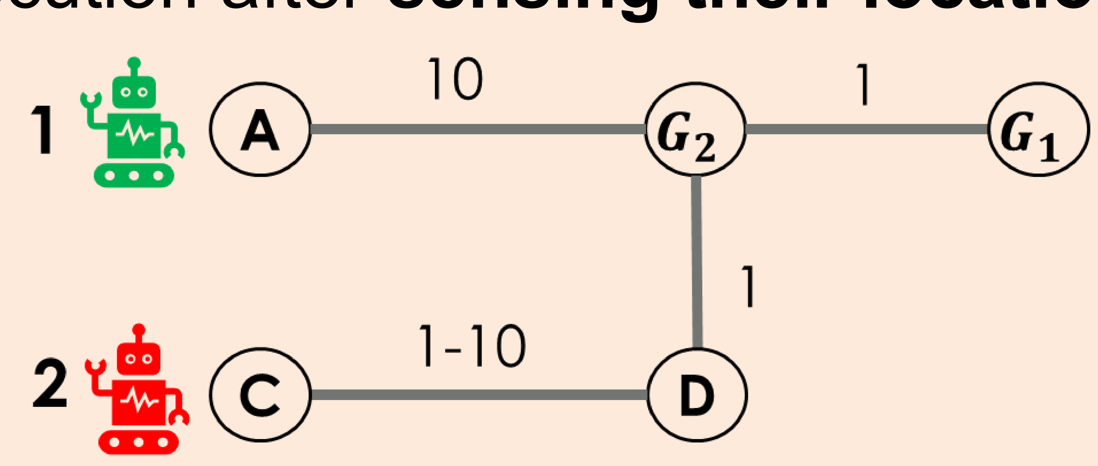


Optimality

- There are multiple optimality criteria.
- Our focus: min. worst or best case sum of cost.
- Contribution: A*+OD_{TU} and CBS_{TU}
- Both algorithms that find safe and optimal plans.

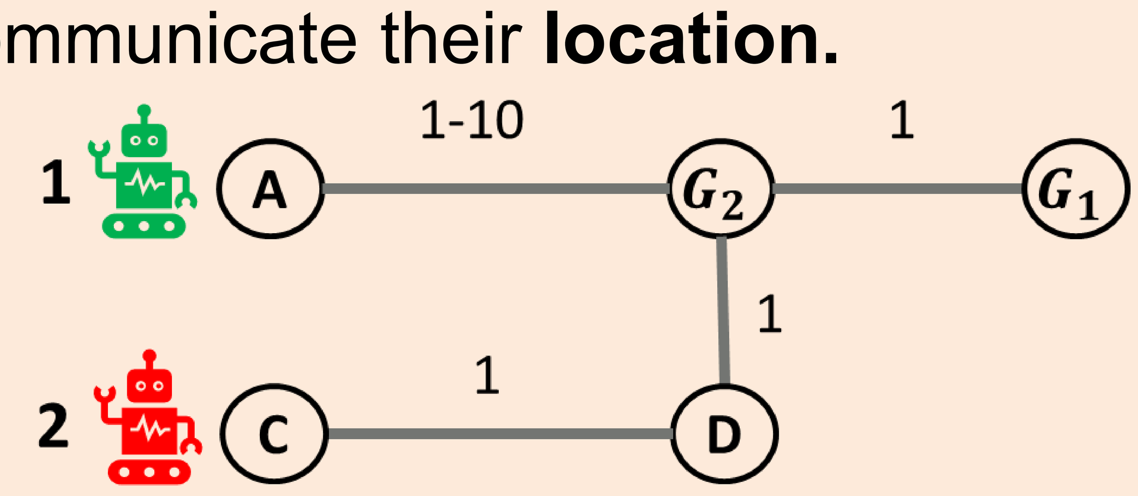
5. Online Replanning

- Replanning can greatly reduce the execution cost as safe replanning is very conservative.
- Online setting #1: agents can replan during execution after **sensing their location.**



The safe offline plan here requires agent 2 to wait at D for 9 time steps. But, by sensing its location agent 2, agent 2 can replan and reduce the time it has to wait at D according to the time it took it to get there.

- Online setting #2: agents can also communicate their **location.**



The safe offline plan here requires agent 2 to wait at D for 9 time steps. But, if agent 3 senses its location and communicates it to agent 2, agent 2 can replan and reduce the time it has to wait at D accordingly.