🐞 Beetle Wars 🐞

A coding challenge inspired by SAEON research associate Joh Henschel's work on Namib Desert beetles.

Introduction

In a patch of desert far, far away, beetle communities eke out a meagre existence, competing for scarce resources in a harsh environment. The populations of the various beetle species follow boom-and-bust cycles, driven by irregular rainfall events that replenish the stock of plant detritus upon which they feed.

Your task is to write a **Python program** that simulates the evolution of beetle population sizes over time in response to rainfall events.

The Model

The beetle ecosystem has two modes of evolution: boom and bust. Beetle populations increase in size during a boom, and decrease during a bust. Booms are triggered by rainfall events, while busts begin any time the ecosystem's carrying capacity – the maximum total number of beetles it can sustain – is exceeded, regardless of rainfall.

The ecosystem evolves in discrete time steps. During a boom, the population size of species X at time step $t+1$ is given by:

$$X_{t+1} = \lceil X_t(1 + r_X) \rceil$$

where r_X is the growth rate peculiar to species X and $0 < r_X < 1$. During a bust, the formula is:

$$X_{t+1} = \lfloor X_t(1 - r_X) \rfloor$$

$\lceil x \rceil$ and $\lfloor x \rfloor$ denote the ceiling and floor of x, respectively.

Three species of beetle – labelled Red, Green and Blue – are known to inhabit the ecosystem. Their empirically determined growth rates are, respectively:

$$r_R = 0.17$$
$$r_G = 0.26$$
$$r_B = 0.11$$

The Test

The program input is a JSON object that specifies:

- the carrying capacity of the ecosystem
- a rainfall time series array, each index corresponding with a time step, each

value (a boolean), indicating whether a rainfall event occurs at that step
- the initial state of the system (at time step 0), consisting of:
  - the current phase (up to the current time step): “boom” or “bust”
  - the population size of each species of beetle

The program output is a JSON array that encodes the state of the system for time steps $0..n$, where n is the length of the rainfall time series. (Note that the length of the output array is $n + 1$).

The following input should be used as a test case:

```
{
    "capacity": 5000,
    "rainfall": [
        false, false, false, true, false,
        false, false, false, false, false,
        true, true, false, false, false
    ],
    "state": {
        "phase": "boom",
        "populations": {
            "Red": 1400,
            "Green": 990,
            "Blue": 2160
        }
    }
}
```

An example of program output follows – for the trivial case of an empty rainfall time series array, with the same initial state as in the above test case:

```
[
    {
        "phase": "boom",
        "populations": {
            "Red": 1400,
            "Green": 990,
            "Blue": 2160
        }
    }
]
```

Test Submission

Your solution must include the program source code, along with a JSON file containing the output that it generates in response to the above input.

We want to see production quality work! Be sure to include a few docstrings. Graphical output is not required.

Please also provide instructions for running your program from the command line.