When to Commit to an Action in Online Planning

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Problem Setting: Plan While Action Execution

Classical Planning Environments:

single agent

discrete state, discrete action

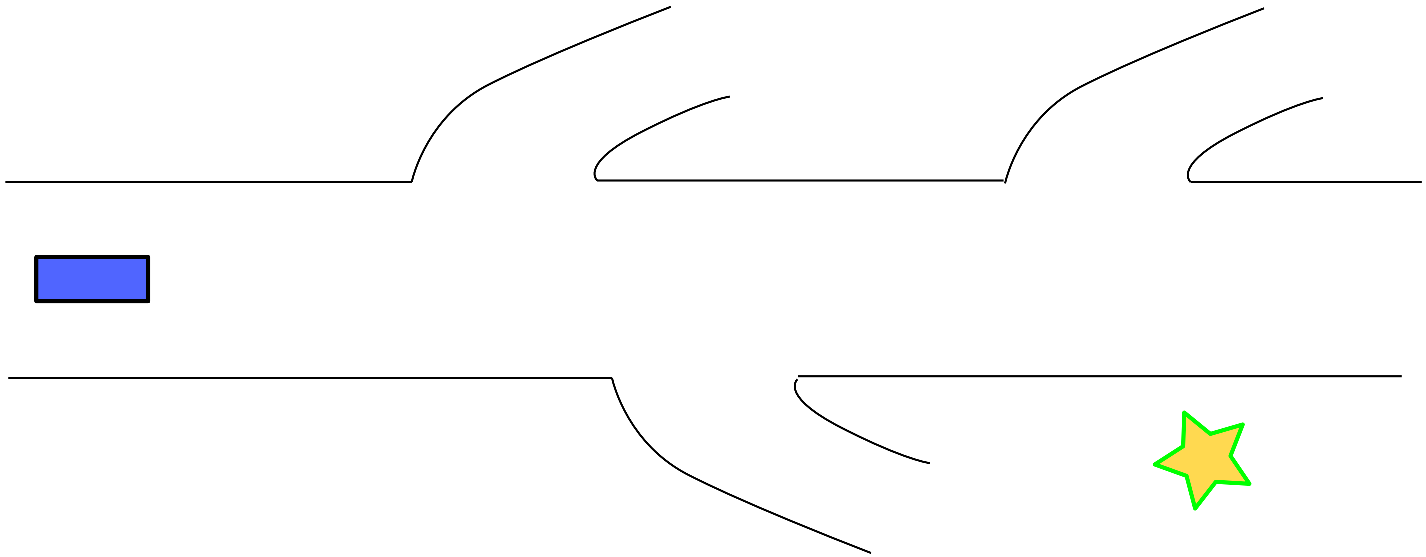
complete observability

deterministic state transition

online planning: interleaving planning and execution

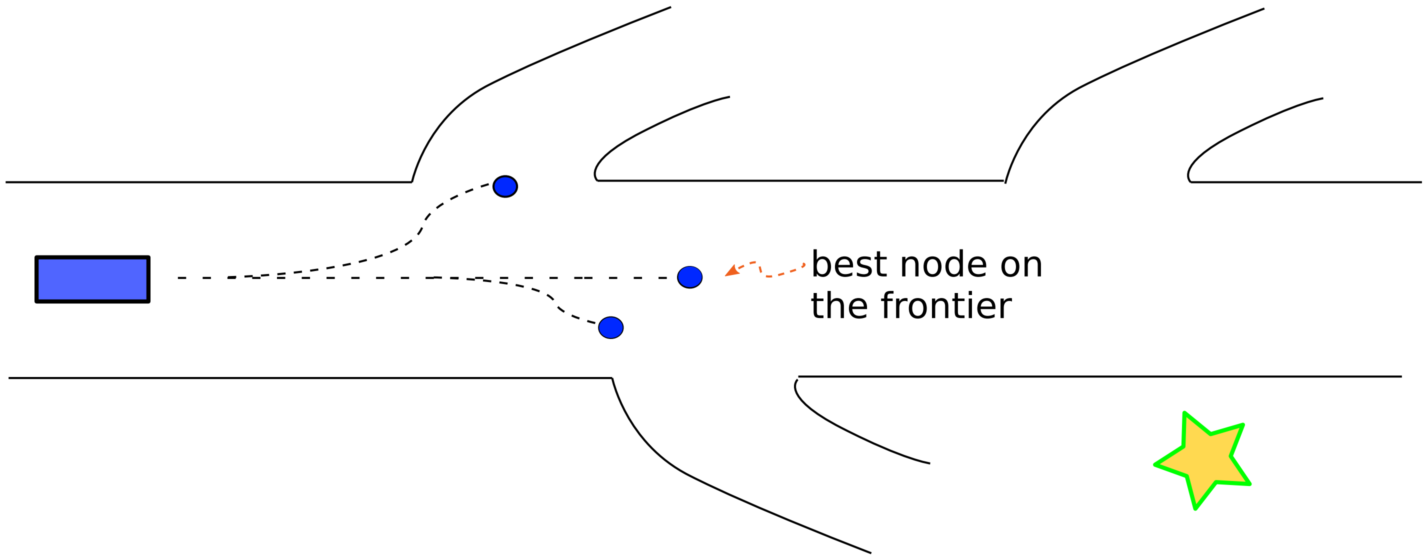
An Example of Online Planning Using Heuristic Search

An example: highway navigation



agent performs search for a bounded time

An example: highway navigation



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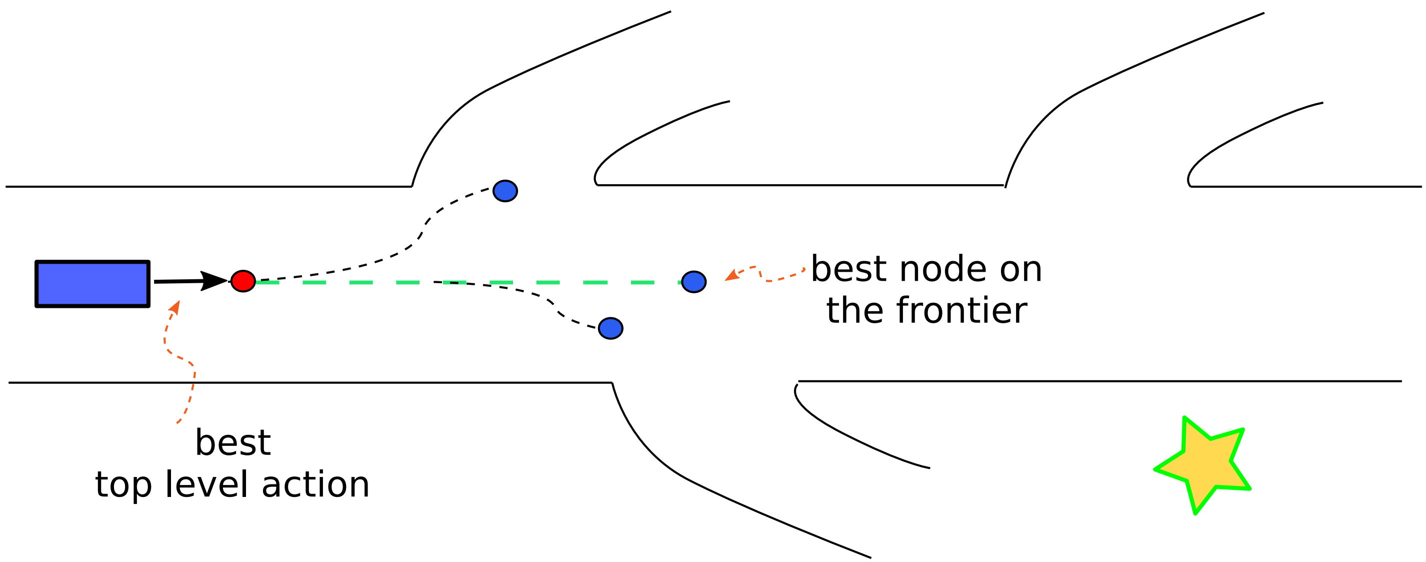

agent commits to best action and executes

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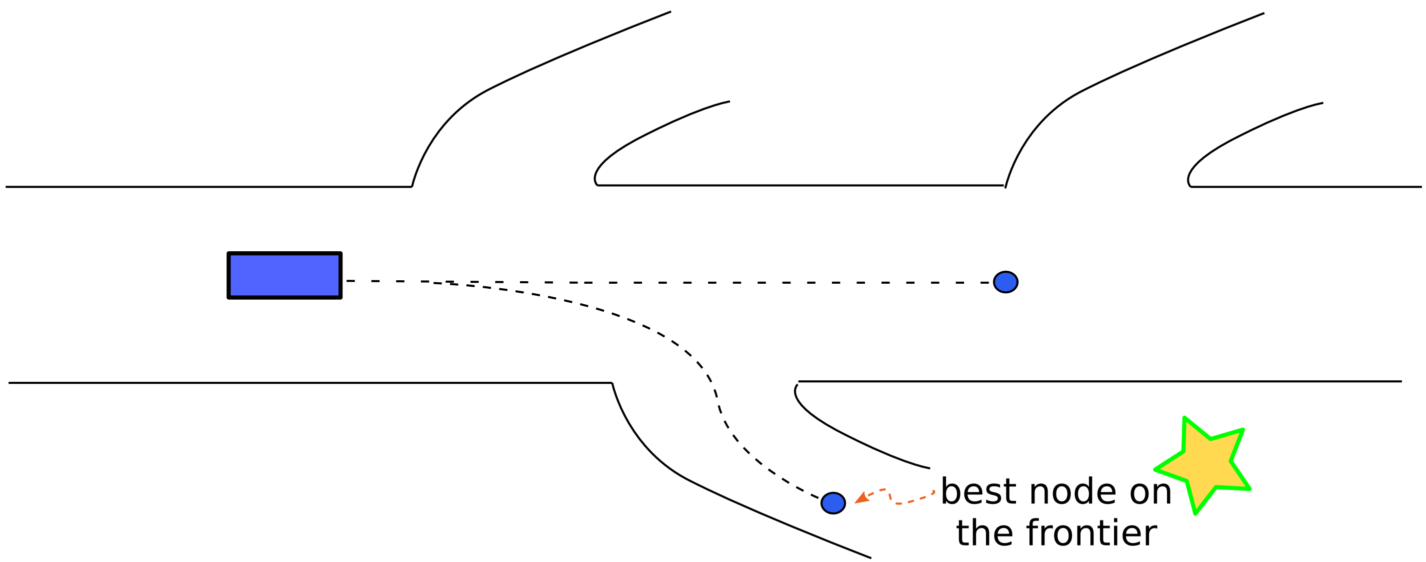

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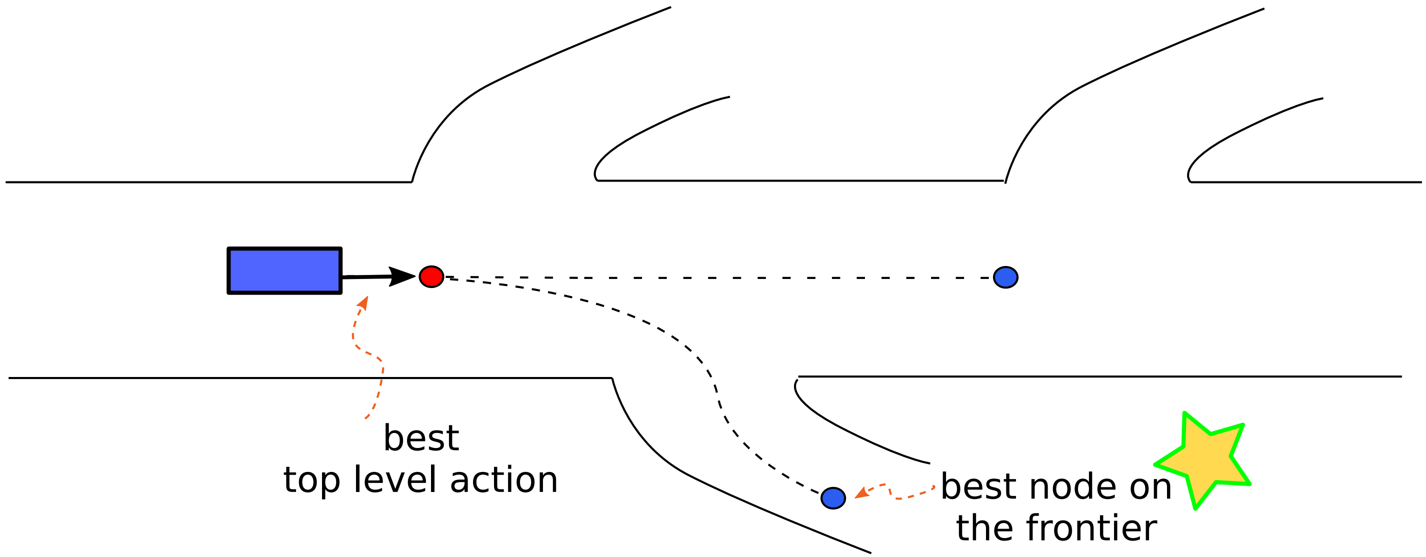

online planning: interleaving search and action execution

"receding horizon control"

The Meta-level Problem: Commit or Not Commit

For each node along the best prefix path:
should we commit?

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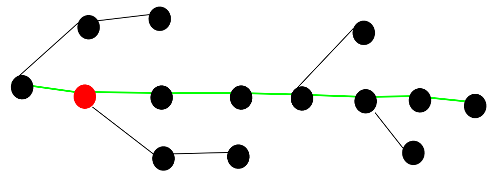
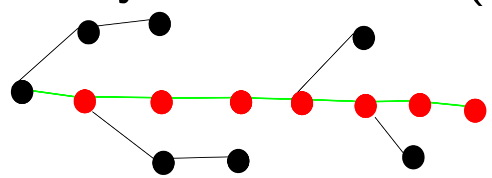
fixed strategies:
always commit one (Korf 1990)

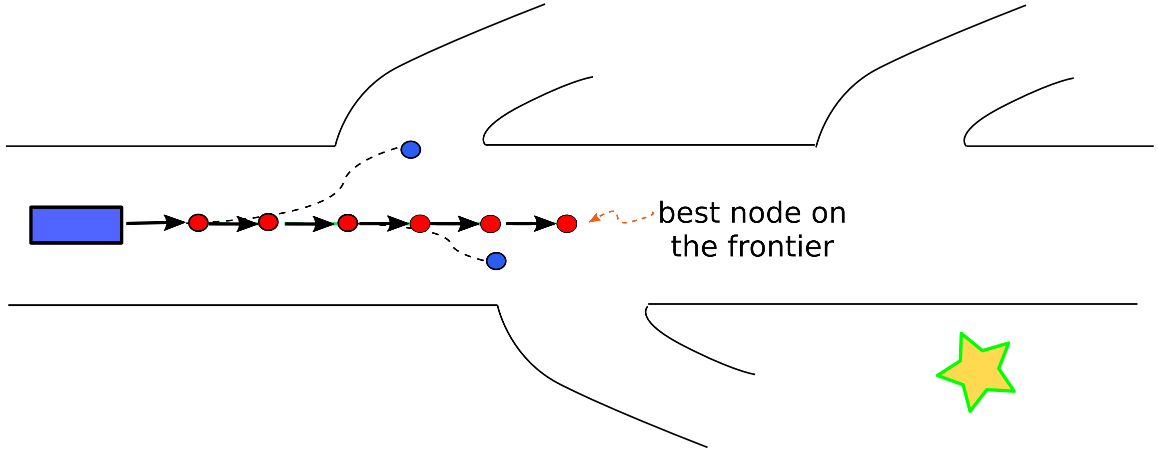


always commit all (Koenig&Sun 2008, Burns et al 2013)



Can we do better?

always commit all is too risky



The Meta-level Problem: Commit or Not Commit

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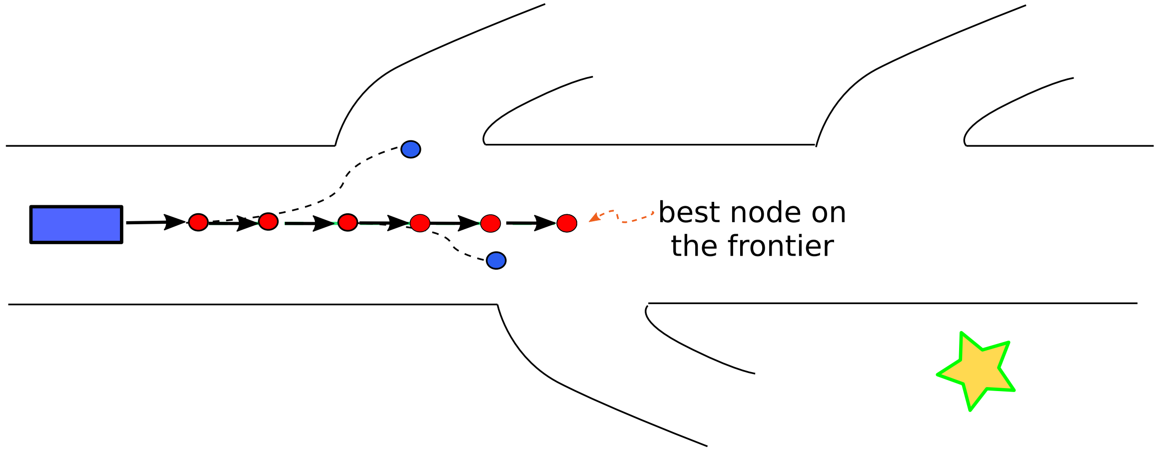


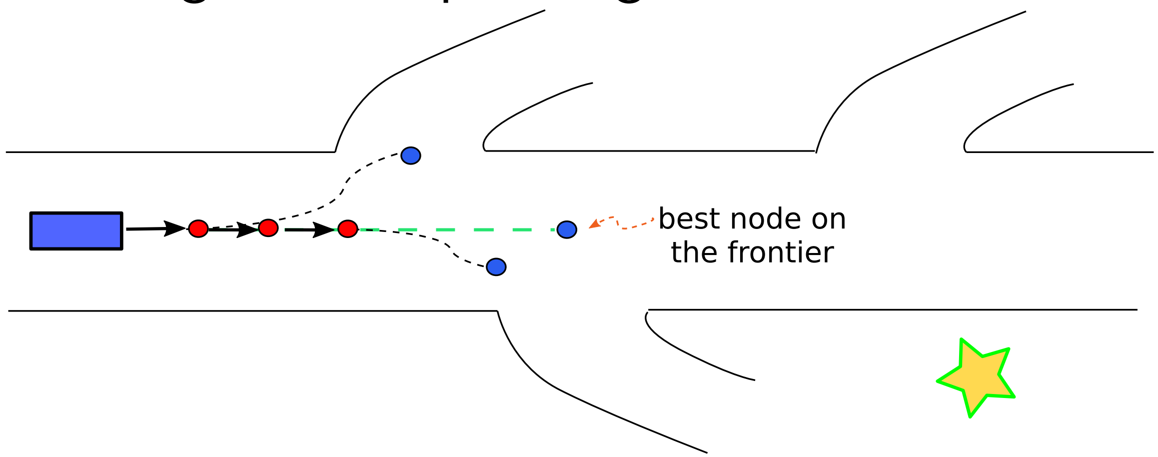
always commit one is too conservative

The Meta-level Problem: Commit or Not Commit

ideal:

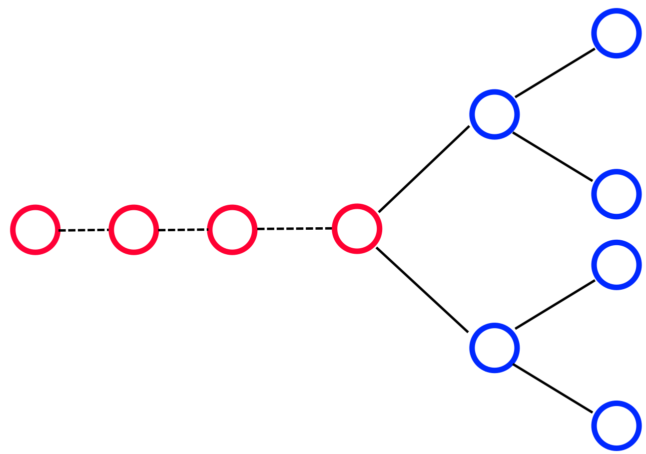
commit if an action in prefix is certainly the best

to gain more planning time for next iteration



Flexible Action Commitment Search

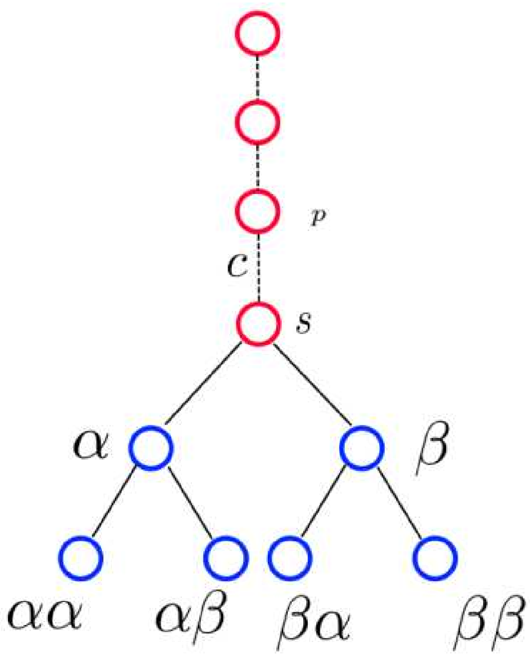
Assumptions

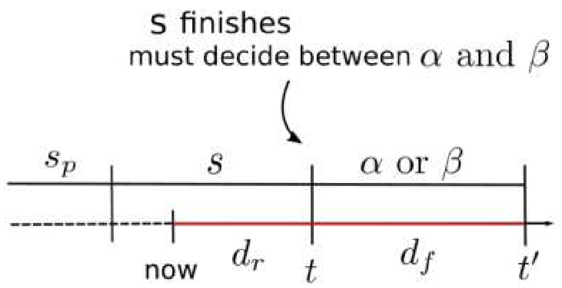


- system can't be uncontrolled, so force to commit if action queue is empty
- search tree structure (order of decisions is fixed)
- deterministic system (no replanning required)

only deal with commitment strategy

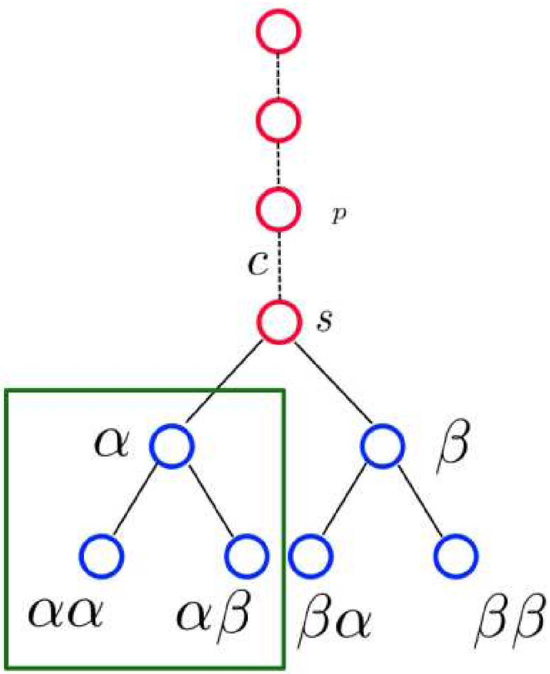
we propose a principled way to make meta-level decision

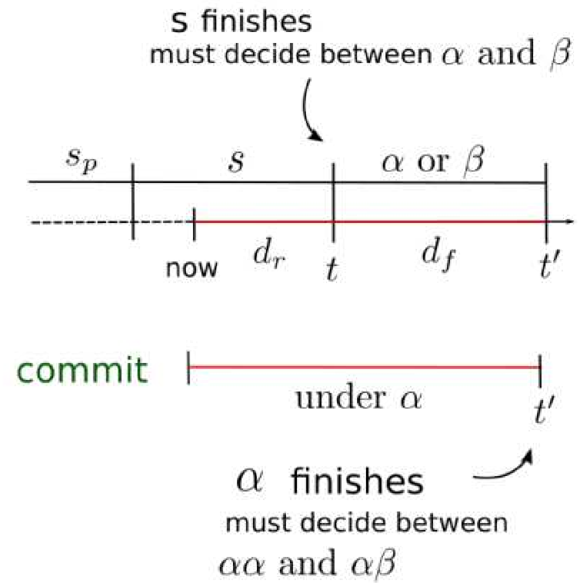




Our Approach: Flexible Action Commitment Search (FACS)

we propose a principled way to make meta-level decision





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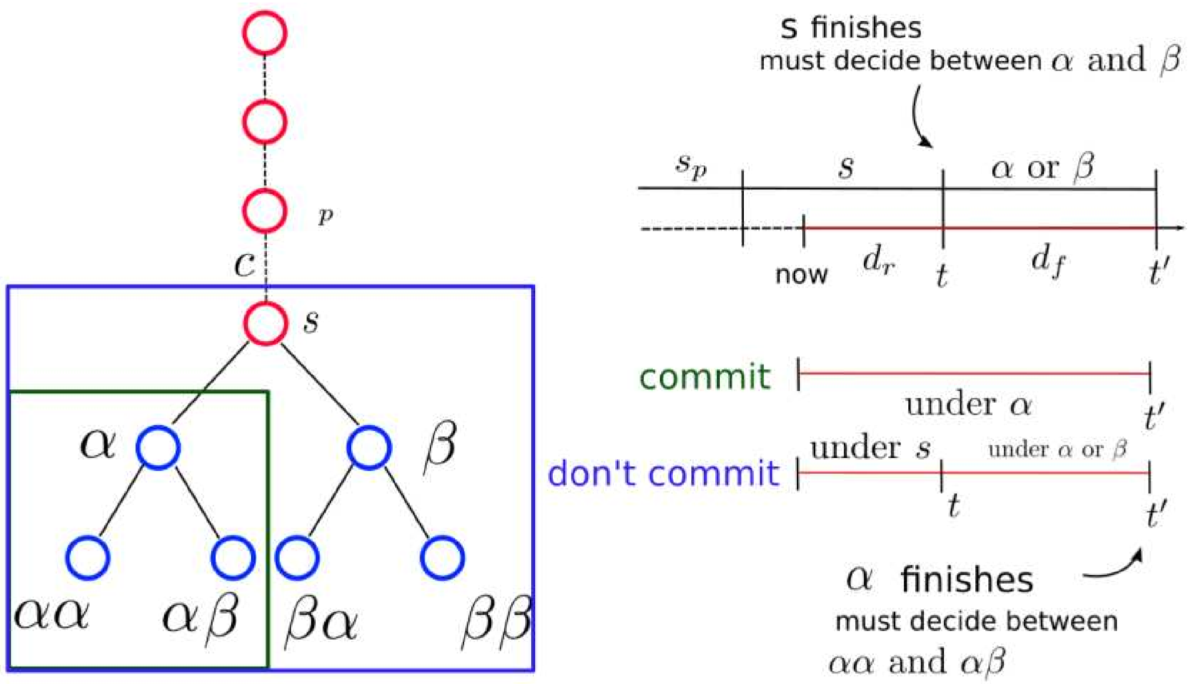
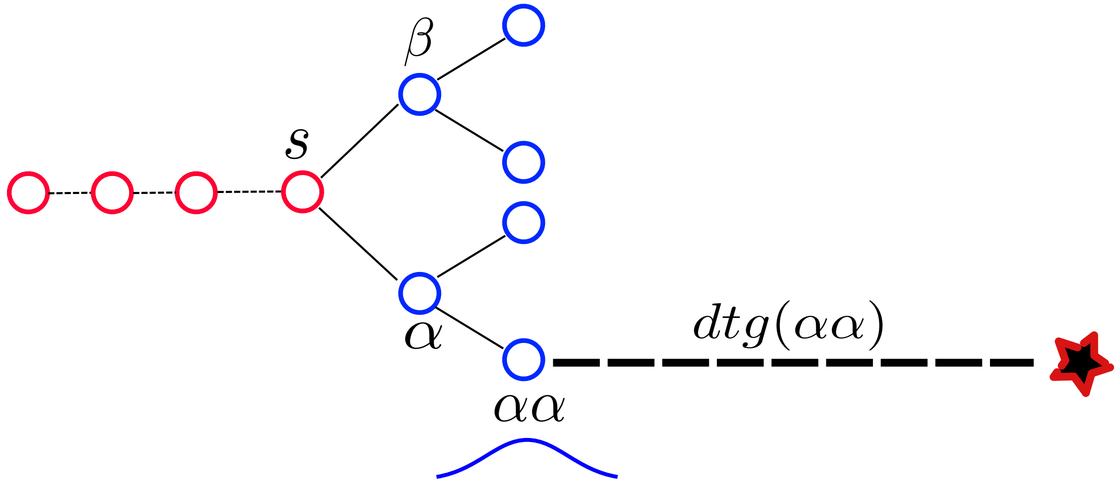
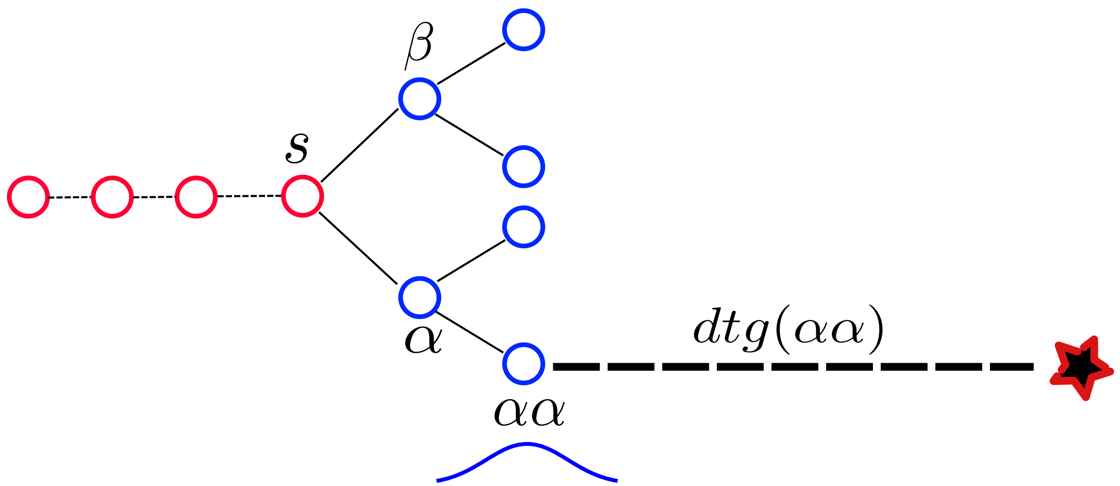


belief of where $\hat{f}$ will be after search:



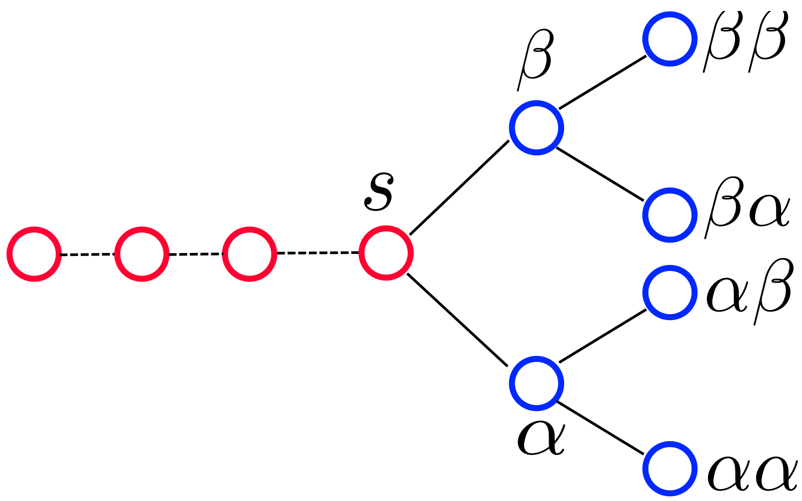
FACS: The Effect of Search

belief of where $\hat{f}$ will be after search:



$$X_{\alpha\alpha}^{d} \sim \mathcal{N}(\hat{f}, var(dtg, d))$$

FACS: Compute Utility



$$U_{\text{commit}} = \mathbb{E}\left[\text{min}(X^d_{\alpha\alpha}, X^d_{\alpha\beta})\right]$$

where $d = (d_r + d_f)/2$

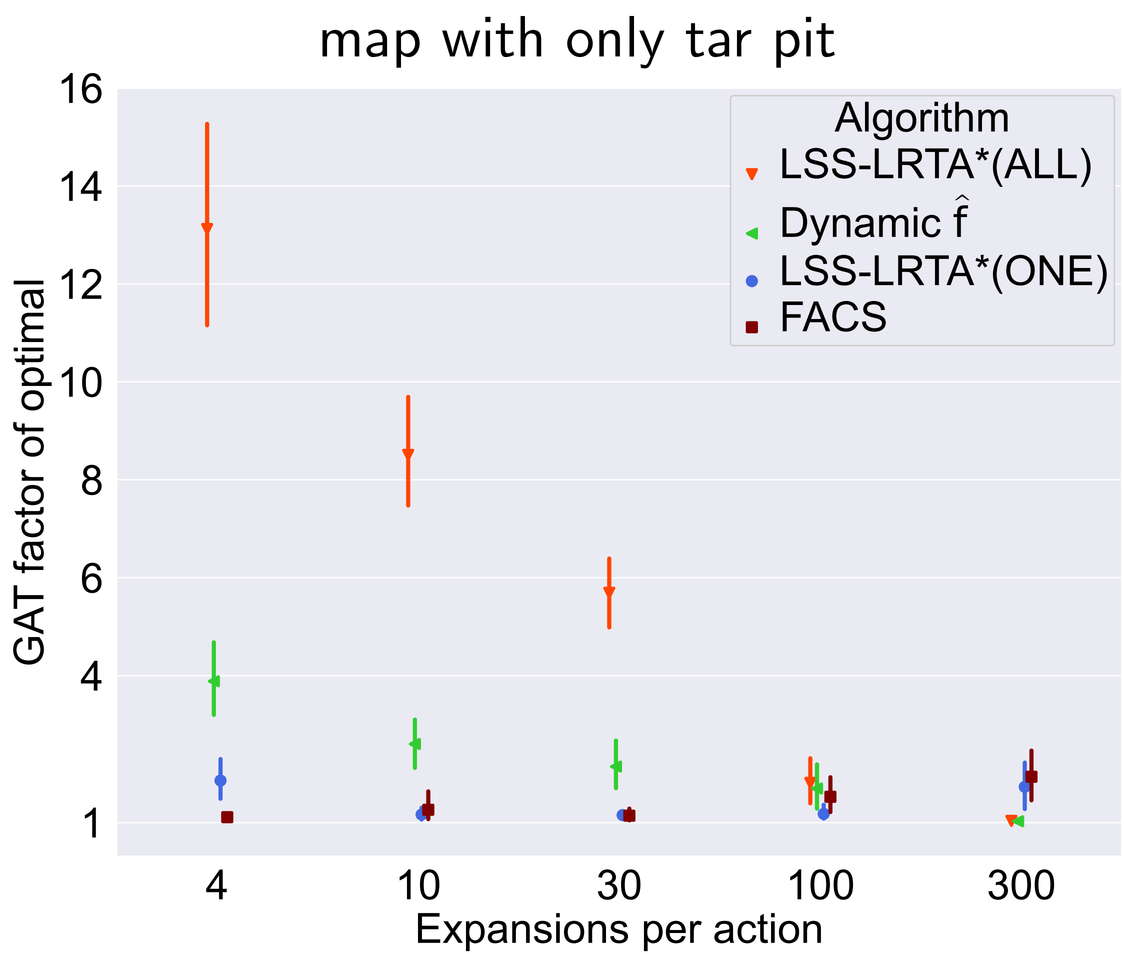
$$U_{\text{don't commit}} = P_{\text{choose } \alpha} \cdot U_\alpha + (1 - P_{\text{choose } \alpha}) \cdot U_\beta$$

commit when $U^{t'}_{\text{commit}} > U^{t'}_{\text{don't commit}}$

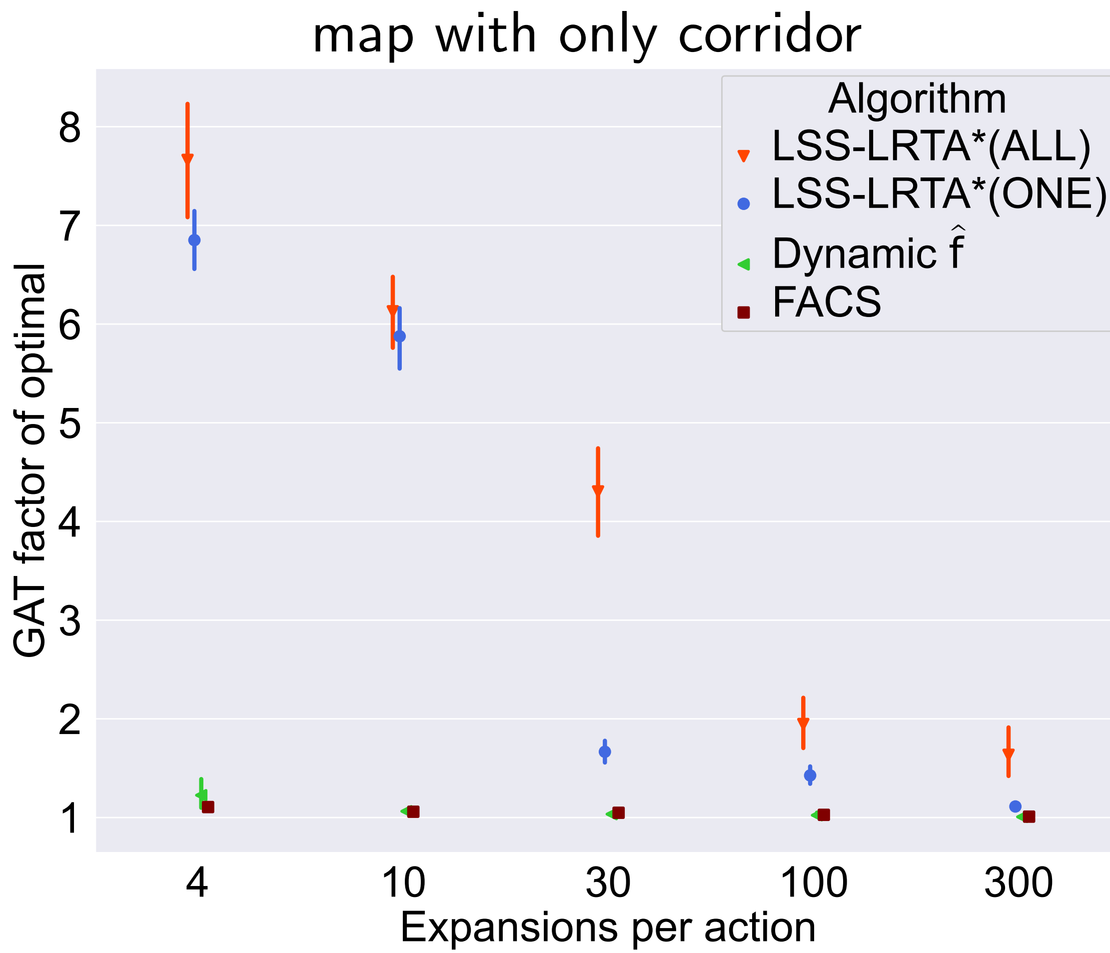
Results

Synthetic Grid Pathfinding

- Left: tar pit area → high cost for reckless committing
- Right: corridor area → need long lookahead to observe the local minima
- Middle: empty area → gain lookahead, no harm to commit

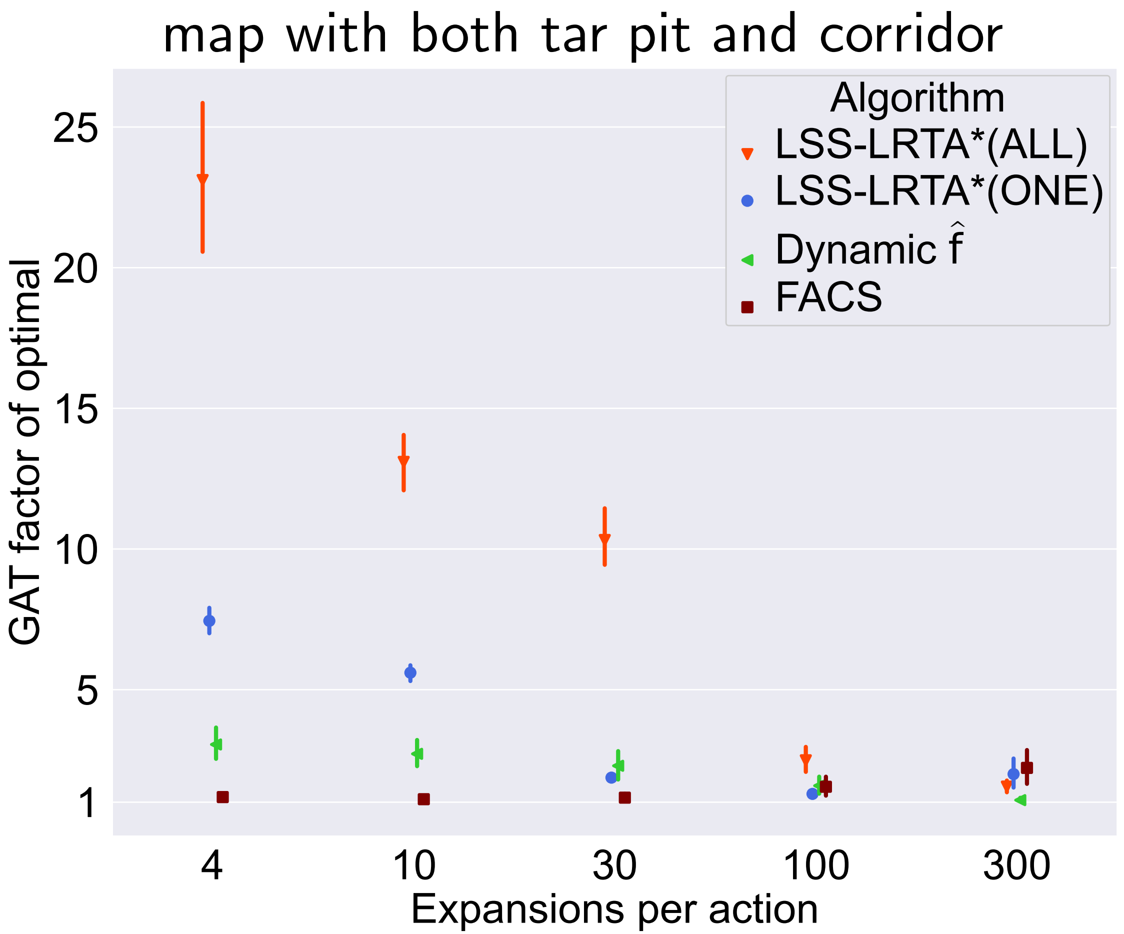


commit-all perform badly



algorithms with small action queue perform badly

Results



FACS consistently performs the best

Summary

- FACS starts to explore a principled way of doing online action commitment
- FACS is better than fixed baseline strategies in synthetic grid pathfinding scenarios.
- Deliberation on how to allocate search effort can benefit online planning

More broadly:

- Metareasoning pays off when planning under time pressure!

Questions?