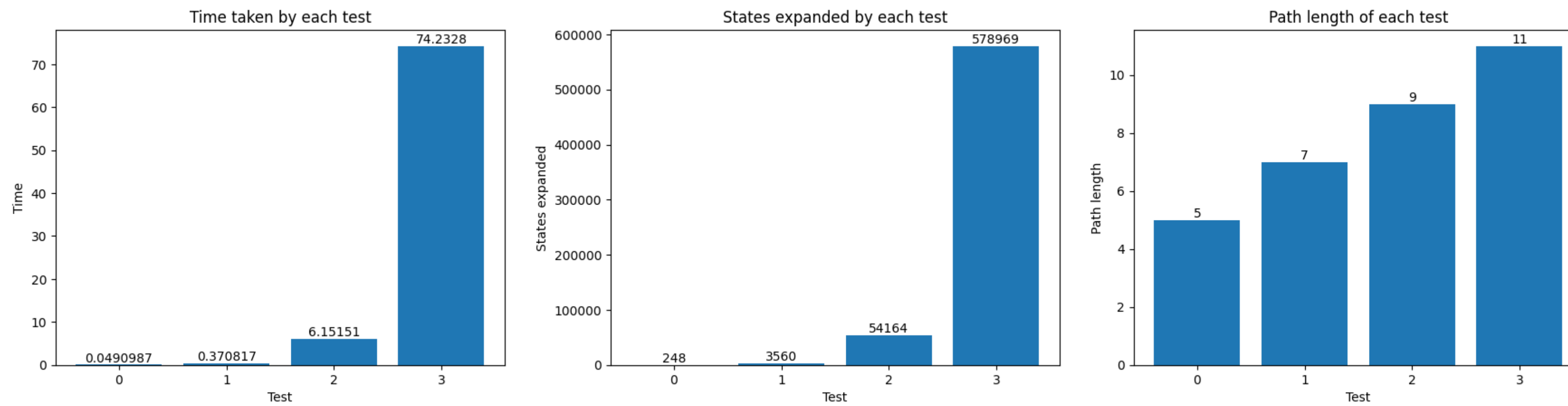
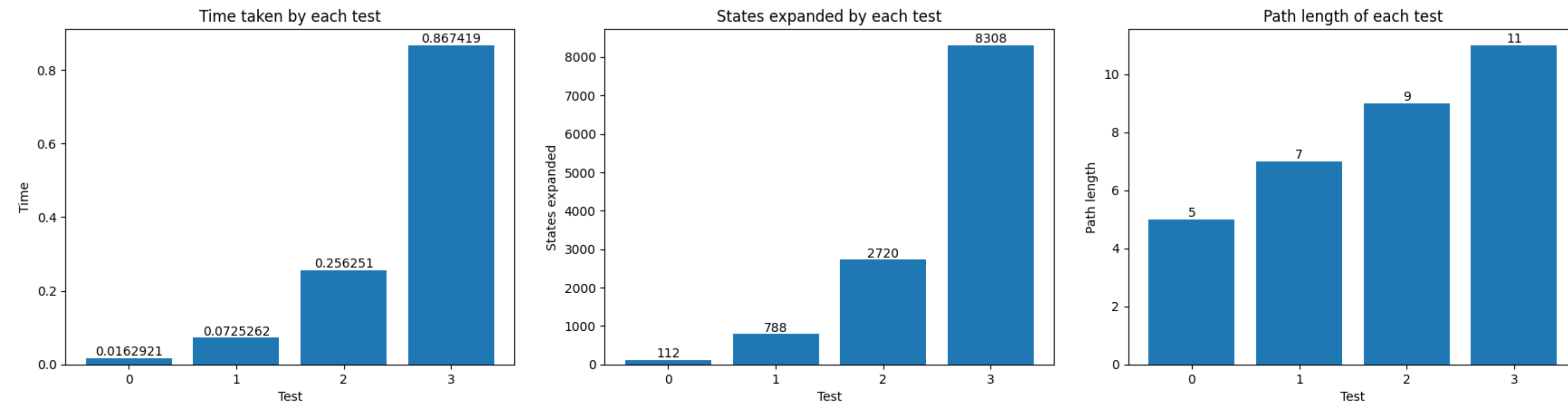


# A\*

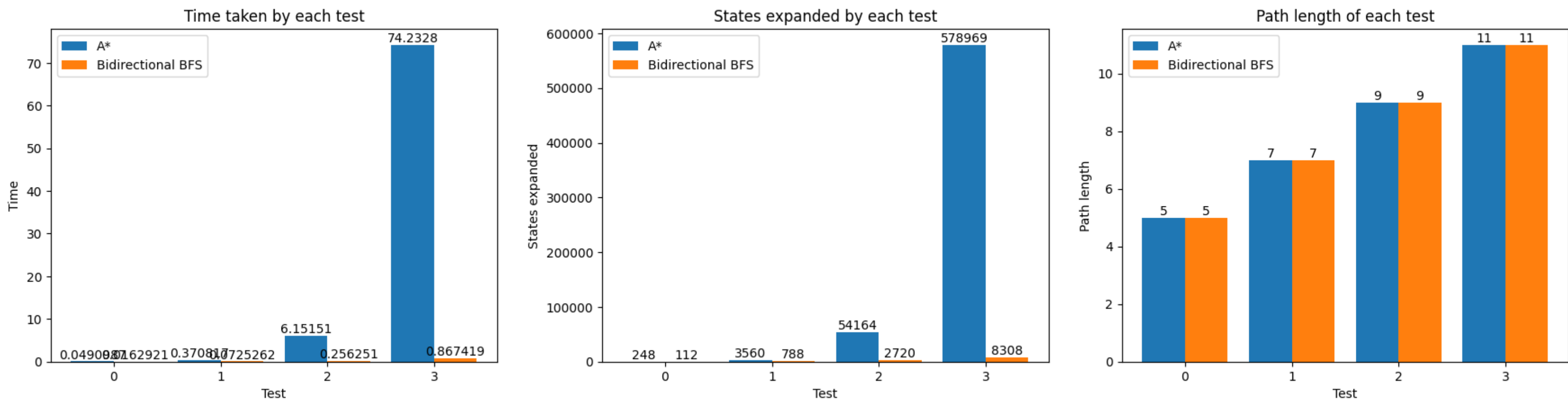


# BFS



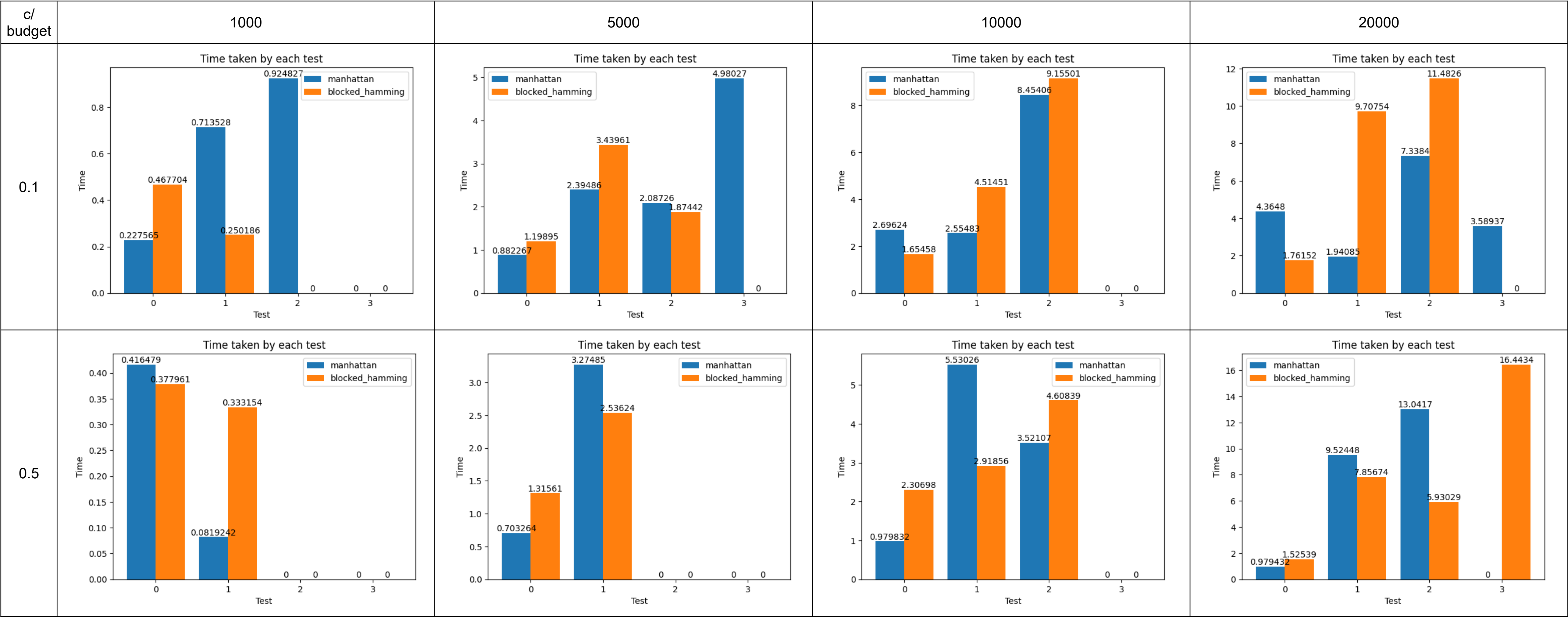
# A\*/BFS Comparison

We can see that BFS is much faster and also expands a lot less states than A\*. The length of the path is the same for both of them and it also is the length of the shortest path. This is expected for BFS and confirms that the heuristic used for A\* is probably admissible.

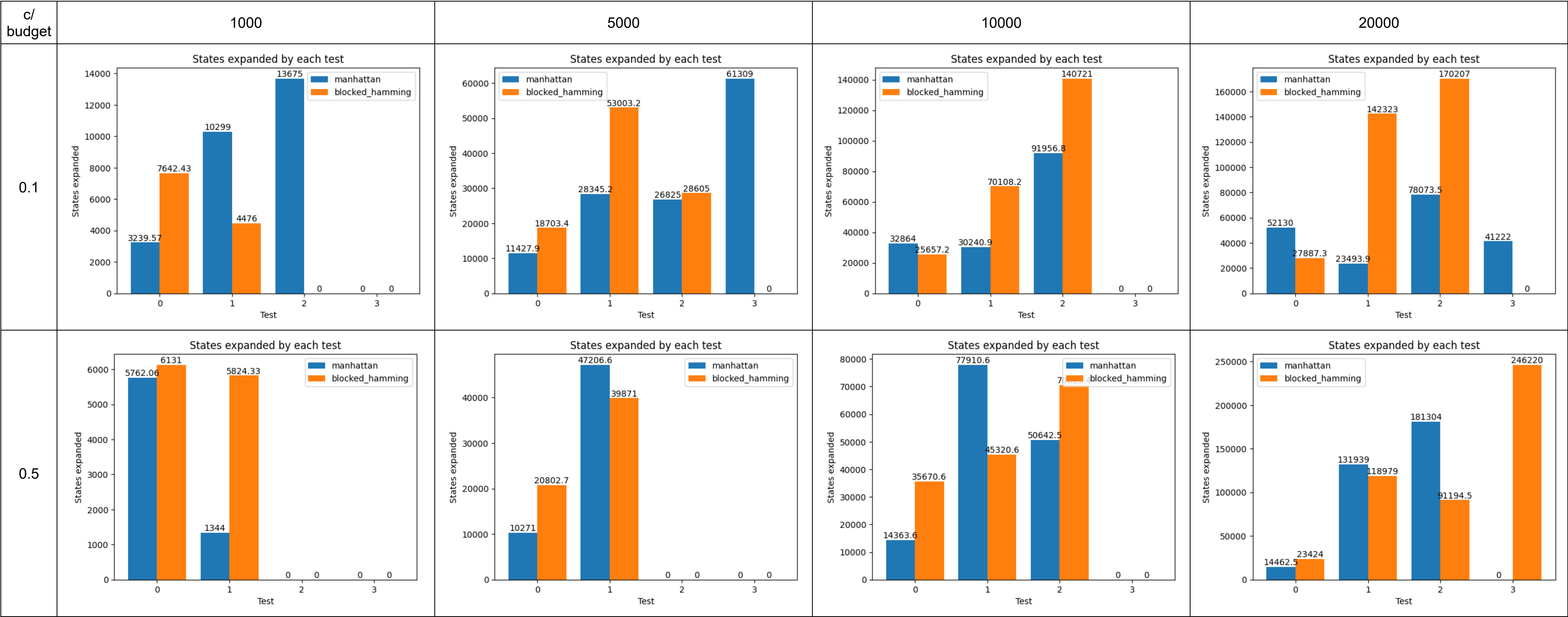


# MCTS

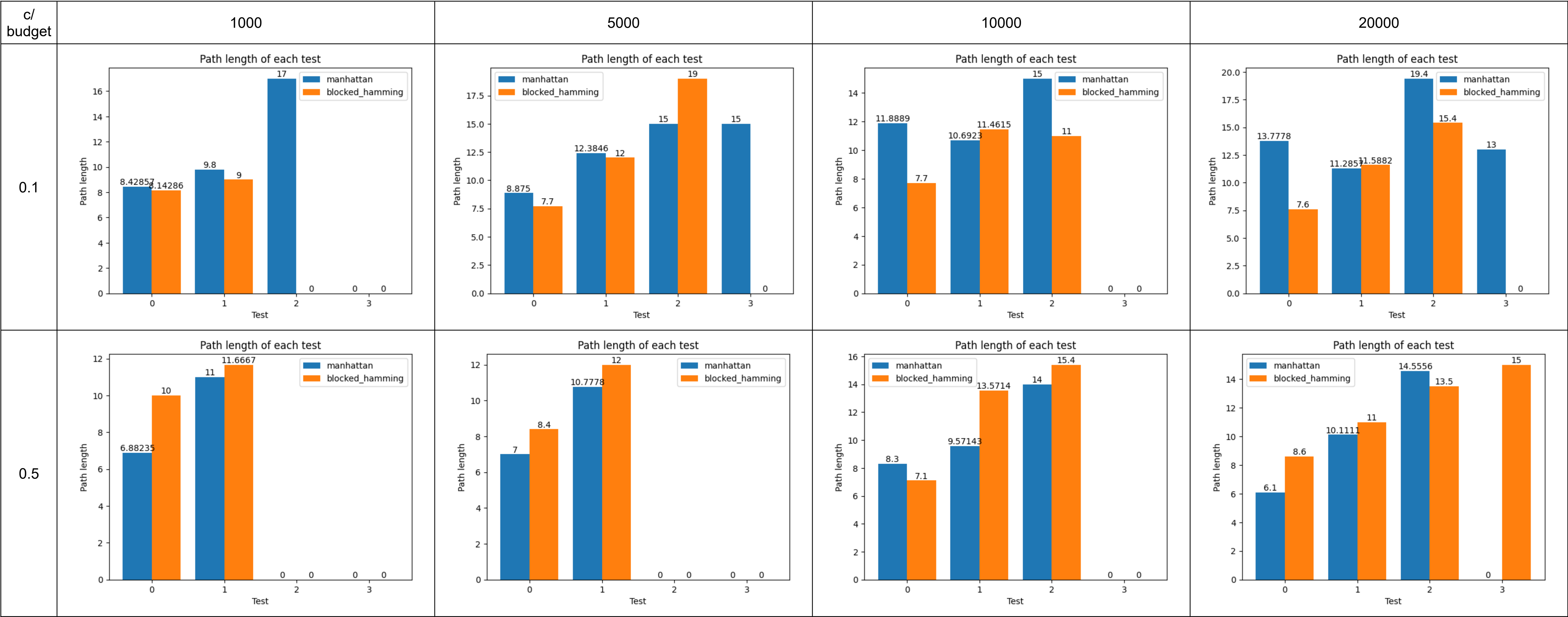
Time taken



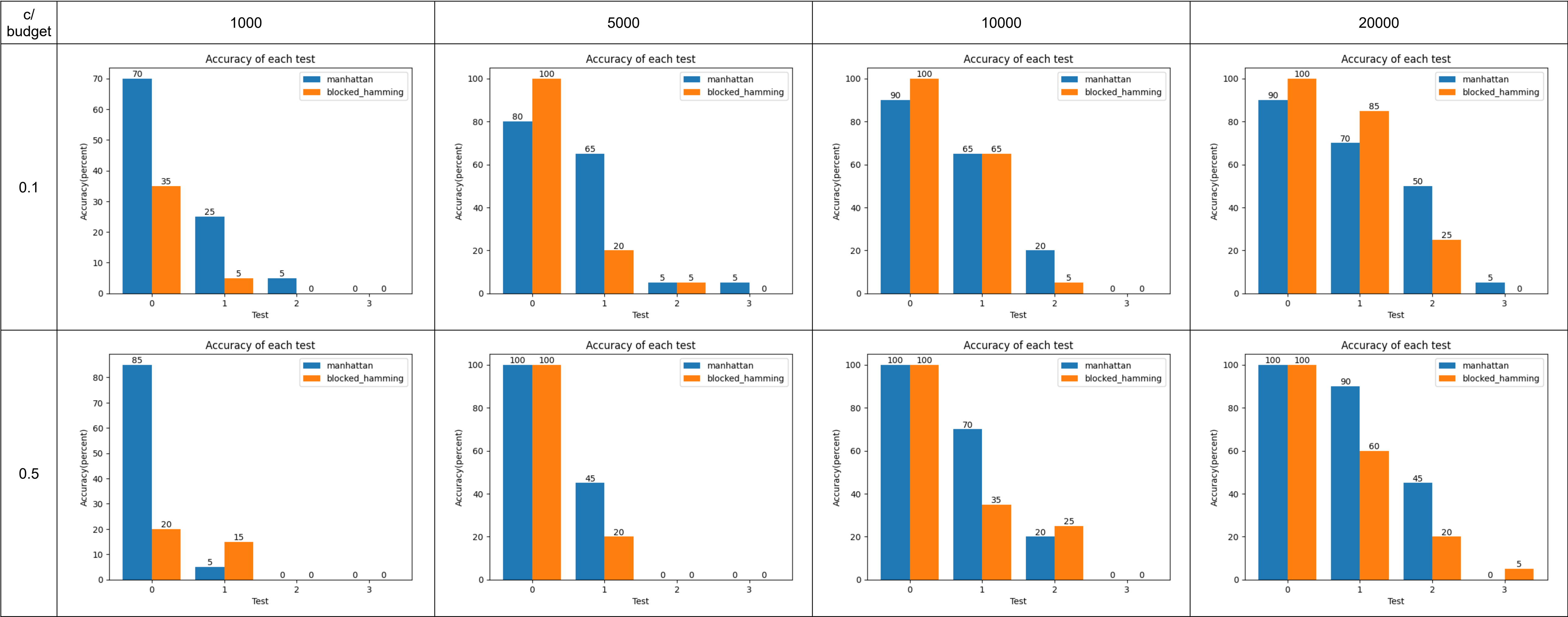
States expanded



Path length



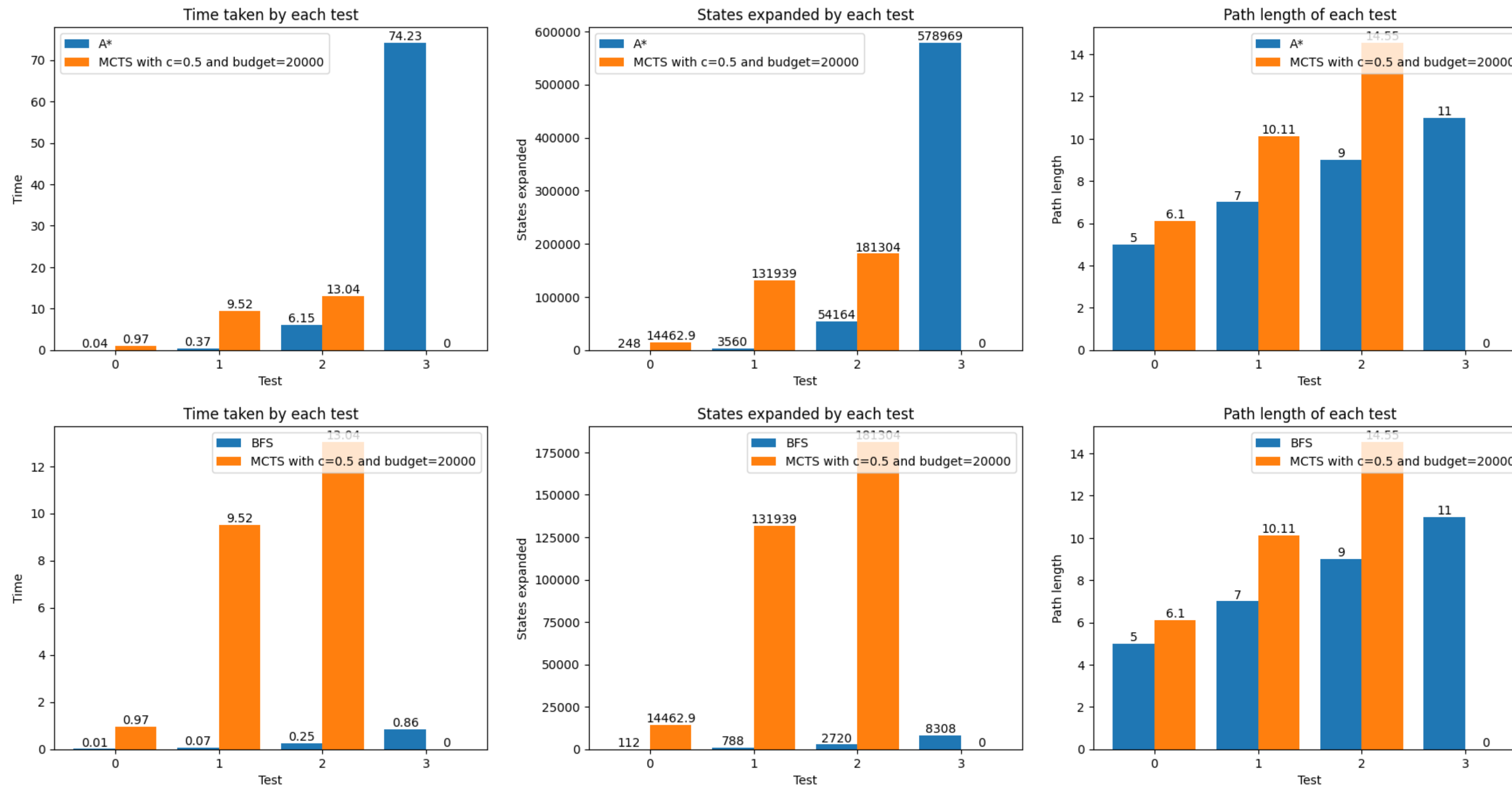
Accuracy



# A\*/BFS/MCTS Comparison

The MCTS with the best results was with  $c=0.5$ , budget=20000 and using the manhattan heuristic. It has better accuracy and finds a shorter path on average. It does take longer and expands more states.

Unfortunately in this run of tests, MCTS did not find any solutions for Test 4, but from other tests I found an accuracy of about 5%, on par with the blocked\_hamming accuracy.

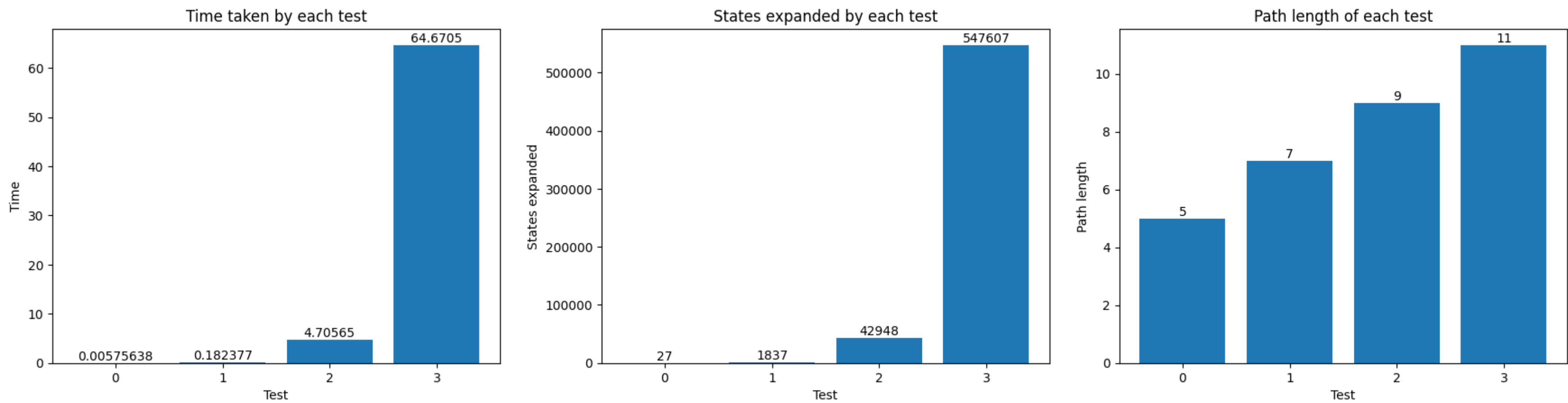


# Database Construction

Database built in 3.521756410598755 seconds.

## A\* with Database

We can see a small improvement in the time taken for the algorithm to run. The length of the path is the same, since the heuristic is admissible. We can also see a small improvement in states expanded, which is to be expected.

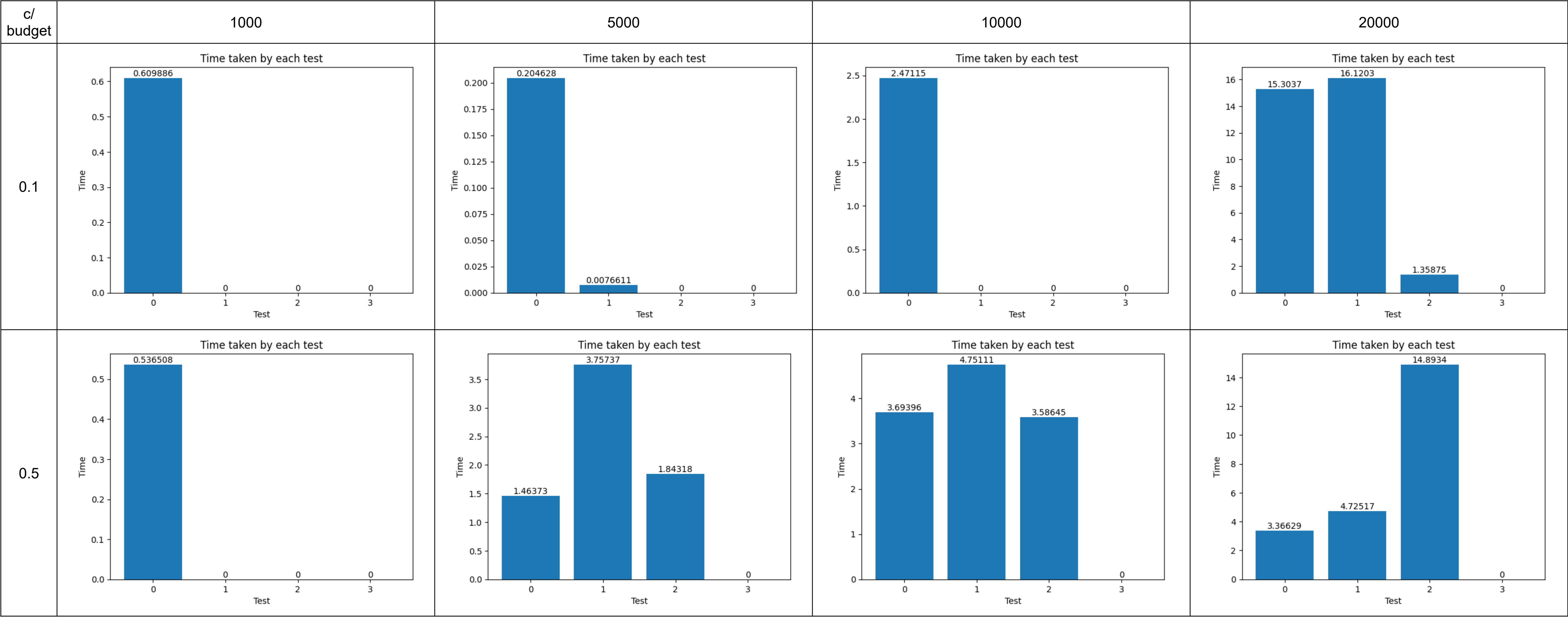




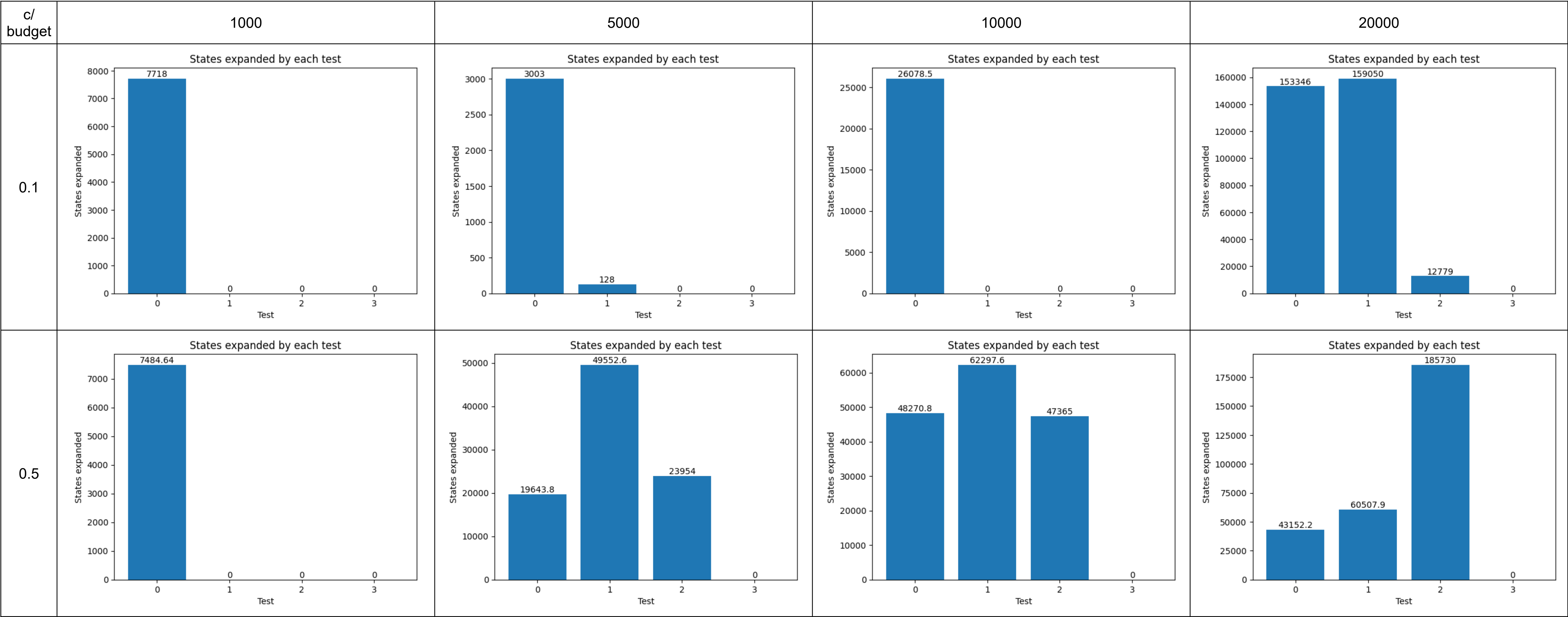
# MCTS with Database

The best parameters to use are by far  $c=0.5$  and budget=20000. Despite using the database heuristic, which I expected to improve the algorithm, the results are worse and the accuracy drops significantly. I do not know how to explain this.

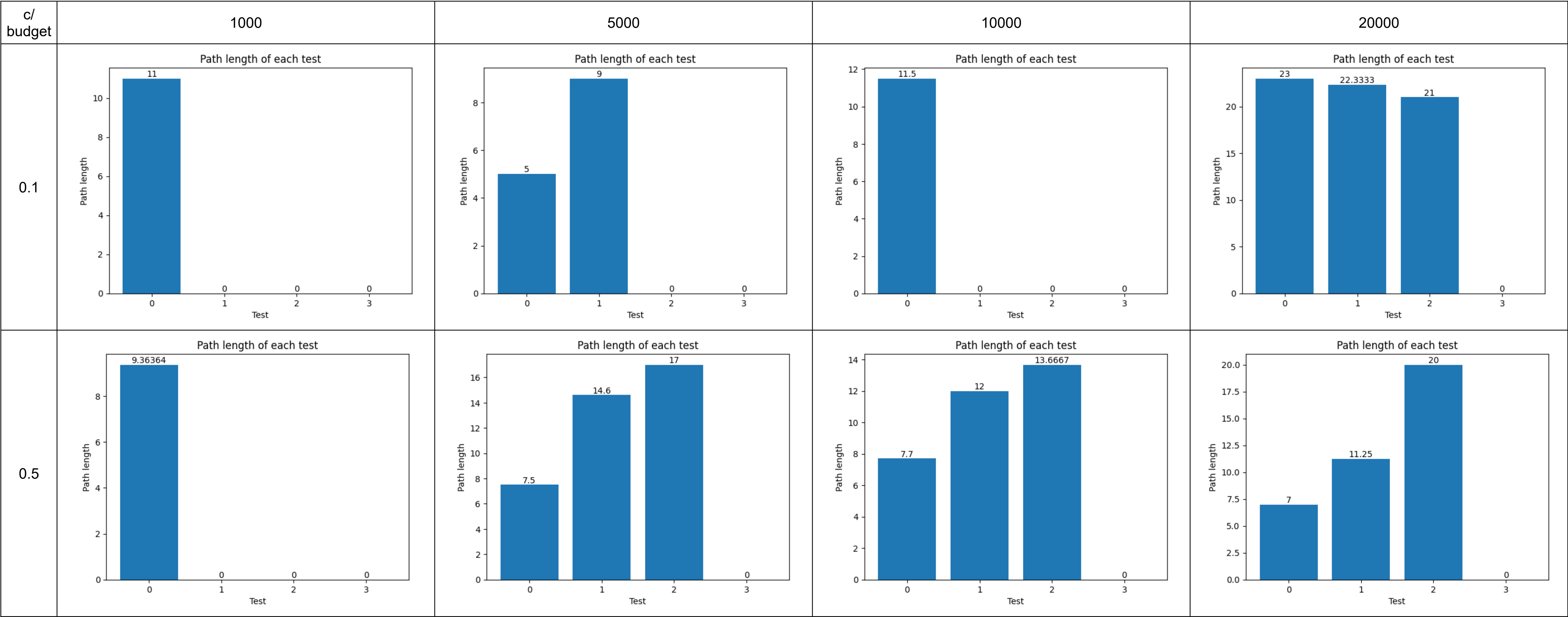
Time taken



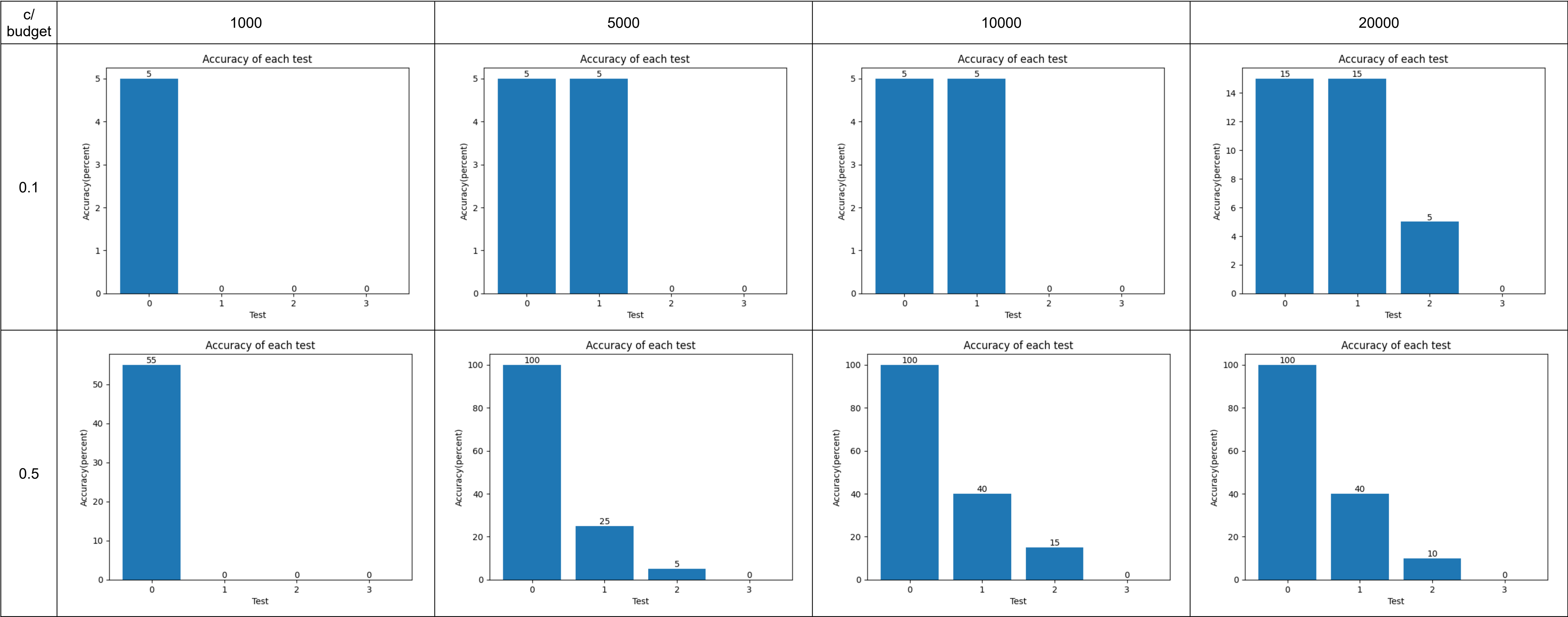
States expanded



Path length

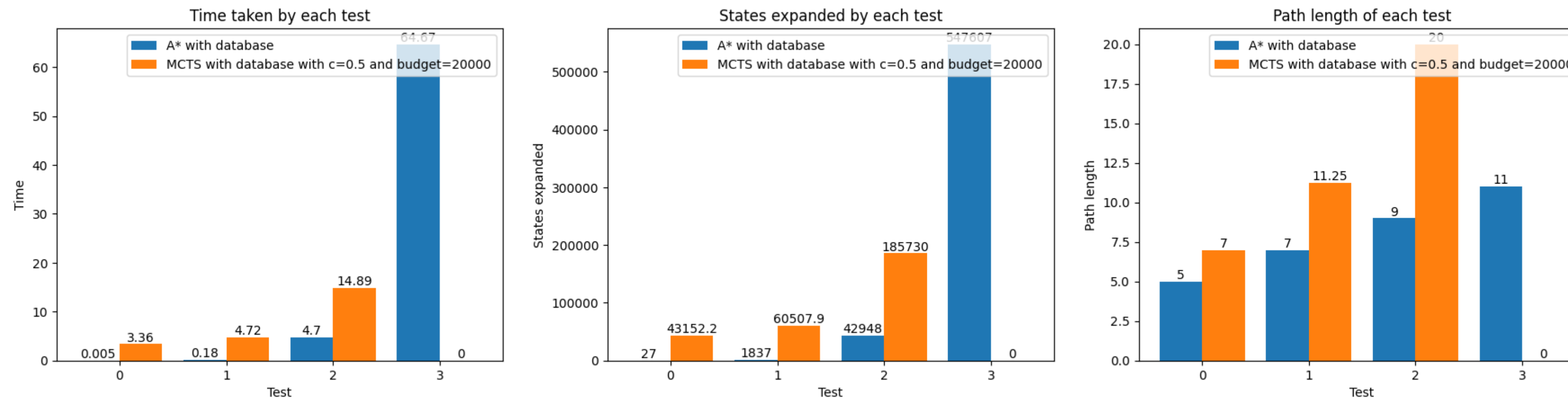


Accuracy



# A\* with database/MCTS with database Comparison

We can see that A\* vastly outperforms MCTS when both of them are using a database heuristic.



## Final Conclusions

The best algorithm to use is BFS. It runs the fastest by a wide margin, with all tests running in under a second. At the same time, it also finds the shortest path and expands less states. This is to be expected, as the time and space complexity is reduced by a lot and an heuristic, no matter how good, can't bring A\* to the same results.

MCTS is very bad for this problem. The randomness leads to very low accuracy and the problem of solving the cube doesn't accept approximate solutions, so the smallest error margin can lead to an useless result.