

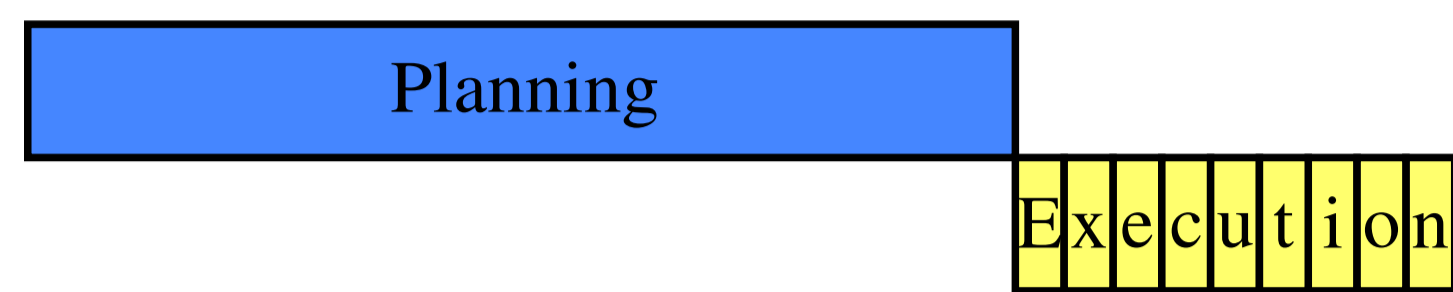
Metareasoning for Concurrent Planning and Execution

Dylan O'Ceallaigh
and Wheeler Ruml

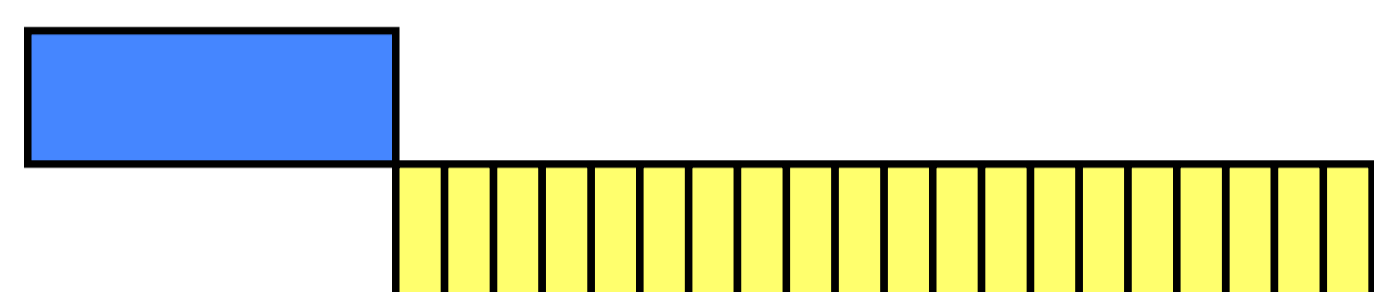


Concurrent Planning and Execution

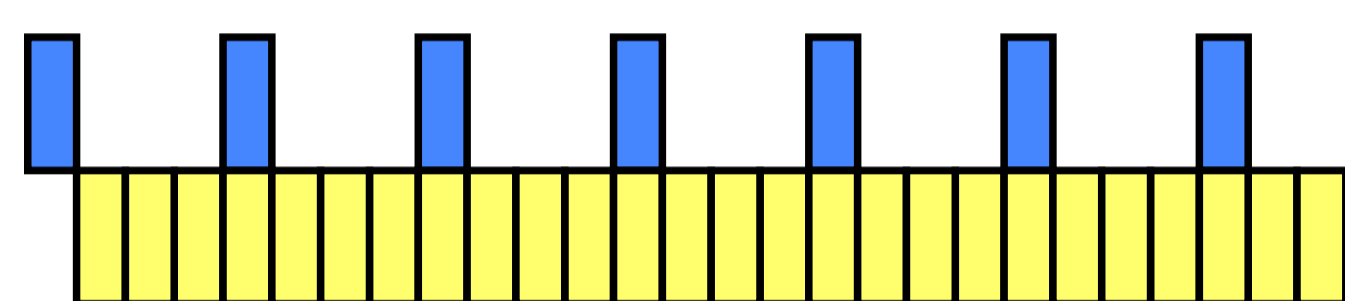
Optimal search (A*): Minimize Execution



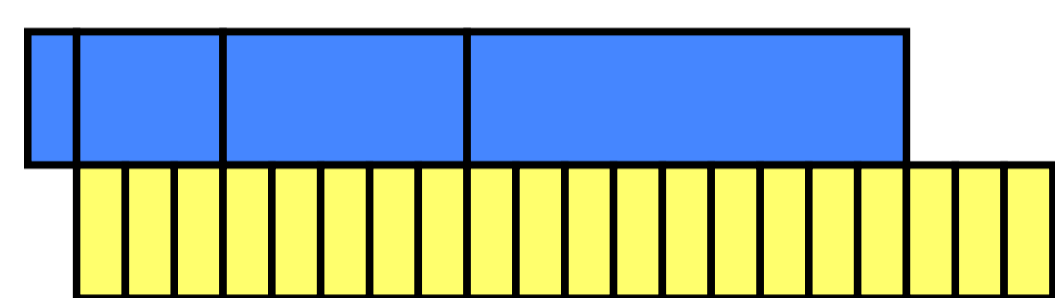
Greedy search: Minimize Planning



Real-time (LSS-LRTA*)



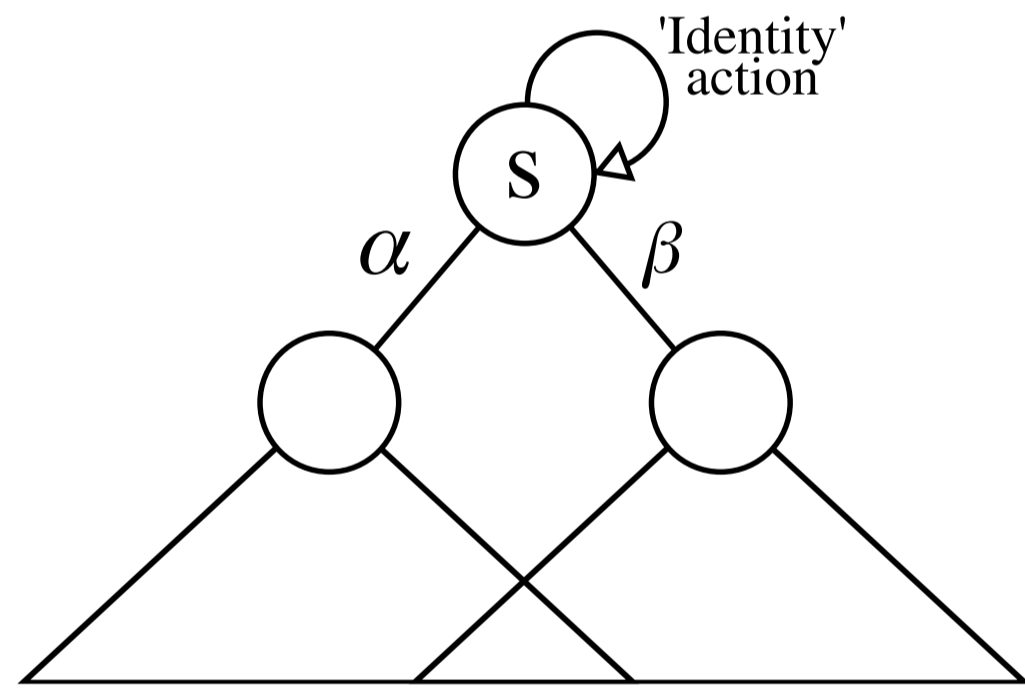
Dynamic Real-time



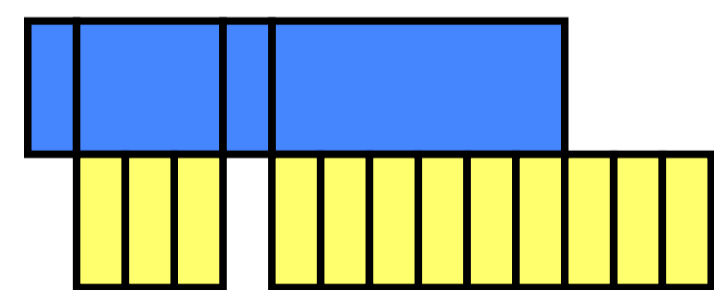
Problem 1: When to act?

Context: Forward state-space search

Identity actions allow the previously generated search space to be reused and extended



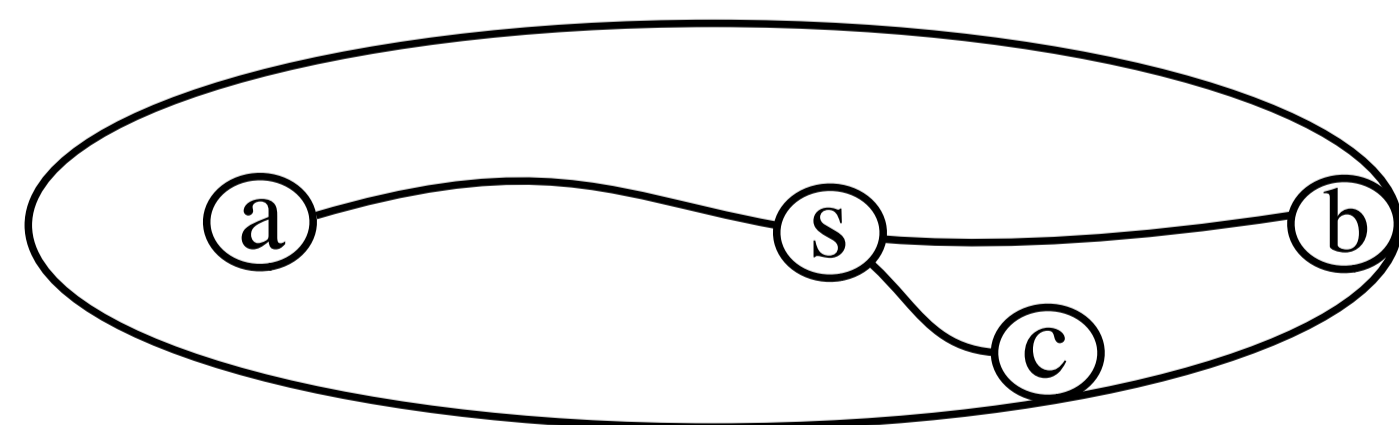
Agent can then choose to deliberate instead of acting:



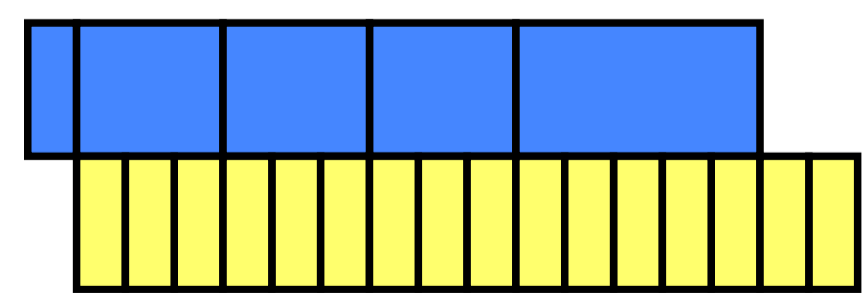
When to do this?

Problem 2: How many actions to commit to?

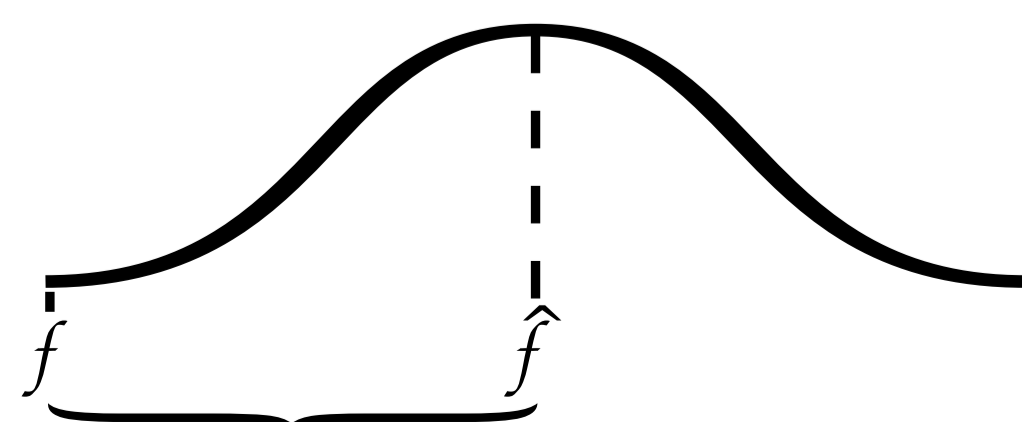
Some algorithms always commit to the lookahead frontier. Is this always best?



Commit to as much of the prefix as we are certain about:



Assume both admissible heuristic h and inadmissible heuristic \hat{h} :



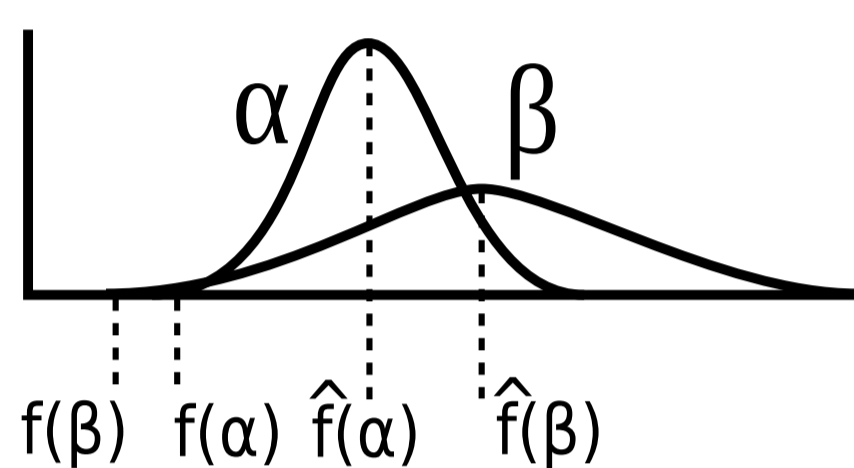
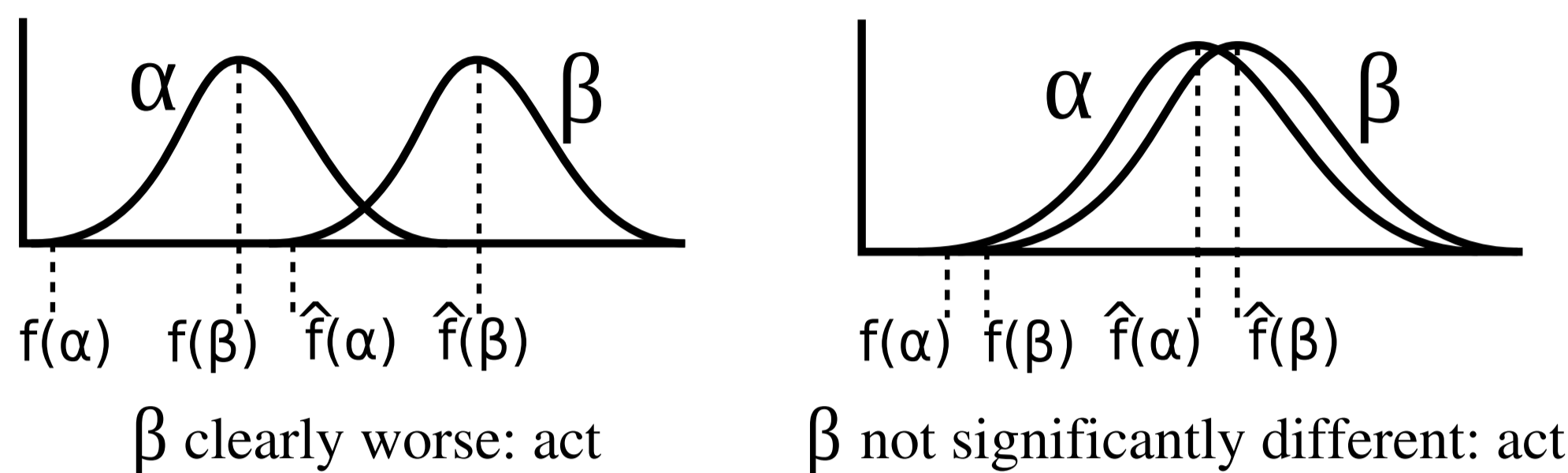
estimated heuristic error

Approach: Metareasoning

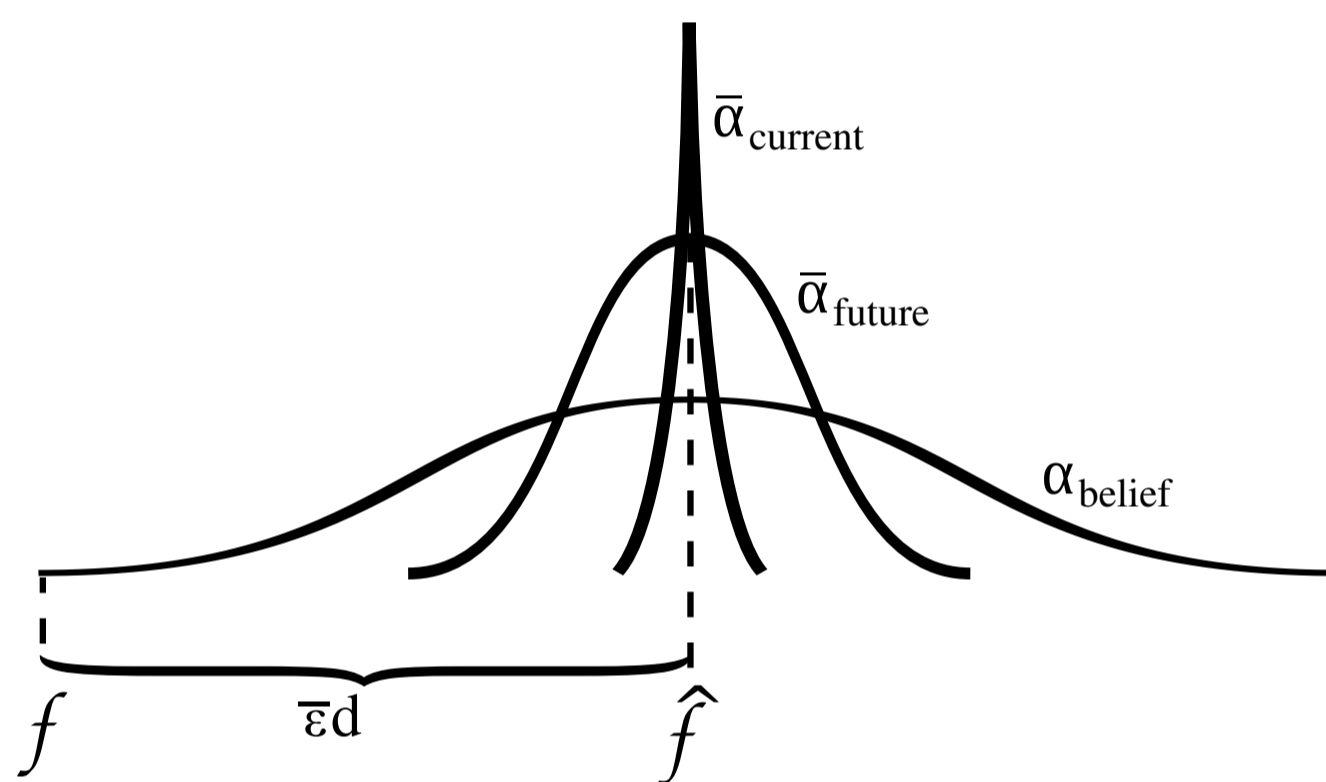
Problem 1: When to act?

Search when expected makespan reduction > planning time

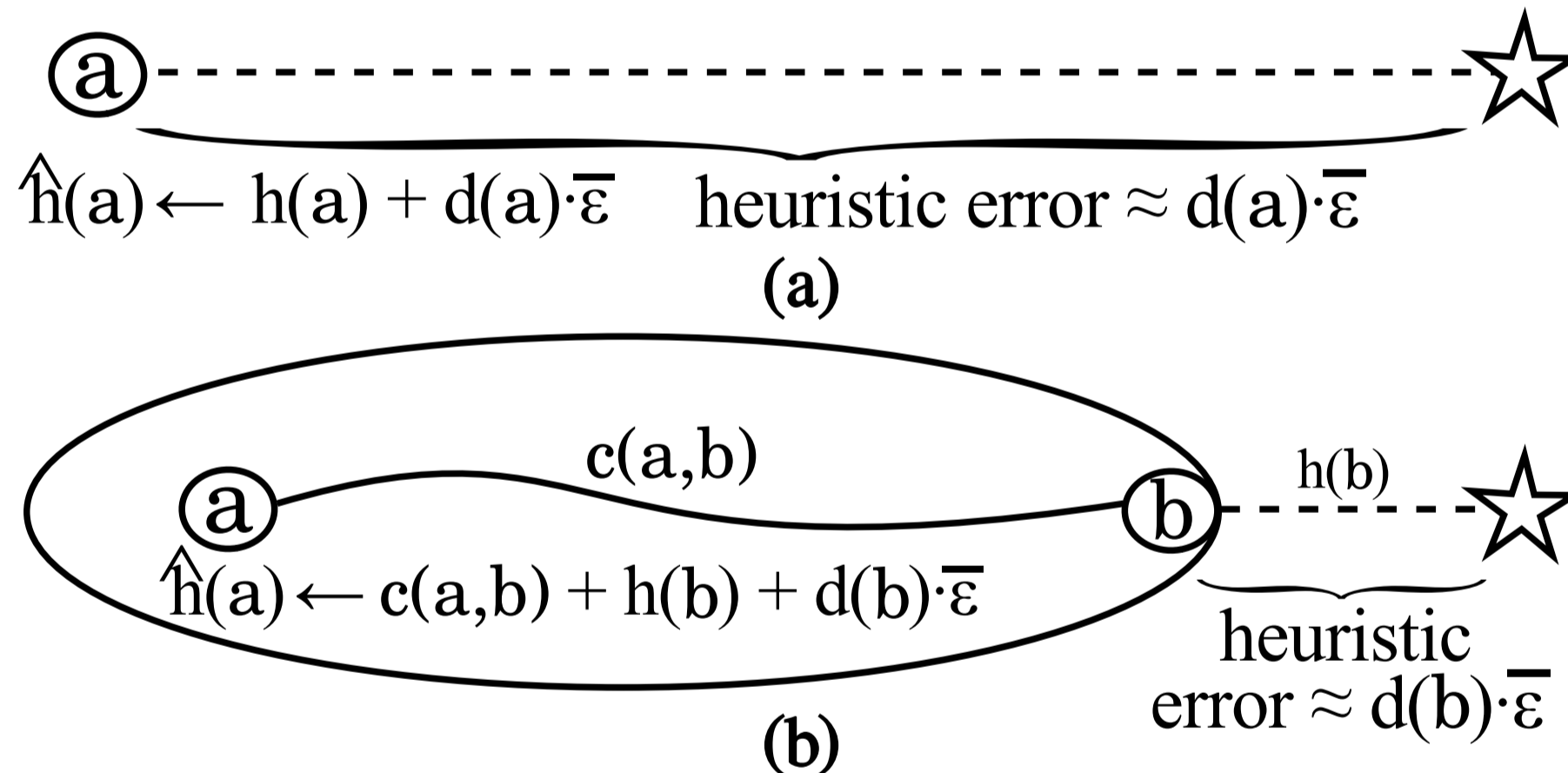
Distinguish between three scenarios



Estimating belief distribution for action values



Measuring heuristic error



Heuristic error applies only to the distance not covered by the LSS

Possible benefit:

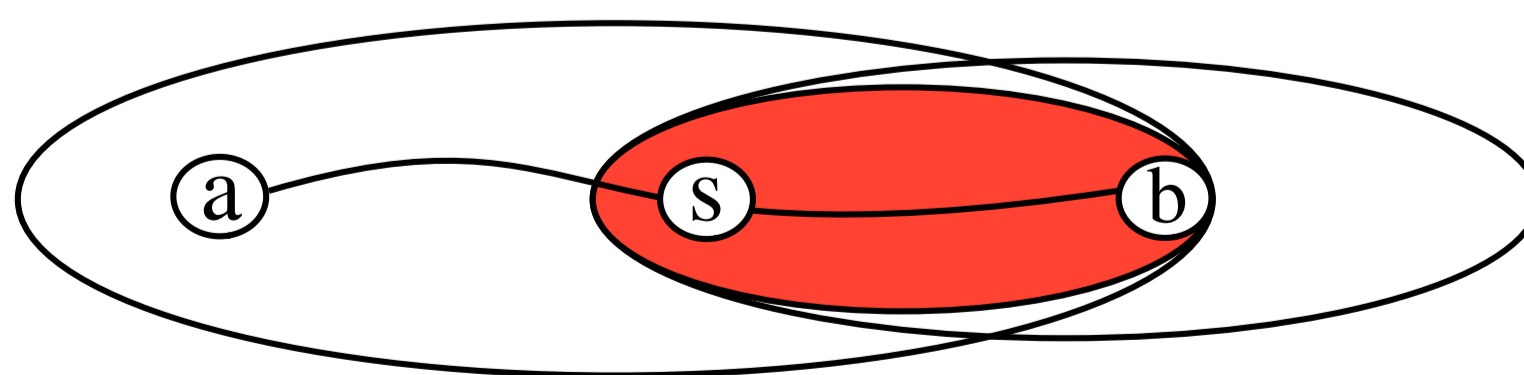
$$b(x_\alpha, x_\beta) = \begin{cases} 0 & \text{if } x_\alpha \leq x_\beta \\ x_\alpha - x_\beta & \text{otherwise} \end{cases}$$

Search benefit estimate:

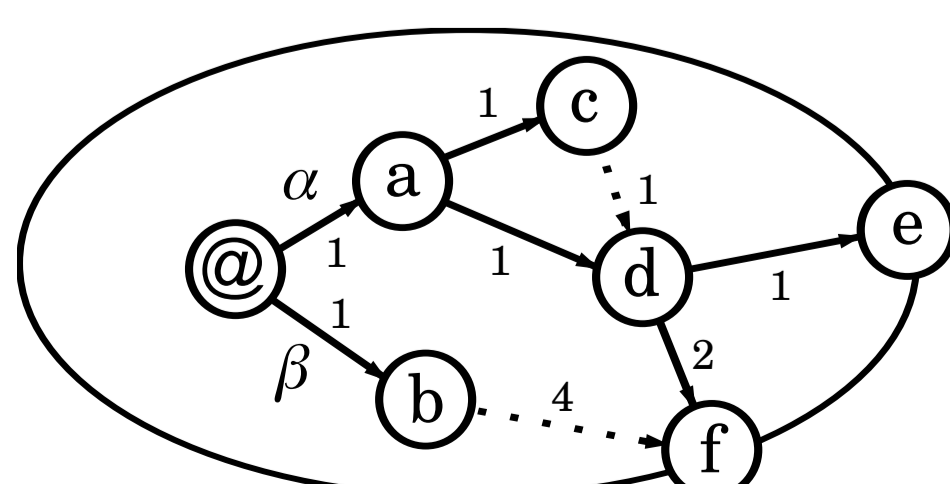
$$B = \int_{x_\alpha} P_\alpha(x_\alpha) \int_{x_\beta} P_\beta(x_\beta) b(x_\alpha, x_\beta) dx_\alpha dx_\beta$$

Problem 2: How many actions to commit to?

Commit to any action where search is not worthwhile



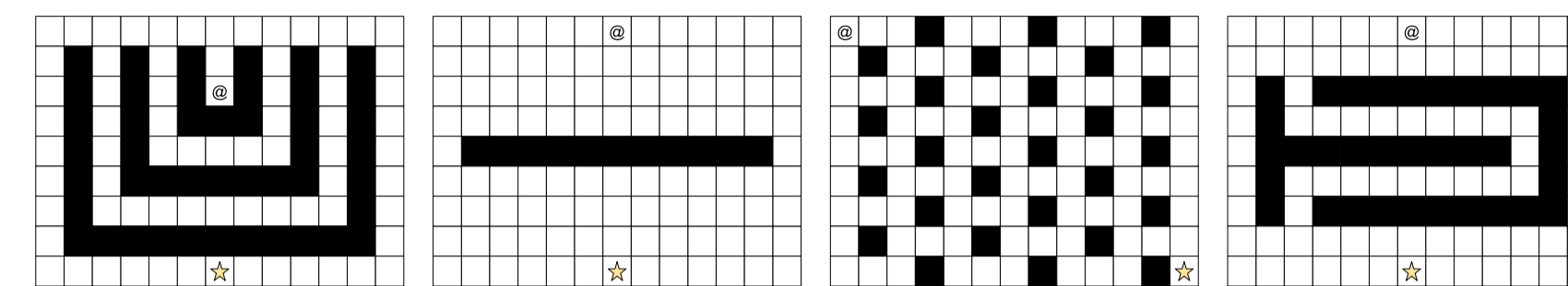
Prefixing cost is approximated as the amount of repeated search



Decisions are useful iff on the best path to an alternative frontier node

Experimental Results

New algorithm Mo'RTS tracks best of A* and real-time



instance	algorithm	GAT	short	identity
cups	A*	166	90	90
	hill-climbing	3108	1	1
	RTA*	1666	1	1
	LSS-LRTA*	3500	1	1
	\hat{f}	5322	1	1
	\hat{f}_{IMR}	970	255	255
wall	\hat{f}_{PMR}	4238	646	1
	Mo'RTS	241	83	82
	A*	102	43	43
	hill-climbing	241	1	1
	RTA*	723	1	1
	LSS-LRTA*	523	1	1
uniform	\hat{f}	717	1	1
	\hat{f}_{IMR}	101	31	31
	\hat{f}_{PMR}	441	100	1
	Mo'RTS	140	64	62
	A*	29578	27180	27180
	hill-climbing	2999	1	1
slalom	RTA*	2997	1	1
	LSS-LRTA*	3195	1	1
	\hat{f}	2997	1	1
	\hat{f}_{IMR}	2997	1	1
	\hat{f}_{PMR}	2997	1	1
	Mo'RTS	2997	1	1

1	2	3	
4	5	6	7
8	9	10	11
12	13	14	15

