INO Games - Software Engineer Technical Assessment

Guilherme Lima Gonçalves

April 4, 2024

Contents

1. Introduction

This document contains a more detailed explanation, from a mathematical perspective, of the computational problem's solution for the challenge stated in the technical assessment provided by the team at INO Games. The purpose of this document is to assist, whoever will perform the revision of the submitted solution, understanding some of the engineering choices made in the TypeScript code base.

2. Problem statements

2.1 Anticipation cadence

In general terms, the constraints of the problem are the following:

- The game has a **slot machine** with N rows and M columns, i.e. a matrix of $N \times M$;

- Every time a new **round** starts, the machine spins all columns and receive a new set of symbol for each position;

- When the machine stop spinning, each column stops with a default **cadence**. But the game has a **special symbol** that can appear when the slot machine receives the new set of symbols, and that special symbol can change the machine column cadence to stop;

- These special symbols have a minimum number of symbols to start changing the cadence and a maximum number of symbols to end the change in cadence. This change of cadence is called **anticipation**.

2.2 Winning combinations

A slot game must be built, and in order for it to perform properly, a functionality that checks whether a pay line has occurred is an integral of the game's architechture.

A **pay line** is a combination of symbols that results in a win on a slot machine. The original slot machines only had one pay line, which would pay if three matching symbols created a horizontal line. You will have an array of numbers with 5 or 6 positions containing the game symbols, but we have some rules regarding the symbols:

- `0` is the **wild symbol**. It forms a pay line with any other paying symbol. For example, if the received array was: `[1, 2, 0, 2, 3]`, we have a pay line;

- The **paying symbols** are: `[1, 2, 3, 4, 5, 6, 7, 8, 9]`;

- And there are the **non-paying symbols**, which are: `[10, 11, 12, 13, 14, 15]`.

- Example: given the input `[1, 2, 6, 6, 6]` the expected output is `[6, [2, 3, 4]]`.

3. Proposed solutions

3.1 Anticipation cadence

Considering a slot machine with N rows and M columns, the **slot cadence** that has to be calculated for each j^{th} column with $j \in \{0, 1, \ldots, M-1\}$, which is a non-negative real number called here $C_j = C(j)$, is given by the recurrence relation:

$$C_{j+1} = C_j + C(N_j), \text{ with } C(N_j) = \begin{cases} C_A, \text{ if } N_j \in \left[N_A^{\text{start}}, N_A^{\text{stop}}\right), \\ C_D, \text{ if } N_j \notin \left[N_A^{\text{start}}, N_A^{\text{stop}}\right). \end{cases} \tag{1}$$

where:

- C_j: Cumulative cadence for the j^{th} column;
- N_j: Number of special symbols, which by specification modulate the anticipation phenomenon, up to a j^{th} column;
- C_A: Anticipation cadence increment;
- C_D: Default cadence increment;
- N_A^{start}: Minimum number of special symbols required to start applying the anticipation increment, i.e. $C(N_j) = C_A$;
- N_A^{stop}: Maximum number of special symbols required to stop applying the anticipation increment, i.e. reverting to C_D.

For the purposes of exemplifying later how this formalism works, we define here with more precision what a slot machine is.

A **slot machine** $\mathcal{M}$ is a tuple of the form:

$$\mathcal{M} = \left(N, M, C_A, C_D, N_A^{\text{start}}, N_A^{\text{stop}}, \mathcal{R}\right), \tag{2}$$

where $\mathcal{R}$ is a collection of all sets of special symbols' coordinates, for each game round $r \in \{0, \ldots, R-1\}$ with $R \in \mathbb{N}$ being the number of rounds. More accurately:

$$\mathcal{R} = \left\{ S_r = \{(i,j) \in \mathbb{Z}_+^2\} \right\}, \tag{3}$$

for all $i \in \{0, \ldots, N-1\}$ and $j \in \{0, \ldots, M-1\}$.

3.1.1 Examples

Considering now a slot machine $\mathcal{M}_1$ with the following parameters:

$$\mathcal{M}_1 = (5, 5, 2, 0.25, 2, 3, \mathcal{R}_1),$$

with $\mathcal{R}_1 = \{S_1, S_2, S_3\}$ being the collection formed by the sets of special symbols' coordinates:

$$S_1 = \{(2,0); (3,1); (4,3)\},$$
$$S_2 = \{(2,0); (3,0)\},$$
$$S_3 = \{(2,4); (3,4)\}.$$

Applying now the recurrence relation (1) for the slot cadence, to the data related to S_1, the results are:

$\boldsymbol{j}$	$\boldsymbol{N_j}$	$\boldsymbol{C(N_j)}$	$\boldsymbol{C_{j+1} = C_j + C(N_j)}$
0	1	$= C_D = 0.25$	$C_0 = 0$
1	2	$= C_A = 2$	$C_1 = C_0 + C(N_0) = 0.25$
2	2	$= C_A = 2$	$C_2 = C_1 + C(N_1) = 2.25$
3	3	$= C_D = 0.25$	$C_3 = C_2 + C(N_2) = 4.25$
4	3	$= C_D = 0.25$	$C_4 = C_3 + C(N_3) = 4.5$

Similarly for S_2:

j	N_j	$C(N_j)$	$C_{j+1} = C_j + C(N_j)$
0	2	$= C_A = 2$	$C_0 = 0$
1	2	$= C_A = 2$	$C_1 = C_0 + C(N_0) = 2$
2	2	$= C_A = 2$	$C_2 = C_1 + C(N_1) = 4$
3	2	$= C_A = 2$	$C_3 = C_2 + C(N_2) = 6$
4	2	$= C_A = 2$	$C_4 = C_3 + C(N_3) = 8$

Finally, for S_3, the resulting slot cadence is:

j	N_j	$C(N_j)$	$C_{j+1} = C_j + C(N_j)$
0	0	$= C_D = 0.25$	$C_0 = 0$
1	0	$= C_D = 0.25$	$C_1 = C_0 + C(N_0) = 0.25$
2	0	$= C_D = 0.25$	$C_2 = C_1 + C(N_1) = 0.5$
3	0	$= C_D = 0.25$	$C_3 = C_2 + C(N_2) = 0.75$
4	2	$= C_A = 2$	$C_4 = C_3 + C(N_3) = 1$

For a example with more columns, it is considered now the slot machine $\mathcal{M}_2$ with the following parameters:

$$\mathcal{M}_2 = (5, 6, 2, 1, 1, 2, \mathcal{R}_2)\,,$$

with $\mathcal{R}_2 = \{S_1\}$ a reduced collection of special symbols' coordinates, where $S_1 = \{(2,1);(3,4)\}$.

Through the same process, we apply the recurrence relation for the data related to $\mathcal{M}_2$ and, by extension, S_1:

j	N_j	$C(N_j)$	$C_{j+1} = C_j + C(N_j)$
0	0	$= C_D = 1$	$C_0 = 0$
1	1	$= C_A = 2$	$C_1 = C_0 + C(N_0) = 1$
2	1	$= C_A = 2$	$C_2 = C_1 + C(N_1) = 3$
3	1	$= C_A = 2$	$C_3 = C_2 + C(N_2) = 5$
4	2	$= C_D = 1$	$C_4 = C_3 + C(N_3) = 7$
5	2	$= C_D = 1$	$C_5 = C_4 + C(N_4) = 8$

Summarizing now the results for the slot machines $\mathcal{M}_1$ and $\mathcal{M}_2$, we have:

- $\mathcal{M}_1 = \big(N, M, C_A, C_D, N_A^{\text{start}}, N_A^{\text{stop}}, \mathcal{R}\big) = (5, 5, 2, 0.25, 2, 3, \mathcal{R}_1)$
  - Game rounds $\mathcal{R}_1 = \{S_1, S_2, S_3\}$ with respective sets of special symbols' coordinates and the associate slot cadence sequences:
    - $S_1 = \{(2,0); (3,1); (4,3)\} \Longrightarrow \boldsymbol{C = (0, 0.25, 2.25, 4.25, 4.5)}$
    - $S_2 = \{(2,0); (3,0)\} \Longrightarrow \boldsymbol{C = (0, 2, 4, 6, 8)}$
    - $S_3 = \{(2,4); (3,4)\} \Longrightarrow \boldsymbol{C = (0, 0.25, 0.5, 0.75, 1)}$
- $\mathcal{M}_2 = \big(N, M, C_A, C_D, N_A^{\text{start}}, N_A^{\text{stop}}, \mathcal{R}\big) = (5, 6, 2, 1, 1, 2, \mathcal{R}_2)$
  - Game round $\mathcal{R}_2 = \{S_1\}$ with respective set of special symbols' coordinates and the associate slot cadence sequence:
    - $S_1 = \{(2,1); (3,4)\} \Longrightarrow \boldsymbol{C = (0, 1, 3, 5, 7, 8)}$

3.2 Winning combinations

To be continued...