# Current-state opacity verification in discrete event systems using an observer net

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## ABSTRACT

## 1 Experimental study data

The effectiveness of the approach developed is investigated by comparing it with the opacity verification methods recently proposed in the literature to demonstrate their advantages and limitations. It is based on the CPU time in seconds of a desktop computer running under the operating system Windows 10 with I7.4 CPU 3.40 GHz, 32 GB memory.

To do so, we apply the proposed on-line algorithm to a larger version of the LPN (presented in the paper), where the initial marking is $M_0 = 15p_1$. Let $S = \{(4p_3 + 11p_5), (5p_1 + 10p_5), (8p_1 + 3p_5 + 4p_6), (11p_1 + 2p_2 + 2p_3), (13p_1 + 2p_5), (14p_1 + p_5), (15p_1)\}$ be a secret. We use the standard opacity verification approach, which consists of computing the RG and converting the obtained RG into its equivalent DFA. After that, for each state of the observer (i.e., $\mathcal{C}(w)$), we check whether it is fully included in the secret or not.

Performance of Algorithm 2

| Event occurrence | time (s) | CSO |
|---|---|---|
| observable event $a$ occurs | $7.4 \times 10^{-2}$ | Y |
| observable event $a$ occurs | $6.7 \times 10^{-1}$ | Y |
| observable event $b$ occurs | $1.1 \times 10^{1}$ | Y |
| observable event $a$ occurs | $2.6 \times 10^{1}$ | Y |
| observable event $a$ occurs | $3.9 \times 10^{1}$ | Y |
| observable event $b$ occurs | $5.7 \times 10^{1}$ | N |

Now, let us implement the on-line algorithm to the same example. Table 1 shows the performance of Algorithm 2. The first column represents the occurrence of an event. The second indicates the time (CPU seconds) required to run an observer net when an event occurs. The third column shows the algorithm's outputs when an event occurs: "Y" if the observation is CSO and "N" otherwise. From Table 1, it is known that the observed event sequence $w = aabaab$ is non-current-state opaque wrt $S$.

Examine the LPN system $G$ (presented in the paper) with initial marking $M_0 = kp_1$, where $k \in \mathbb{N}$. Accordingly, we consider a family of nets rather than a single LPN, which is parameterized by the initial marking. Table 2 compares the colored estimator construction using the observer net, i.e., $EST_\Phi$, as shown in Algorithm 3, with the standard approach for observer construction, i.e., DFA construction using the RG of an LPN. The first column shows the value of $k$. The number of reachable markings is represented in Column 2. Columns 3 and 4 give the number of states of the standard observer and its construction time, respectively. Finally, Columns 5 and 6, respectively, expose the number of states in the observer net and the time of its construction. We use the notation "o.t." (out of time) to indicate that the computation takes more than three hours to complete.

| K | \|RG\| | \|OBS\| |
|---|---|---|
| K=2[200000] | **States=21**<br>[([2,0,0,0,0,0]),([1,1,0,0,0,0]),([1,0,1,0,0,0]),([0,2,0,0,0,0]),([0,1,1,0,0,0]),([1,0,0,1,0,0]),([0,0,2,0,0,0]),([1,0,0,0,1,0]),([0,1,0,1,0,0]),([0,0,1,1,0,0]),([0,1,0,0,1,0]),([1,0,0,0,0,1]),([0,0,1,0,1,0]),([0,0,0,2,0,0]),([0,1,0,0,0,1]),([0,0,0,1,1,0]),([0,0,1,0,0,1]),([0,0,0,2,0]),([0,0,0,1,0,1]),([0,0,0,0,1,1]),([0,0,0,0,0,2])] | **States=6**<br>[([[2,0,0,0,0,0],[1,0,1,0,0,0],[0,0,2,0,0,0],[1,0,0,1,0,0],[0,0,1,0,1,0],[0,0,0,0,2,0]]),([[0,0,0,0,1,1],[0,0,0,1,1,0],[0,0,1,0,0,1],[0,0,1,1,0,0],[0,1,0,0,1,0],[0,1,1,0,0,0],[1,0,0,0,0,1],[1,0,0,1,0,0],[1,1,0,0,0,0]]),([[0,0,0,0,0,2],[0,0,0,1,0,1],[0,0,0,2,0,0],[0,1,0,0,0,1],[0,1,0,1,0,0],[0,2,0,0,0,0]]),([[0,0,0,0,1,1],[0,0,0,1,1,0],[0,0,1,0,0,1],[0,0,1,1,0,0],[1,0,0,0,0,1],[1,0,0,1,0,0]]),([[0,0,0,0,0,2],[0,0,0,0,2,0],[0,0,0,1,0,1],[0,0,0,2,0,0],[0,0,1,0,1,0],[0,0,2,0,0,0],[0,1,0,0,0,1],[0,1,0,1,0,0],[1,0,0,0,1,0],[1,0,1,0,0,0],[2,0,0,0,0,0]]),([[0,0,0,0,0,2],[0,0,0,1,0,1],[0,0,0,2,0,0],[0,1,0,0,0,1],[0,1,0,1,0,0]])] |
| K=4[400000] | **States=126**<br>[([4,0,0,0,0,0]),([3,1,0,0,0,0]),([3,0,1,0,0,0]),([2,2,0,0,0,0]),([2,1,1,0,0,0]),([3,0,0,1,0,0]),([2,0,2,0,0,0]),([3,0,0,0,1,0]),([1,3,0,0,0,0]),([1,2,1,0,0,0]),([2,1,0,1,0,0]),([1,1,2,0,0,0]),([2,0,1,1,0,0]),([2,1,0,0,1,0]),([3,0,0,0,0,1]),([1,0,3,0,0,0]),([2,0,1,0,1,0]),([0,4,0,0,0,0]),([0,3,1,0,0,0]),([1,2,0,1,0,0]),([0,2,2,0,0,0]),([1,1,1,1,0,0]),([1,2,0,0,1,0]),([2,0,0,2,0,0]),([2,1,0,0,0,1]),([0,1,3,0,0,0]),([1,0,2,1,0,0]),([1,1,1,0,1,0]),([2,0,0,1,1,0]),([2,0,1,0,0,1]),([0,0,4,0,0,0]),([1,0,2,0,1,0]),([2,0,0,0,2,0]),([0,3,0,1,0,0]),([0,2,1,1,0,0]),([0,3,0,0,1,0]),([1,1,0,2,0,0]),([1,2,0,0,0,1]),([0,1,2,1,0,0]),([0,2,1,0,1,0]),([1,0,1,2,0,0]),([1,1,0,1,1,0]),([1,1,1,0,0,1]),([2,0,0,1,0,1]),([0,0,3,1,0,0]),([0,1,2,0,1,0]),([1,0,1,1,1,0]),([1,0,2,0,0,1]),([1,1,0,0,2,0]),([2,0,0,0,1,1]),([0,0,3,0,1,0]),([1,0,1,0,2,0]),([0,2,0,2,0,0]),([0,3,0,0,0,1]),([0,1,1,2,0,0]),([0,2,0,1,1,0]),([0,2,1,0,0,1]),([1,0,0,3,0,0]),([1,1,0,1,0,1]),([0,0,2,2,0,0]),([0,1,1,1,1,0]),([0,1,2,0,0,1]),([0,2,0,0,2,0]),([1,0,0,2,1,0]),([1,0,1,1,0,1]),([1,1,0,0,1,1]),([2,0,0,0,0,2]),([0,0,2,1,1,0]),([0,0,3,0,0,1]),([0,1,1,0,2,0]),([1,0,0,1,2,0]),([1,0,1,0,1,1]),([0,0,2,0,2,0]),([1,0,0,0,3,0]),([0,1,0,3,0,0]),([0,2,0,1,0,1]),([0,0,1,3,0,0]),([0,1,0,2,1,0]),([0,1,1,1,0,1]),([0,2,0,0,1,1]),([1,0,0,2,0,1]),([1,1,0,0,0,2]),([0,0,1,2,1,0]),([0,0,2,1,0,1]),([0,1,0,1,2,0]),([0,1,1,0,1,1]),([1,0,0,1,1,1]),([1,0,1,0,0,2]),([0,0,1,1,2,0]),([0,0,2,0,1,1]),([0,1,0,0,3,0]),([1,0,0,0,2,1]),([0,0,1,0,3,0]),([0,0,0,4,0,0]),([0,1,0,2,0,1]),([0,2,0,0,0,2]),([0,0,0,3,1,0]),([0,0,1,2,0,1]),([0,1,0,1,1,1]),([0,1,1,0,0,2]),([1,0,0,1,0,2]),([0,0,0,2,2,0]),([0,0,1,1,1,1]),([0,0,2,0,0,2]),([0,1,0,0,2,1]),([1,0,0,0,1,2]),([0,0,0,1,3,0]),([0,0,1,0,2,1]),([0,0,0,0,4,0]),([0,0,0,3,0,1]),([0,1,0,1,0,2]),([0,0,0,2,1,1]),([0,0,1,1,0,2]),([0,1,0,0,1,2]),([1,0,0,0,0,3]),([0,0,1,2,1]),([0,0,1,0,1,2]),([0,0,0,0,3,1]),([0,0,0,2,0,2]),([0,1,0,0,0,3]),([0,0,0,1,1,2]),([0,0,1,0,0,3]),([0,0 | **States=15**<br>[([[4,0,0,0,0,0],[3,0,1,0,0,0],[2,0,2,0,0,0],[3,0,0,1,0,0],[1,0,3,0,0,0],[2,0,1,0,1,0],[0,0,4,0,0,0],[1,0,2,0,1,0],[2,0,0,0,2,0],[0,0,3,0,1,0],[1,0,1,0,2,0],[0,0,2,0,2,0],[1,0,0,0,3,0],[0,0,1,0,3,0],[0,0,0,0,4,0]]),([[0,0,0,0,3,1],[0,0,0,1,3,0],[0,0,1,0,2,1],[0,0,1,1,2,0],[0,0,2,0,1,1],[0,0,2,1,1,0],[0,0,3,0,0,1],[0,0,3,1,0,0],[0,1,0,0,3,0],[0,1,1,0,2,0],[0,1,2,0,1,0],[0,1,3,0,0,0],[1,0,0,0,2,1],[1,0,0,1,2,0],[1,0,1,0,1,1],[1,0,1,1,1,0],[1,0,2,0,0,1],[1,0,2,1,0,0],[1,1,0,0,2,0],[1,1,1,0,1,0],[1,1,2,0,0,0],[2,0,0,0,1,1],[2,0,0,1,1,0],[2,0,1,0,0,1],[2,0,1,1,0,0],[2,1,0,0,1,0],[2,1,1,0,0,0],[3,0,0,0,0,1],[3,0,0,1,0,0],[3,1,0,0,0,0]]),([[0,0,0,0,2,2],[0,0,0,1,2,1],[0,0,0,2,2,0],[0,0,1,0,1,2],[0,0,1,1,1,1],[0,0,1,2,1,0],[0,0,2,0,0,2],[0,0,2,1,0,1],[0,0,2,2,0,0],[0,1,0,0,2,1],[0,1,0,1,2,0],[0,1,1,0,1,1],[0,1,1,1,1,0],[0,1,2,0,0,1],[0,1,2,1,0,0],[0,2,0,0,2,0],[0,2,1,0,1,0],[0,2,2,0,0,0],[1,0,0,0,1,2],[1,0,0,1,1,1],[1,0,0,2,1,0],[1,0,1,0,0,2],[1,0,1,1,0,1],[1,0,1,2,0,0],[1,1,0,0,1,1],[1,1,0,1,1,0],[1,1,1,0,0,1],[1,1,1,1,0,0],[1,2,0,0,1,0],[1,2,1,0,0,0],[2,0,0,0,0,2],[2,0,0,1,0,1],[2,0,0,2,0,0],[2,1,0,0,0,1],[2,1,0,1,0,0],[2,2,0,0,0,0]]),([[0,0,0,0,3,1],[0,0,0,1,3,0],[0,0,1,0,2,1],[0,0,1,1,2,0],[0,0,2,0,1,1],[0,0,2,1,1,0],[0,0,3,0,0,1],[0,0,3,1,0,0],[1,0,0,0,2,1],[1,0,0,1,2,0],[1,0,1,0,1,1],[1,0,1,1,1,0],[1,0,2,0,0,1],[1,0,2,1,0,0],[2,0,0,0,1,1],[2,0,0,1,1,0],[2,0,1,0,0,1],[2,0,1,1,0,0],[3,0,0,0,0,1],[3,0,0,1,0,0]]),([[0,0,0,0,1,3],[0,0,0,1,1,2],[0,0,0,2,1,1],[0,0,0,3,1,0],[0,0,1,0,0,3],[0,0,1,1,0,2],[0,0,1,2,0,1],[0,0,1,3,0,0],[0,1,0,0,1,2],[0,1,0,1,1,1],[0,1,0,2,1,0],[0,1,1,0,0,2],[0,1,1,1,0,1],[0,1,1,2,0,0],[0,2,0,0,1,1],[0,2,0,1,1,0],[0,2,1,0,0,1],[0,2,1,1,0,0],[0,3,0,0,1,0],[0,3,1,0,0,0],[1,0,0,0,0,3],[1,0,0,1,0,2],[1,0,0,2,0,1],[1,0,0,3,0 |

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,1],[0,0,0,2,0,2],[0,0,0,2,2,0],[0,0,0,3,0,1],[0,
0,0,4,0,0],[0,0,1,0,1,2],[0,0,1,1,1,1],[0,0,1,2,1

,0],[0,0,2,0,0,2],[0,0,2,1,0,1],[0,0,2,2,0,0],[0,1,0,0,0,3],[0,1,0,0,2,1],[0,1,0,1,0,2],[0,1,0,1,2,0],[0,1,0,2,0,1],[0,1,0,3,0,0],[0,1,1,0,1,1],[0,1,1,1,1,0],[0,1,2,0,0,1],[0,1,2,1,0,0],[0,2,0,0,0,2],[0,2,0,0,2,0],[0,2,0,1,0,1],[0,2,0,2,0,0],[0,2,1,0,1,0],[0,2,2,0,0,0],[0,3,0,0,0,1],[0,3,0,1,0,0],[1,0,0,0,1,2],[1,0,0,1,1,1],[1,0,0,2,1,0],[1,0,1,0,0,2],[1,0,1,1,0,1],[1,0,1,2,0,0],[1,1,0,0,1,1],[1,1,0,1,1,0],[1,1,1,0,0,1],[1,1,1,1,0,0],[1,2,0,0,1,0],[1,2,1,0,0,0],[2,0,0,0,0,2],[2,0,0,1,0,1],[2,0,0,2,0,0],[2,1,0,0,0,1],[2,1,0,1,0,0],[2,2,0,0,0,0]]),([[0,0,0,0,0,4],[0,0,0,1,0,3],[0,0,0,2,0,2],[0,0,0,3,0,1],[0,0,0,4,0,0],[0,1,0,0,0,3],[0,1,0,1,0,2],[0,1,0,2,0,1],[0,1,0,3,0,0],[0,2,0,0,0,2],[0,2,0,1,0,1],[0,2,0,2,0,0],[0,3,0,0,0,1],[0,3,0,1,0,0]]),([[0,0,0,0,0,4],[0,0,0,0,2,2],[0,0,0,0,4,0],[0,0,0,1,0,3],[0,0,0,1,2,1],[0,0,0,2,0,2],[0,0,0,2,2,0],[0,0,0,3,0,1],[0,0,0,4,0,0],[0,0,1,0,1,2],[0,0,1,0,3,0],[0,0,1,1,1,1],[0,0,1,2,1,0],[0,0,2,0,0,2],[0,0,2,0,2,0],[0,0,2,1,0,1],[0,0,2,2,0,0],[0,0,3,0,1,0],[0,0,4,0,0,0],[0,1,0,0,0,3],[0,1,0,0,2,1],[0,1,0,1,0,2],[0,1,0,1,2,0],[0,1,0,2,0,1],[0,1,0,3,0,0],[0,1,1,0,1,1],[0,1,1,1,1,0],[0,1,2,0,0,1],[0,1,2,1,0,0],[0,2,0,0,0,2],[0,2,0,0,2,0],[0,2,0,1,0,1],[0,2,0,2,0,0],[0,2,1,0,1,0],[0,2,2,0,0,0],[0,3,0,0,0,1],[0,3,0,1,0,0],[1,0,0,0,1,2],[1,0,0,0,3,0],[1,0,0,1,1,1],[1,0,0,2,1,0],[1,0,1,0,0,2],[1,0,1,0,2,0],[1,0,1,1,0,1],[1,0,1,2,0,0],[1,0,2,0,1,0],[1,0,3,0,0,0],[1,1,0,0,1,1],[1,1,0,1,1,0],[1,1,1,0,0,1],[1,1,1,1,0,0],[1,2,0,0,1,0],[1,2,1,0,0,0],[2,0,0,0,0,2],[2,0,0,0,2,0],[2,0,0,1,0,1],[2,0,0,2,0,0],[2,0,1,0,1,0],[2,0,2,0,0,0],[2,1,0,0,0,1],[2,1,0,1,0,0],[2,2,0,0,0,0],[3,0,0,0,1,0],[3,0,1,0,0,0],[4,0,0,0,0,0]]),([[0,0,0,0,1,3],[0,0,0,0,3,1],[0,0,0,1,1,2],[0,0,0,1,3,0],[0,0,0,2,1,1],[0,0,0,3,1,0],[0,0,1,0,0,3],[0,0,1,0,2,1],[0,0,1,1,0,2],[0,0,1,1,2,0],[0,0,1,2,0,1],[0,0,1,3,0,0],[0,0,2,0,1,1],[0,0,2,1,1,0],[0,0,3,0,0,1],[0,0,3,1,0,0],[0,1,0,0,1,2],[0,1,0,0,3,0],[0,1,0,1,1,1],[0,1,0,2,1,0],[0,1,1,0,0,2],[0,1,1,0,2,0],[0,1,1,1,0,1],[0,1,1,2,0,0],[0,1,2,0,1,0],[0,1,3,0,0,0],[0,2,0,0,1,1],[0,2,0,1,1,0],[0,2,1,0,0,1],[0,2,1,1,0,0],[0,3,0,0,1,0],[0,3,1,0,0,0],[1,0,0,0,0,3],[1,0,0,0,2,1],[1,0,0,1,0,2],[1,0,0,1,2,0],[1,0,0,2,0,1],[1,0,0,3,0,0],[1,0,1,0,1,1],[1,0,1,1,1,0],[1,0,2,0,0,1],[1,0,2,1,0,0],[1,1,0,0,0,2],[1,1,0,0,2,0],[1,1,0,1,0,1],[1,1,0,2,0,0],[1,1,1,0,1,0],[1,1,2,0,0,0],[1,2,0,0,0,1],[1,2,0,1,0,0],[1,3,0,0,0,0],[2,0,0,0,1,1],[2,0,0,1,1,0],[2,0,1,0,0,1],[2,0,1,1,0,0],[2,1,0,0,1,0],[2,1,1,0,0,0],[3,0,0,0,0,1],[3,0,0,1,0,0],[3,1,0,0,0,0]]),([[0,0,0,0,0,4],[0,0,0,0,2,2],[0,0,0,1,0,3],[0,0,0,1,2,1],[0,0,0,2,0,2],[0,0,0,2,2,0],[0,0,0,3,0,1],[0,0,0,4,0,0],[0,0,1,0,1,2],[0,0,1,1,1,1],[0,0,1,2,1,0],[0,0,2,0,0,2],[0,0,2,1,0,1],[0,

0,2,2,0,0],[0,1,0,0,0,3],[0,1,0,0,2,1],[0,1,0,1,0,2],[0,1,0,1,2,0],[0,1,0,2,0,1],[0,1,0,3,0,0],[0,1,1,0,1,1],[0,1,1,1,1,0],[0,1,2,0,0,1],[0,1,2,1,0,0],[0,2,0,0,0,2],[0,2,0,0,2,0],[0,2,0,1,0,1],[0,2,0,2,0,0],[0,2,1,0,1,0],[0,2,2,0,0,0],[0,3,0,0,0,1],[0,3,0,1,0,0],[0,4,0,0,0,0],[1,0,0,0,1,2],[1,0,0,1,1,1],[1,0,0,2,1,0],[1,0,1,0,0,2],[1,0,1,1,0,1],[1,0,1,2,0,0],[1,1,0,0,1,1],[1,1,0,1,1,0],[1,1,1,0,0,1],[1,1,1,1,0,0],[1,2,0,0,1,0],[1,2,1,0,0,0],[2,0,0,0,0,2],[2,0,0,1,0,1],[2,0,0,2,0,0],[2,1,0,0,0,1],[2,1,0,1,0,0],[2,2,0,0,0,0]]])]

| K=8[800000] | States=1287 | States=39 |
|---|---|---|

States=1287 column:

[([8,0,0,0,0,0]),([7,1,0,0,0,0]),([7,0,1,0,0,0]),([6,2,0,0,0,0]),([6,1,1,0,0,0]),([7,0,0,1,0,0]),([6,0,2,0,0,0]),([7,0,0,0,1,0]),([5,3,0,0,0,0]),([5,2,1,0,0,0]),([6,1,0,1,0,0]),([5,1,2,0,0,0]),([6,0,1,1,0,0]),([6,1,0,0,1,0]),([7,0,0,0,0,1]),([5,0,3,0,0,0]),([6,0,1,0,1,0]),([4,4,0,0,0,0]),([4,3,1,0,0,0]),([5,2,0,1,0,0]),([4,2,2,0,0,0]),([5,1,1,1,0,0]),([5,2,0,0,1,0]),([6,0,0,2,0,0]),([6,1,0,0,0,1]),([4,1,3,0,0,0]),([5,0,2,1,0,0]),([5,1,1,0,1,0]),([6,0,0,1,1,0]),([6,0,1,0,0,1]),([4,0,4,0,0,0]),([5,0,2,0,1,0]),([6,0,0,0,2,0]),([3,5,0,0,0,0]),([3,4,1,0,0,0]),([4,3,0,1,0,0]),([3,3,2,0,0,0]),([4,2,1,1,0,0]),([4,3,0,0,1,0]),([5,1,0,2,0,0]),([5,2,0,0,0,1]),([3,2,3,0,0,0]),([4,1,2,1,0,0]),([4,2,1,0,1,0]),([5,0,1,2,0,0]),([5,1,0,1,1,0]),([5,1,1,0,0,1]),([6,0,0,1,0,1]),([3,1,4,0,0,0]),([4,0,3,1,0,0]),([4,1,2,0,1,0]),([5,0,1,1,1,0]),([5,0,2,0,0,1]),([5,1,0,0,2,0]),([6,0,0,0,1,1]),([3,0,5,0,0,0]),([4,0,3,0,1,0]),([5,0,1,0,2,0]),([2,6,0,0,0,0]),([2,5,1,0,0,0]),([3,4,0,1,0,0]),([2,4,2,0,0,0]),([3,3,1,1,0,0]),([3,4,0,0,1,0]),([4,2,0,2,0,0]),([4,3,0,0,0,1]),([2,3,3,0,0,0]),([3,2,2,1,0,0]),([3,3,1,0,1,0]),([4,1,1,2,0,0]),([4,2,0,1,1,0]),([4,2,1,0,0,1]),([5,0,0,3,0,0]),([5,1,0,1,0,1]),([2,2,4,0,0,0]),([3,1,3,1,0,0]),([3,2,2,0,1,0]),([4,0,2,2,0,0]),([4,1,1,1,1,0]),([4,1,2,0,0,1]),([4,2,0,0,2,0]),([5,0,0,2,1,0]),([5,0,1,1,0,1]),([5,1,0,0,1,1]),([6,0,0,0,0,2]),([2,1,5,0,0,0]),([3,0,4,1,0,0]),([3,1,3,0,1,0]),([4,0,2,1,1,0]),([4,0,3,0,0,1]),([4,1,1,0,2,0]),([5,0,0,1,2,0]),([5,0,1,0,1,1]),([2,0,6,0,0,0]),([3,0,4,0,1,0]),([4,0,2,0,2,0]),([5,0,0,0,3,0]),([1,7,0,0,0,0]),([1,6,1,0,0,0]),([2,5,0,1,0,0]),([1,5,2,0,0,0]),([2,4,1,1,0,0]),([2,5,0,0,1,0]),([3,3,0,2,0,0]),([3,4,0,0,0,1]),([1,4,3,0,0,0]),([2,3,2,1,0,0]),([2,4,1,0,1,0]),([3,2,1,2,0,0]),([3,3,0,1,1,0]),([3,3,1,0,0,1]),([4,1,0,3,0,0]),([4,2,0,1,0,1]),([1,3,4,0,0,0]),([2,2,3,1,0,0]),([2,3,2,0,1,0]),([3,1,2,2,0,0]),([3,2,1,1,1,0]),([3,2,2,0,0,1]),([3,3,0,0,2,0]),([4,0,1,3,0,0]),([4,1,0,2,1,0]),([4,1,1,0,1,1]),([4,2,0,0,1,1]),([5,0,0,2,0,1]),([5,1,0,0,0,2]),([1,2,5,0,0,0]),([2,1,4,1,0,0]),([2,2,3,0,1,0]),([3,0,3,2,0,0]),([3,1,2,1,1,0]),([3,1,3,0,0,1]),([3,2,1,0,2,0]),([4,0,1,2,1,0]),([4,0,2,1,0,1]),([4,1,0,1,2,0]),([4,1,1,0,0,2]),([5,0,0,1,1,1]),([5,0,1,0,0,2]),([1,1,6,0,0,0]),([2,0,5,1,0,0]),([2,1,4,0,1,0]),([3,0,3,1,1,0]),([3,0

States=39 column:

[[[8,0,0,0,0,0],[7,0,1,0,0,0],[6,0,2,0,0,0],[7,0,0,0,1,0],[5,0,3,0,0,0],[6,0,1,0,1,0],[4,0,4,0,0,0],[5,0,2,0,1,0],[6,0,0,0,2,0],[3,0,5,0,0,0],[4,0,3,0,1,0],[5,0,1,0,2,0],[2,0,6,0,0,0],[3,0,4,0,1,0],[4,0,2,0,2,0],[5,0,0,0,3,0],[1,0,7,0,0,0],[2,0,5,0,1,0],[3,0,3,0,2,0],[4,0,1,0,3,0],[0,0,8,0,0,0],[1,0,6,0,1,0],[2,0,4,0,2,0],[3,0,2,0,3,0],[4,0,0,0,4,0],[0,0,7,0,1,0],[1,0,5,0,2,0],[2,0,3,0,3,0],[3,0,1,0,4,0],[0,0,6,0,2,0],[1,0,4,0,3,0],[2,0,2,0,4,0],[3,0,0,0,5,0],[0,0,5,0,3,0],[1,0,3,0,4,0],[2,0,1,0,5,0],[0,0,4,0,4,0],[1,0,2,0,5,0],[2,0,0,0,6,0],[0,0,3,0,5,0],[1,0,1,0,6,0],[0,0,2,0,6,0],[1,0,0,0,7,0],[0,0,1,0,7,0],[0,0,0,0,8,0]]),([[0,0,0,0,7,1],[0,0,0,1,7,0],[0,0,1,0,6,1],[0,0,1,1,6,0],[0,0,2,0,5,1],[0,0,2,1,5,0],[0,0,3,0,4,1],[0,0,3,1,4,0],[0,0,4,0,3,1],[0,0,4,1,3,0],[0,0,5,0,2,1],[0,0,5,1,2,0],[0,0,6,0,1,1],[0,0,6,1,1,0],[0,0,7,0,0,1],[0,0,7,1,0,0],[0,1,0,0,7,0],[0,1,1,0,6,0],[0,1,2,0,5,0],[0,1,3,0,4,0],[0,1,4,0,3,0],[0,1,5,0,2,0],[0,1,6,0,1,0],[0,1,7,0,0,0],[1,0,0,0,6,1],[1,0,0,1,6,0],[1,0,1,0,5,1],[1,0,1,1,5,0],[1,0,2,0,4,1],[1,0,2,1,4,0],[1,0,3,0,3,1],[1,0,3,1,3,0],[1,0,4,0,2,1],[1,0,4,1,2,0],[1,0,5,0,1,1],[1,0,5,1,1,0],[1,0,6,0,0,1],[1,0,6,1,0,0],[1,1,0,0,6,0],[1,1,1,0,5,0],[1,1,2,0,4,0],[1,1,3,0,3,0],[1,1,4,0,2,0],[1,1,5,0,1,0],[1,1,6,0,0,0],[2,0,0,0,5,1],[2,0,0,1,5,0],[2,0,1,0,4,1],[2,0,1,1,4,0],[2,0,2,0,3,1],[2,0,2,1,3,0],[2,0,3,0,2,1],[2,0,3,1,2,0],[2,0,4,0,1,1],[2,0,4,1,1,0],[2,0,5,0,0,1],[2,0,5,1,0,0],[2,1,0,0,5,0],[2,1,1,0,4,0],[2,1,2,0,3,0],[2,1,3,0,2,0],[2,1,4,0,1,0],[2,1,5,0,0,0],[3,0,0,0,4,1],[3,0,0,1,4,0],[3,0,1,0,3,1],[3,0,1,1,3,0],[3,0,2,0,2,1],[3,0,2,1,2,0],[3,0,3,0,1,1],[3,0,3,1,1,0],[3,0,4,0,0,1],[3,0,4,1,0,0],[3,1,0,0,4,0],[3,1,1,0,3,0],[3,1,2,0,2,0],[3,1,3,0,1,0],[3,1,4,0,0,0],[4,0,0,0,3,1],[4,0,0,1,3,0],[4,0,1,0,2,1],[4,0,1,1,2,0],[4,0,2,0,1,1],[4,0,2,1,1,0],[4,0,3,0,0,1],[4,0,3,1,0,0],[4,1,0,0,3,0],[4,1,1,0,2,0],[4,1,2,0,1,0],[4,1,3,0,0,0],[5,0,0,0,2,1],[5,0,0,1,2,0],[5,0,1,0,1,1],[5,0,1,1,1,0],[5,0,2,0,0,1],[5,0,2,1,0,0],[5,1,0,0,2,0],[5,1,1,0,1,0],

,4,0,0,1]),([3,1,2,0,2,0]),([4,0,1,1,2,0]),([4,0,2,0,1,1]),([4,1,0,0,3,0]),([5,0,0,0,2,1]),([1,0,7,0,0,0]),([2,0,5,0,1,0]),([3,0,3,0,2,0]),([4,0,1,0,3,0]),([0,8,0,0,0,0]),([0,7,1,0,0,0]),([1,6,0,1,0,0]),([0,6,2,0,0,0]),([1,5,1,1,0,0]),([1,6,0,0,1,0]),([2,4,0,2,0,0]),([2,5,0,0,0,1]),([0,5,3,0,0,0]),([1,4,2,1,0,0]),([1,5,1,0,1,0]),([2,3,1,2,0,0]),([2,4,0,1,1,0]),([2,4,1,0,0,1]),([3,2,0,3,0,0]),([3,3,0,1,0,1]),([0,4,4,0,0,0]),([1,3,3,1,0,0]),([1,4,2,0,1,0]),([2,2,2,2,0,0]),([2,3,1,1,1,0]),([2,3,2,0,0,1]),([2,4,0,0,2,0]),([3,1,1,3,0,0]),([3,2,0,2,1,0]),([3,2,1,1,0,1]),([3,3,0,0,1,1]),([4,0,0,4,0,0]),([4,1,0,2,0,1]),([4,2,0,0,0,2]),([0,3,5,0,0,0]),([1,2,4,1,0,0]),([1,3,3,0,1,0]),([2,1,3,2,0,0]),([2,2,2,1,1,0]),([2,2,3,0,0,1]),([2,3,1,0,2,0]),([3,0,2,3,0,0]),([3,1,1,2,1,0]),([3,1,2,1,0,1]),([3,2,0,1,2,0]),([3,2,1,0,1,1]),([4,0,0,3,1,0]),([4,0,1,2,0,1]),([4,1,0,1,1,1]),([4,1,1,0,0,2]),([5,0,0,1,0,2]),([0,2,6,0,0,0]),([1,1,5,1,0,0]),([1,2,4,0,1,0]),([2,0,4,2,0,0]),([2,1,3,1,1,0]),([2,1,4,0,0,1]),([2,2,2,0,2,0]),([3,0,2,2,1,0]),([3,0,3,1,0,1]),([3,1,1,1,2,0]),([3,1,2,0,1,1]),([3,2,0,0,3,0]),([4,0,0,2,2,0]),([4,0,1,1,1,1]),([4,0,2,0,0,2]),([4,1,0,0,2,1]),([5,0,0,0,1,2]),([0,1,7,0,0,0]),([1,0,6,1,0,0]),([1,1,5,0,1,0]),([2,0,4,1,1,0]),([2,0,5,0,0,1]),([2,1,3,0,2,0]),([3,0,2,1,2,0]),([3,0,3,0,1,1]),([3,1,1,0,3,0]),([4,0,0,1,3,0]),([4,0,1,0,2,1]),([0,0,8,0,0,0]),([1,0,6,0,1,0]),([2,0,4,0,2,0]),([3,0,2,0,3,0]),([4,0,0,0,4,0]),([0,7,0,1,0,0]),([0,6,1,1,0,0]),([0,7,0,0,1,0]),([1,5,0,2,0,0]),([1,6,0,0,0,1]),([0,5,2,1,0,0]),([0,6,1,0,1,0]),([1,4,1,2,0,0]),([1,5,0,1,1,0]),([1,5,1,0,0,1]),([2,3,0,3,0,0]),([2,4,0,1,0,1]),([0,4,3,1,0,0]),([0,5,2,0,1,0]),([1,3,2,2,0,0]),([1,4,1,1,1,0]),([1,4,2,0,0,1]),([1,5,0,0,2,0]),([2,2,1,3,0,0]),([2,3,0,2,1,0]),([2,3,1,1,0,1]),([2,4,0,0,1,1]),([3,1,0,4,0,0]),([3,2,0,2,0,1]),([3,3,0,0,0,2]),([0,3,4,1,0,0]),([0,4,3,0,1,0]),([1,2,3,2,0,0]),([1,3,2,1,1,0]),([1,3,3,0,0,1]),([1,4,1,0,2,0]),([2,1,2,3,0,0]),([2,2,1,2,1,0]),([2,2,2,1,0,1]),([2,3,0,1,2,0]),([2,3,1,0,1,1]),([3,0,1,4,0,0]),([3,1,0,3,1,0]),([3,1,1,2,0,1]),([3,2,0,1,1,1]),([3,2,1,0,0,2]),([4,0,0,3,0,1]),([4,1,0,1,0,2]),([0,2,5,1,0,0]),([0,3,4,0,1,0]),([1,1,4,2,0,0]),([1,2,3,1,1,0]),([1,2,4,0,0,1]),([1,3,2,0,2,0]),([2,0,3,3,0,0]),([2,1,2,2,1,0]),([2,1,3,1,0,1]),([2,2,1,1,2,0]),([2,2,2,0,1,1]),([2,3,0,0,3,0]),([3,0,1,3,1,0]),([3,0,2,2,0,1]),([3,1,0,2,2,0]),([3,1,1,1,1,1]),([3,1,2,0,0,2]),([3,2,0,0,2,1]),([4,0,0,2,1,1]),([4,0,1,1,0,2]),([4,1,0,0,1,2]),([5,0,0,0,0,3]),([0,1,6,1,0,0]),([0,2,5,0,1,0]),([1,0,5,2,0,0]),([1,1,4,1,1,0]),([1,1,5,0,0,1]),([1,2,3,0,2,0]),([2,0,3,2,1,0]),([2,0,4,1,0,1]),([2,1,2,1,2,0]),([2,1,3,0,1,1]),([2,2,1,0,3,0]),([3,0,1,2,2,0]),([3,0,2,1,1,1]),([3,0,3,0,0,2]),([3,1,0,1,3,0]),([3,1,1,0,2,1]),([4,0,0,1,2,1]),([4,0,1,0,1,2]),([0,0,7,1,0,0]),([0,1,6,0,1,0]),([1,0,5,1,1,0]),([1,0,6,0,0,1]),([1,1,4,0,2,0]),([2,0,3,1,2,0]),([2,0,4,0,1,1]),([2,1,2,0,3,0]),([3,0,1,1,3,0]),([3,0,2,0,2,1]),([3,1,0,0,4,0]),([4,0,0,0,3,1]),([0,0,7,0,1,0]),([1,0,5,0,2,0]),([2,0,3,0,3,0]),([3,0,1,0,4,0]),([0,6,0,2,0,0]),([0,7,0,0,0,1]),([0,5,1,2,0,0]),([0,6,0,1,1,0

[5,1,2,0,0,0],[6,0,0,0,1,1],[6,0,0,1,1,0],[6,0,1,0,0,1],[6,0,1,1,0,0],[6,1,0,0,1,0],[6,1,1,0,0,0],[7,0,0,0,0,1],[7,0,0,1,0,0],[7,1,0,0,0,0]]),([[0,0,0,0,6,2],[0,0,0,1,6,1],[0,0,0,2,6,0],...,[6,1,0,0,0,1],[6,1,0,1,0,0],[6,2,0,0,0,0]]),([[0,0,0,0,7,1],[0,0,0,1,7,0],[0,0,1,0,6,1],[0,0,1,1,6,0],[0,0,2,0,5,1],[0,0,2,1,5,0],[0,0,3,0,4,1],[0,0,3,1,4,0],[0,0,4,0,3,1],[0,0,4,1,3,0],[0,0,5,0,2,1],[0,0,5,1,2,0],[0,0,6,0,1,1],[0,0,6,1,1,0],[0,0,7,0,0,1],[0,0,7,1,0,0],[1,0,0,0,6,1],[1,0,0,1,6,0],[1,0,1,0,5,1],[1,0,1,1,5,0],[1,0,2,0,4,1],[1,0,2,1,4,0],[1,0,3,0,3,1],[1,0,3,1,3,0],[1,0,4,0,2,1],[1,0,4,1,2,0],[1,0,5,0,1,1],[1,0,5,1,1,0],[1,0,6,0,0,1],[1,0,6,1,0,0],[2,0,0,0,5,1],[2,0,0,1,5,0],[2,0,1,0,4,1],[2,0,1,1,4,0],[2,0,2,0,3,1],[2,0,2,1,3,0],[2,0,3,0,2,1],[2,0,3,1,2,0],[2,0,4,0,1,1],[2,0,4,1,1,0],[2,0,5,0,0,1],[2,0,5,1,0,0],[3,0,0,0,4,1],[3,0,0,1,4,0],[3,0,1,0,3,1],[3,0,1,1,3,0],[3,0,2,0,2,1],[3,0,2,1,2,0],[3,0,3,0,1,1],[3,0,3,1,1,0],[3,0,4,0,0,1],[3,0,4,1,0,0],[4,0,0,0,3,1],[4,0,0,1,3,0],[4,0,1,0,2,1],[4,0,1,1,2,0],[4,0,2,0,1,1],[4,0,2,1,1,0],[4,0,3,0,0,1],[4,0,3,1,0,0],[5,0,0,0,2,1],[5,0,0,1,2,0],[5,0,1,0,1,1],[5,0,1,1,1,0],[5,0,2,0,0,1],[5,0,2,1,0,0],[6,0,0,0,1,1],[6,0,0,1,1,0],[6,0,1,0,0,1],[6,0,1,1,0,0],[7,0,0,0,0,1],[7,0,0,1,0,0]]),([[0,0,0,0,5,3],[0,0,0,1,5,2],[0,0,0,2,5,1],...,[5,2,0,0,0,1],[5,2,0,1,0,0],[5,3,0,0,0,0]]),([[0,0,0,0,6,2],[0,0,0,0,8,0],[0,0,0,1,6,1],...,[7,0,0,0,1,0],[7,0,1,0,0,0],[8,0,0,0,0,0]]),([[0,0,0,0,6,2],[0,0,0,1,6,1],[0,0,0,2,6,0],[0,0,1,0,5,2],[0,0,1,1,5,1],[0,0,1,2,5,0],[0,0,2,0,4,2],[0,0,2,1,4,1],[0,0,2,2,4,0],[0,0,3,0,3,2],[0,0,3,1,3,1],[0,0,3,2,3,0],[0,0,4,0,2,2],[0,0,4,1,2,1],[0,0,4,2,2,0],[0,0,5,0,1,2],[0,0,5,1,1,1],[0,0,5,2,1,0],[0,0,6,0,0,2],[0,0,6,1,0,1],[0,0,6,2,0,0],[0,1,0,0,6,1],[0,1,0,1,6,0],[0,1,1,0,5,1],[0,1,1,1,5,0],[0,1,2,0,4,1],[0,1,2,1,4,0],[0,1,3,0,3,1],[0,1,3,1,3,0],[0,1,4,0,2,1],[0,1,4,1,2,0],[0,1,5,0,1,1],[0,1,5,1,1,0],[0,1,6,0,0,1],[0,1,6,1,0,0],[1,0,0,0,5,2],[1,0,0,1,5,1],[1,0,0,2,5,0],[1,0,1,0,4,2],[1,0,1,1,4,1],[1,0,1,2,4,0],[1,0,2,0,3,2],[1,0,2,1,3,1],[1,0,2,2,3,0],[1,0,3,0,2,2],[1,0,3,1,2,1],[1,0,3,2,2,0],[1,0,4,0,1,2],[1,0,4,1,1,1],[1,0,4,2,1,0],[1,0,5,0,0,2],[1,0,5,1,0,1],[1,0,5,2,0,0],[1,1,0,0,5,1],[1,1,0,1,5,0],[1,1,1,0,4,1],[1,1,1,1,4,0],[1,1,2,0,3,1],[1,1,2,1,3,0],[1,1,3,0,2,1],[1,1,3,1,2,0],[1,1,4,0,1,1],[1,1,4,1,1,0],[1,1,5,0,0,1],[1,1,5,1,0,0],[2,0,0,0,4,2],[2,0,0,1,4,1],[2,0,0,2,4,0],[2,0,1,0,3,2],[2,0,1,1,3,1],[2,0,1,2,3,0],[2,0,2,0,2,2],[2,0,2,1,2,1],[2,0,2,2,2,0],[2,0,3,0,1,2],[2,0,3,1,1,1],[2,0,3,2,1,0],[2,0,4,0,0,2],[2,0,4,1,0,1],[2,0,4,2,0,0],[2,1,0,0,4,1],[2,1,0,1,4,0],[2,1,1,0,3,1],[2,1,1,1,3,0],[2,1,2,0,2,1],[2,1,2,1,2,0],[2,1,3,0,1,1],[2,1,3,1,1,0],[2,1,4,0,0,1],[2,1,4,1,0,0],[3,0,0,0,3

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,0,1,0,0,0],[8,0,0,0,0,0]]),([[0,0,0,0,0,8],[0,0,0,1,0,7],[0,0,0,2,0,6],[0,0,0,3,0,5],[0,0,0,4,0,4],[0,0,0,5,0,3],[0,0,0,6,0,2],[0,0,0,7,0,1],[0,0,0,8,0,0],[0,1,0,0,0,7],[0,1,0,1,0,6],[0,1,0,2,0,5],[0,1,0,3,0,4],[0,1,0,4,0,3],[0,1,0,5,0,2],[0,1,0,6,0,1],[0,1,0,7,0,0],[0,2,0,0,0,6],[0,2,0,1,0,5],[0,2,0,2,0,4],[0,2,0,3,0,3],[0,2,0,4,0,2],[0,2,0,5,0,1],[0,2,0,6,0,0],[0,3,0,0,0,5],[0,3,0,1,0,4],[0,3,0,2,0,3],[0,3,0,3,0,2],[0,3,0,4,0,1],[0,3,0,5,0,0],[0,4,0,0,0,4],[0,4,0,1,0,3],[0,4,0,2,0,2],[0,4,0,3,0,1],[0,4,0,4,0,0],[0,5,0,0,0,3],[0,5,0,1,0,2],[0,5,0,2,0,1],[0,5,0,3,0,0],[0,6,0,0,0,2],[0,6,0,1,0,1],[0,6,0,2,0,0],[0,7,0,0,0,1],[0,7,0,1,0,0]]),([[0,0,0,0,0,8],[0,0,0,0,2,6],[0,0,0,0,4,4],...,[4,3,0,0,0,1],[4,3,0,1,0,0],[4,4,0,0,0,0]]),([[0,0,0,0,1,7],[0,0,0,0,3,5],[0,0,0,0,5,3],...,[7,0,0,0,0,1],[7,0,0,1,0,0],[7,1,0,0,0,0]]),([[0,0,0,0,1,7],[0,0,0,0,3,5],[0,0,0,1,1,6],...,[3,4,0,0,0,1],[3,4,0,1,0,0],[3,5,0,0,0,0]]),([[0,0,0,0,0,8],[0,0,0,0,2,6],[0,0,0,0,4,4],...,[6,1,0,0,0,1],[6,1,0,1,0,0],[6,2,0,0,0,0]]),([[0,0,0,0,0,8],[0,0,0,0,2,6],[0,0,0,1,0,7],...,[2,5,0,0,0,1],[2,5,0,1,0,0],[2,6,0,0,0,0]]),([[0,0,0,0,1,7],[0,0,0,0,3,5],[0,0,0,0,5,3],...,[5,2,0,0,0,1],[5,2,0,1,0,0],[5,3,0,0,0,0]]),([[0,0,0,0,0,8],[0,0,0,0,2,6],[0,0,0,0,4,4],...,[7,0,0,0,1,0],[7,0,1,0,0,0],[8,0,0,0,0,0]]),([[0,0,0,0,0,8],[0,0,0,0,2,6],[0,0,0,0,4,4],...,[4,3,0,0,0,1],[4,3,0,1,0,0],[4,4,0,0,0,0]]),([[0,0,0,0,1,7],[0,0,0,0,3,5],[0,0,0,0,5,3],...,[7,0,0,0,0,1],[7,0,0,1,0,0],[7,1,0,0,0,0]]),([[0,0,0,0,0,8],[0,0,0,0,2,6],[0,0,0,0,4,4],...,[6,1,0,0,0,1],[6,1,0,1,0,0],[6,2,0,0,0,0]]])]

]),([0,0,2,2,2,2]),([0,0,3,1,1,3]),([0,0,4,0,0,4]),([0,1,0,2,4,1]),([0,1,1,1,3,2]),([0,1,2,0,2,3]),([0,2,0,0,4,2]),([1,0,0,2,3,2]),([1,0,1,1,2,3]),([1,0,2,0,1,4]),([1,1,0,0,3,3]),([2,0,0,0,2,4]),([0,0,0,3,5,0]),([0,0,1,2,4,1]),([0,0,2,1,3,2]),([0,0,3,0,2,3]),([0,1,0,1,5,1]),([0,1,1,0,4,2]),([1,0,0,1,4,2]),([1,0,1,0,3,3]),([0,0,0,2,6,0]),([0,0,1,1,5,1]),([0,0,2,0,4,2]),([0,1,0,0,6,1]),([1,0,0,0,5,2]),([0,0,0,1,7,0]),([0,0,1,0,6,1]),([0,0,0,0,8,0]),([0,0,0,7,0,1]),([0,1,0,5,0,2]),([0,2,0,3,0,3]),([0,3,0,1,0,4]),([0,0,0,6,1,1]),([0,0,1,5,0,2]),([0,1,0,4,1,2]),([0,1,1,3,0,3]),([0,2,0,2,1,3]),([0,2,1,1,0,4]),([0,3,0,0,1,4]),([1,0,0,4,0,3]),([1,1,0,2,0,4]),([1,2,0,0,0,5]),([0,0,0,5,2,1]),([0,0,1,4,1,2]),([0,0,2,3,0,3]),([0,1,0,3,2,2]),([0,1,1,2,1,3]),([0,1,2,1,0,4]),([0,2,0,1,2,3]),([0,2,1,0,1,4]),([1,0,0,3,1,3]),([1,0,1,2,0,4]),([1,1,0,1,1,4]),([1,1,1,0,0,5]),([2,0,0,1,0,5]),([0,0,0,4,3,1]),([0,0,1,3,2,2]),([0,0,2,2,1,3]),([0,0,3,1,0,4]),([0,1,0,2,3,2]),([0,1,1,1,2,3]),([0,1,2,0,1,4]),([0,2,0,0,3,3]),([1,0,0,2,2,3]),([1,0,1,1,1,4]),([1,0,2,0,0,5]),([1,1,0,0,2,4]),([2,0,0,0,1,5]),([0,0,0,3,4,1]),([0,0,1,2,3,2]),([0,0,2,1,2,3]),([0,0,3,0,1,4]),([0,1,0,1,4,2]),([0,1,1,0,3,3]),([1,0,0,1,3,3]),([1,0,1,0,2,4]),([0,0,0,2,5,1]),([0,0,1,1,4,2]),([0,0,2,0,3,3]),([0,1,0,0,5,2]),([1,0,0,0,4,3]),([0,0,0,1,6,1]),([0,0,1,0,5,2]),([0,0,0,0,7,1]),([0,0,0,6,0,2]),([0,1,0,4,0,3]),([0,2,0,2,0,4]),([0,3,0,0,0,5]),([0,0,0,5,1,2]),([0,0,1,4,0,3]),([0,1,0,3,1,3]),([0,1,1,2,0,4]),([0,2,0,1,1,4]),([0,2,1,0,0,5]),([1,0,0,3,0,4]),([1,1,0,1,0,5]),([0,0,0,4,2,2]),([0,0,1,3,1,3]),([0,0,2,2,0,4]),([0,1,0,2,2,3]),([0,1,1,1,1,4]),([0,1,2,0,0,5]),([0,2,0,0,2,4]),([1,0,0,2,1,4]),([1,0,1,1,0,5]),([1,1,0,0,1,5]),([2,0,0,0,0,6]),([0,0,0,3,3,2]),([0,0,1,2,2,3]),([0,0,2,1,1,4]),([0,0,3,0,0,5]),([0,1,0,1,3,3]),([0,1,1,0,2,4]),([1,0,0,1,2,4]),([1,0,1,0,1,5]),([0,0,0,2,4,2]),([0,0,1,1,3,3]),([0,0,2,0,2,4]),([0,1,0,0,4,3]),([1,0,0,0,3,4]),([0,0,0,1,5,2]),([0,0,1,0,4,3]),([0,0,0,0,6,2]),([0,0,0,5,0,3]),([0,1,0,3,0,4]),([0,2,0,1,0,5]),([0,0,0,4,1,3]),([0,0,1,3,0,4]),([0,1,0,2,1,4]),([0,1,1,1,0,5]),([0,2,0,0,1,5]),([1,0,0,2,0,5]),([1,1,0,0,0,6]),([0,0,0,3,2,3]),([0,0,1,2,1,4]),([0,0,2,1,0,5]),([0,1,0,1,2,4]),([0,1,1,0,1,5]),([1,0,0,1,1,5]),([1,0,1,0,0,6]),([0,0,0,2,3,3]),([0,0,1,1,2,4]),([0,0,2,0,1,5]),([0,1,0,0,3,4]),([1,0,0,0,2,5]),([0,0,0,1,4,3]),([0,0,1,0,3,4]),([0,0,0,0,5,3]),([0,0,0,4,0,4]),([0,1,0,2,0,5]),([0,2,0,0,0,6]),([0,0,0,3,1,4]),([0,0,1,2,0,5]),([0,1,0,1,1,5]),([0,1,1,0,0,6]),([1,0,0,1,0,6]),([0,0,0,2,2,4]),([0,0,1,1,1,5]),([0,0,2,0,0,6]),([0,1,0,0,2,5]),([1,0,0,0,1,6]),([0,0,0,1,3,4]),([0,0,1,0,2,5]),([0,0,0,0,4,4]),([0,0,0,3,0,5]),([0,1,0,1,0,6]),([0,0,0,2,1,5]),([0,0,1,1,0,6]),([0,1,0,0,1,6]),([1,0,0,0,0,7]),([0,0,0,1,2,5]),([0,0,1,0,1,6]),([0,0,0,0,3,5]),([0,0,0,2,0,6]),([0,1,0,0,0,7]),([0,0,0,1,1,6]),([0,0,1,0,0,7]),([0,0,0,0,2,6]),([0,0,0,1,0,7]),([0,0,0,0,1,7]),([0,0,0,0,0,8]])]

| K=10[1000000] | States=3003 | States=54 |
|---|---|---|

NOT ENOUGH SPACE

Performance of Algorithm 3

| $k$ | $|RG|$ | $|Obs_{RG}|$ | time (s) | $|EST_\Phi|$ | time (s) |
|---|---|---|---|---|---|
| 2 | 21 | 6 | $0.8 \times 10^1$ | 6 | $0.2 \times 10^1$ |
| 4 | 126 | 15 | $1.4 \times 10^2$ | 15 | $0.4 \times 10^2$ |
| 8 | 1287 | 39 | $4.7 \times 10^3$ | 39 | $1.4 \times 10^3$ |
| 10 | 3003 | - | o.t. | 54 | $5.2 \times 10^3$ |
| 20 | 53130 | - | o.t. | 159 | $1.0 \times 10^4$ |
| 40 | - | - | o.t. | - | o.t. |

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