Society Simulation Software Documentation

Draft 0

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1. Overview

The purpose of this simulation is to figure out how to create a utopia. This society should be able to sustain a balanced state without conflict or disease for multiple generations. Also, if a random societal interruption (S.I.) is added to the simulation it must be able to quickly (within weeks - sim time) regain a state of balance. The program will be easily configurable to model a society with specified environmental characteristics and common personality traits of individuals.

A secondary objective for this project is to observe how a society evolves over multiple generations and log how they develop unique traits and norms based on random historic events. Ultimately, I would like for this simulation to be useful for testing theories related to social behavior of large groups to help prevent societal interruptions like: war and conflict, economic inequality, and spread of pathogens in a community.

Modes

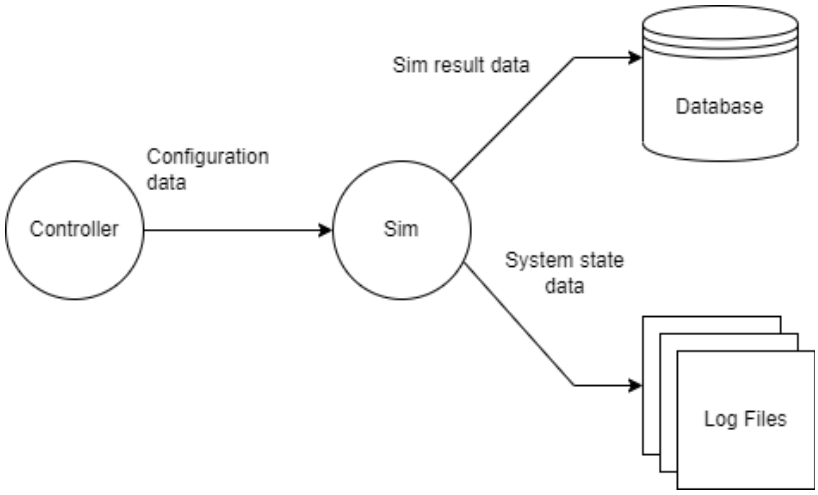
- Interactive
    - Adjust or view individual people and historic events at run time to try and create a utopia.
- Autopilot
    - Set a number of years to run and view data in post from the logs and database.

***TODO**:*

- *The ratios and values of this simulation do not have to be correct at first, just the architecture. Research will be needed to get correct values and behavior.*
- *EPA (Environmental Protection Agency) has databases and research articles that you can use to make this simulation more accurate.*

Level 0

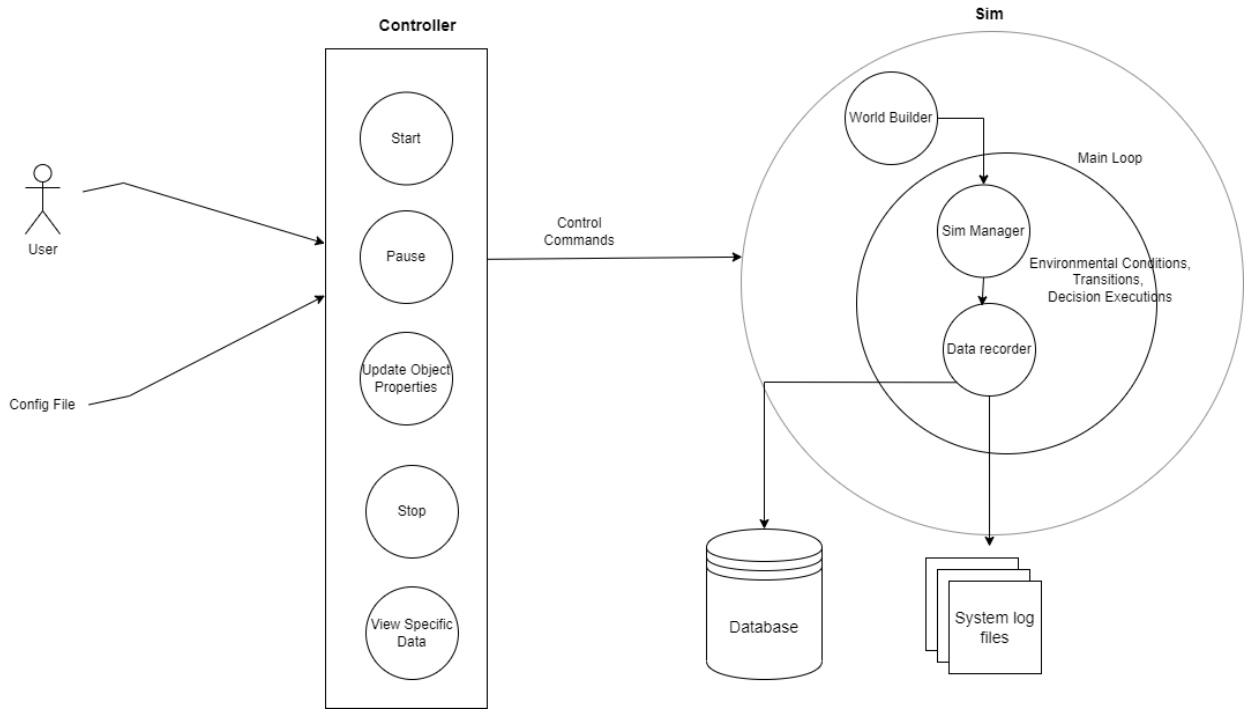
The level 0 diagram below shows the highest possible level of the overall simulation. The main two components are the **Controller** and the **Sim Object**. The controller feeds commands into the sim object and the sim object executes internal processes and stores all results.



Level 1

The level 1 diagram below shows a slightly more low level design compared to level 0. You'll notice next to the Controller there are now two external entities, the **User** and the **Configuration File.** The purpose for this is to show that the sim can support both interactive and passive modes. Inside of the controller you'll see all of the current commands that it can send to the sim object.

Inside of the Sim Object you'll notice the **World Builder.** This object will be able to read a **WorldConfig.json** file and create the listed objects with their desired properties and pass those objects to the **Sim Manager.**



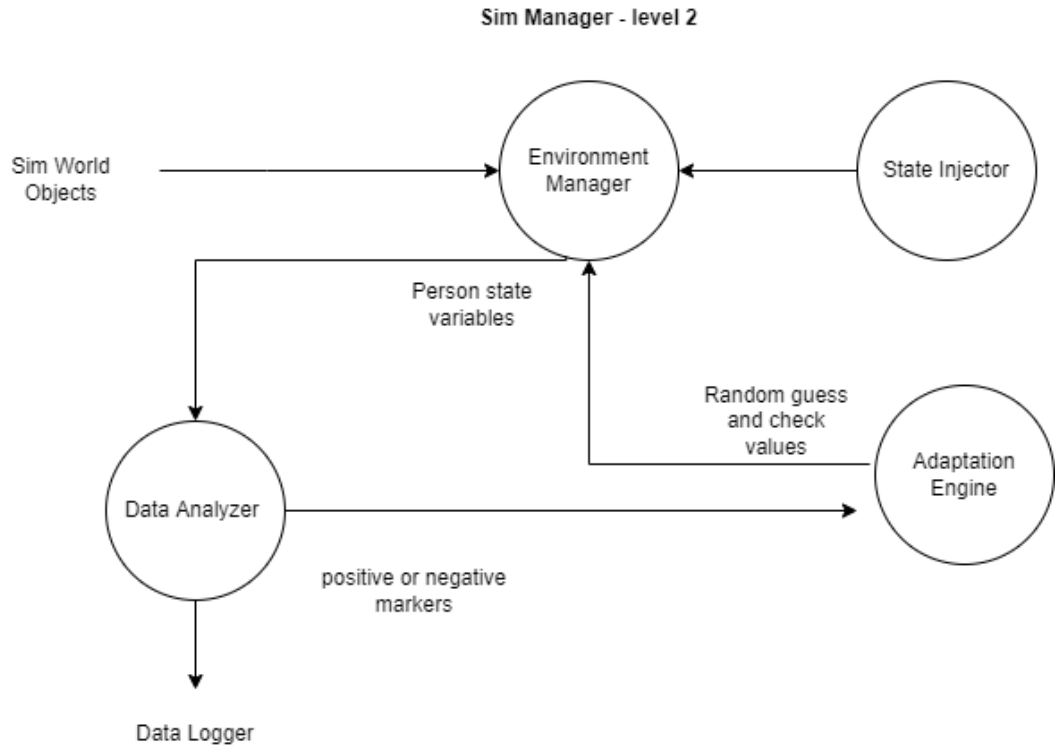
Level 2

In the level 2 diagram below you'll notice the following new items: **Environment Manager**, **Data Analyzer**, and the **State Injector.**

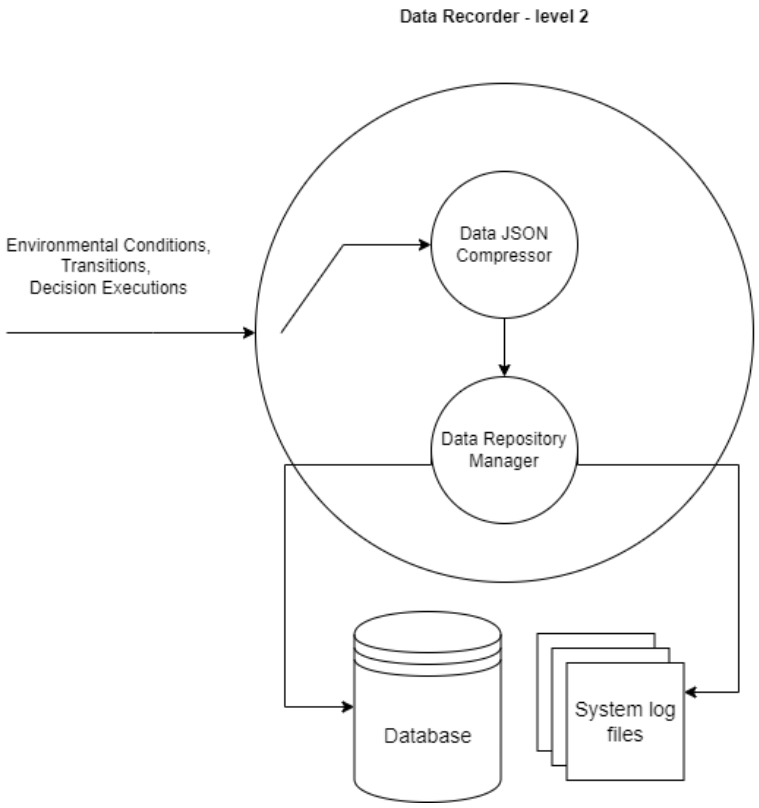
1. Environment Manager
    a. This object's main goal is to manage the assignment of **Environmental Conditions** and **Environmental Decisions** to the correct Environments. However, since this manager has direct access to all populations of each environment then it will also be incharge of handling the **Relocation of Persons** based on their schedules and executing all other tasks on their daily schedule.
2. Data Analyzer
    a. This object's main goal is to analyze the state of the simulation's operations and make sure that everything is running as expected as far as each component is giving expected outputs. But also the Data Analyzer will be responsible for checking every frame for **Historical Events**. The World Configuration JSON file will have the needed threshold values for each H.E and the Event Logs JSON file will have the current running values for each threshold of each H.E. The Data Analyzer will be responsible for keeping the Event Logs JSON file updated and checking if any H.E has happened.

3. State Injector
    a. The objective of this object is to be able to add random **Societal Interruptions**. This will most likely be done by modifying the **WorldConfig.json** with values associated with the given Societal Interruption. (pandemic, war, riots, etc..)

4. Adaptation Engine
    a. The **Adaption Engine** will try multiple scenarios with different values for each person's variables associated with how they make decisions. Once the correct values are found to counter the effects of the Societal Interruption (S.I), those values will be stored for future reference for combating that specific S.I.



5. Data Recorder
    a. The responsibility of the Data Recorder is to write major state change events to the database. It will also write all decisions that a Person makes to their own table/collection in the database. *(For this reason, it is probably not necessary to have the life time decision tree variable in Person)*



    b. An important capability of the data recorder will be having it able to compress all of the JSON data of each Person and Environment in the world, each frame, into a simple and short line of characters that can be logged every simulated clock tick. This is important because I want to be able to completely trace back every decision that each person made throughout their lifetime to see exactly how the world state got to where it currently is.
        i. *To achieve this feature you will need to come up with a simple and fast* ***compression algorithm***.
    c.

2. CSCIs (Computer Software Configuration Items)

Listed below are all of the computer software configuration items that will be required for this simulation:

1. Person
2. Historic Event
3. Schedule
4. Decision Tree
5. Environment
6. Societal Interruption

3. Person

A person object is a representation of an individual that can interact with other persons in different environments to achieve a task from their schedule by making decisions. All interactions and decisions will be logged for each person and the effect will be calculated.

Person Roles in Different Environments:

- Employer/Employee (Work)
- Teacher/Student (School)
- Adult/Child (Home)

The most important aspects of this simulation that will need to be properly captured is how to model the happiness of an individual. This will impact how effective individuals are on a day to day basis in their jobs and in their lives in general. Which will also impact how effective they are making their respective companies and businesses that they work for, which will ultimately affect the country and world as a whole.

The variable that each person will have that will contribute to calculating their happiness is going to be called **Days Since Made Significant Progress On Personal Goals (DSSPG)**. This variable will be affected by the **discipline variable**. Discipline for each person will be set once when they are first initialized.

Disciplined is initialized randomly 0.20 - 0.50
(This user will work on their goals 12 days this month.)

TODO:

You should come up with a formula for evenly distributing these 12 goal days throughout the month. But for now just have them work on a goal every other day and - - goal days from 12 until it's 0.

DSSPG Formula

Example likelihood of an individual working on their personal goal today is:

d = disciplined % = 0.40
m = month = January
c = days in month = 31
x = d * c = 12.4 (round down) = 12 (goal days)

Happy Formula

Happy = focus - ((dsspg * 0.10) * focus)

Expected outputs:

- If dsspg reaches 10 then happy = 0
- If dsspg > 10 then happy < 0

Focus Formula

```
double a = hoursSinceSlept
double b = hoursSinceAte

double fWeightHigh = (6.0 - (b - (MAX_HOURS_NO_EAT / 2.0)) * c2);
double fWeightLow = (6.0 + ((MAX_HOURS_NO_EAT / 2.0) - b) * c1);

double chosenWeight =
        (b >= (MAX_HOURS_NO_EAT / 2)) ? fWeightHigh : fWeightLow;
```

double focus = initialFocus - ((2 * a * 0.10) + (chosenWeight * b * 0.10));

Expected outputs:

- If a >= many && b >= many c = very low
- If a >= many || b >= many c = low
- Else c = high

Properties:

1. ID
2. Daily Schedule
3. Disciplined %
4. DSSPG
5. Happy %
6. Hours Since Slept
7. Hours Since Ate
8. Is Employed
9. Potential Fields
    a. Life decision tree
    b. Literacy
        i. Level of education { high school, bachelors, masters, phd}
    c. Annual Salary
    d. Ethnicity or Ethnicities and their percentages
        i. 20% African American. 20%Asian, 15%Indian
    e. Gender
    f. Age
    g. Health
        i. Healthy, Common Cold, Specific Virus, Specific Terminal Illness
    h. Social Network Graph
        i. Friends and family

Person Functions:

1. addFriend()
2. removeFriend()
3. addAssociate()
4. removeAssociate()

Birth/Death:

- A person is born and can also pass away in this simulation. To properly handle the creation and deletion of these objects, all people will be **smart pointers** (std::unique_ptr)

- Their entire life and history of actions will be logged to the database. However, when they die, their object will be deleted from memory to help manage a large population.

- Capturing the birth/death cycle of people in this simulation will allow it to process **multi-generational effects** on society.

4. Historic Event

A historic event is a major event that can occur automatically once all environmental factors and social traits have met given thresholds.

Radical Innovation

My stretch goal for historic events is to find a way to have the system automatically generate new kinds of historic events based on how the society evolves. That way historic events won't be limited to the finite number that I program into the simulation. Find out how to generalize the person's properties also because they are currently directly related to what is needed for measuring the threshold of current historic events.

Initial Historic Events:

1. First World Country
2. Social Equality
3. High Quality of Health

Thresholds to measure:

First_World_Country{

{"Stable Democracies": true},
{"High Standard of Living": true},
{"Capitalist Economy": true },
{"Economic Stability": true},
{"Gross Domestic Product": $200,000,000,000},
{ "Average Education Level": Bachelors }
}

School Decision “Study/Homework” will increase the “knowledge” of an individual which will lead to their “**EducationLevel**” increasing, Knowledge++ every hour of study. If a study averages 5 hours of studying per day that's roughly 30 hours of studying a week *(120 hours studying / month)*. A school year is roughly 9 months, so 9 * 120 = 1,080 hours of studying / school year.

Therefore, 1 academic year == 1,080 knowledge
So, a student graduating high school will have 12 years of education or knowledge level of 1,080 * 12 = 12,960 knowledge.

High School = Grade 12 = Knowledge **12,960**
Bachelors = Grade 16 = Knowledge **17,280**
Masters = Grade 18 = Knowledge **19,440**

How to calculate GDP?
https://www.britannica.com/topic/gross-domestic-product

Social_Equality
{
Time Since Last Race Riot: 10years +,
AverageEthnicDiversityInFriendGroup: 3+ (3+ ethnicities)
AverageEthnicDiversityInOffspring: 2+ (2+ ethnicities)
Average Ethnic Income Equality: > 85%

}

High_Quality_of_Health
{
Life_Expectancy: 100 years
Less than 1% of population dies of sickness or disease annually: Boolean
95% of Diseases are cured or managable: Boolean
}

***IMPORTANT**: Develop a simple ICD language for translating H.E thresholds from world config JSON to C++ conditionals.*

5. Schedule

A schedule is an object that will be automatically generated for each person and it will consist of multiple tasks with times and daily frequencies along with location that the task must take place.

1. Relocation
    a. These tasks will physically relocate the person to a new environment which will introduce them to a different tree of decisions and a different group of people to interact with. The schedule will start out as a basic list of relations such as: go home, go to school, and go to work (different times for each day to reflect class workload.)

Relocation Task Example:
{
Days: “MWF”
Time: “1:00pm”
Location: “School”
Task Name: “Math Class”
}

6. Environment

An environment is a **home**, **school**, or **work** location that a person can be in at any given time during the simulation.

Environment specific properties:

- Work (Business / Company)
    - Annual Profits (Contributes to GDP of country)
        - Goes up when workers are more productive and innovative (How to measure this well enough?)
- School
    - State test scores
        - Goes up when students make decisions to **Study/Homework** more
- Home
    -

7. Environmental Conditions

For each environment there will be associated conditions based on the current Societal Interruption that is activated. For example, during a recession all work environments would have a given unemployment rate and individuals in that environment will have increased workload and stress.

8. Environmental Decisions

An environmental decision is an object that will be automatically generated for each unique type of environment. Once a person enters that environment then they will execute tasks based on decisions made from the decision tree. Each decision made will affect the mood of the person that made it in some predetermined way.

List of all possible decisions with their choices, mood outcomes, effects, and which choices could possibly be child nodes of parent choices.

Mood = mental state = happy & focus
Happy = DSSPG formula
Focus = Last date & Last Slept formula

Environments:
Each environment (Work, School, Home) will have a list of decisions that can be made at specific times while a person is there.

Only one Environmental decision can be performed at a time. If the conditions are met for 2 or more conditions to be met in a given environment then the system will just choose a random decision that has been met to execute. (For example: With school conditions, Eat and Sleep both have criteria that could be met at the same time. If that happens then the system will choose random which to execute.)

Decision Flow: For each decision that is chosen for an individual based on criteria, it will have a *Task* created with a *Task Name* and *Time Duration*. This Task will be added to their schedule. Once the task is executed then the outcome will be applied and another task will be chosen based on criteria.

1. Work (Weekdays @ 12 Noon / Lunch)

	Eat Lunch	**Work**	**Socialize**
Criteria	1. Happy < 80% 2. hoursSinceAte >= 5 (No breakfast)	1. Happy > 90% 2. hoursSinceAte < 5 (Had breakfast)	1. Compatibility Score
Outcome	1. Happy += 10 2. hoursSinceAte = 0	1. Happy += 5 2. businessProfits += 2	1. Happy ++ or - -

The outcomes of the above work decisions directionally affect the S.I. Recession because they modify the business profitability. Therefore, when the AdapationEngine tries different decisions for countering the effects of Recession for example, “Eat Lunch” wouldn’t help as much as “Work”. When the work decision is chosen over the other decisions, it will lead to more profitability, which will counter the variable “**StockMarketPerformanceDecline**” and over a set amount of time the company will be able to afford hiring new employees, which will counter the variable “**UnemploymentRate**”. So, to counter the S.I. Recession successfully, 70% of the businesses in the society will have to report 22% increase in profitability compared to their

profitability at the start of the recession. Also, having 2 consecutive quarters of increased profitability after that will be a stipulation.

2. School (@ Between classes on Schedule)

	Eat	**Sleep**	**Study/Homework**	**Socialize**
Criteria	1.hoursSinceAte >= 5	1.hoursSinceSleep >= 8	1.hoursSinceAte <5 2.hoursSinceSleep<8	1. Compatibility Score
Outcome	1.Increases Focus with formula	1.Increases Focus with formula	1.Knowledge ++	1. Happy ++ or - -

With regards to the S.I. Pandemic, the above decision "Socialize" will be the decision that directly increases the rate at which the pathogen spreads i.e., the condition "**NewCasesPerDayByPopulationPercentage**". Therefore, when the AdaptationEngine tries different decisions for countering the effects of S.I. Pandemic for example, any other decision that is NOT "Socialize", it will help to slow the spread of the disease and lead to it being successfully countered.

Slowing the spread to 1% or less of the population having new infections per day over 90 days will be sufficient enough to count this S.I as being successfully countered. *(90 days is long enough to develop a vaccine/cure for this society)*

3. Home (@ 6p - 10p Weekdays & Anytime on weekends)

	Family time	**Hobbies/Personal Goals**	**Social Events**
Criteria	1. DSSPG < 7	1. DSSPG > 7 2. Happy < 60%	1. Compatibility Score
Outcome	1. Happy += 3	1. DSSPG = 0 2. Happy += 5	1. Happy ++ or - -

<u>Example Schedule and decision tree:</u>

{task:"School", time: 1p}

{task:”Work”, time: 5p}
{task:”Home”, time: 11p}
…

This example schedule will have the person at school for 4h. In that time they will evaluate and make decisions from that school environment's decision tree and complete the tree every hour and their mood and properties will be adjusted accordingly.

9. Social Interactions

These interactions will cause the interacting parties to have their properties (i.e mood, literacy, decisions, etc.) change based on each other’s properties. (Develop the algorithm for this, it can be very simple for a crawl phase)

Whenever the criteria is met for an individual to choose to have a social interaction with another individual, there needs to be a formula or algorithm that can be used to properly calculate the effects for both people and it should be based on frequency and duration of interactions.

Social Interaction Event Example:
{
Individuals: [<PersonID>, …]
Compatability_Score: < 0.1 - 0.9> // Random
Duration: 1h
Sign: <Positive or Negative> // Random
Effect: Happy = Happy <Sign> (Compatability_Score)(10)
}

- Compatibility Algorithm
  - Crawl
    - Currently, the algorithm is very simple. It just assigns a random score to the individuals that are socializing and that score affects their mood, which affects their decision making in each environment.

- Walk
  - However, eventually this algorithm could take into account more variables like: age, interests, career, education, personality, etc. to come up with a more accurate assessment of how compatible each individual is.
- Run
  - AI

10. Societal Interruptions

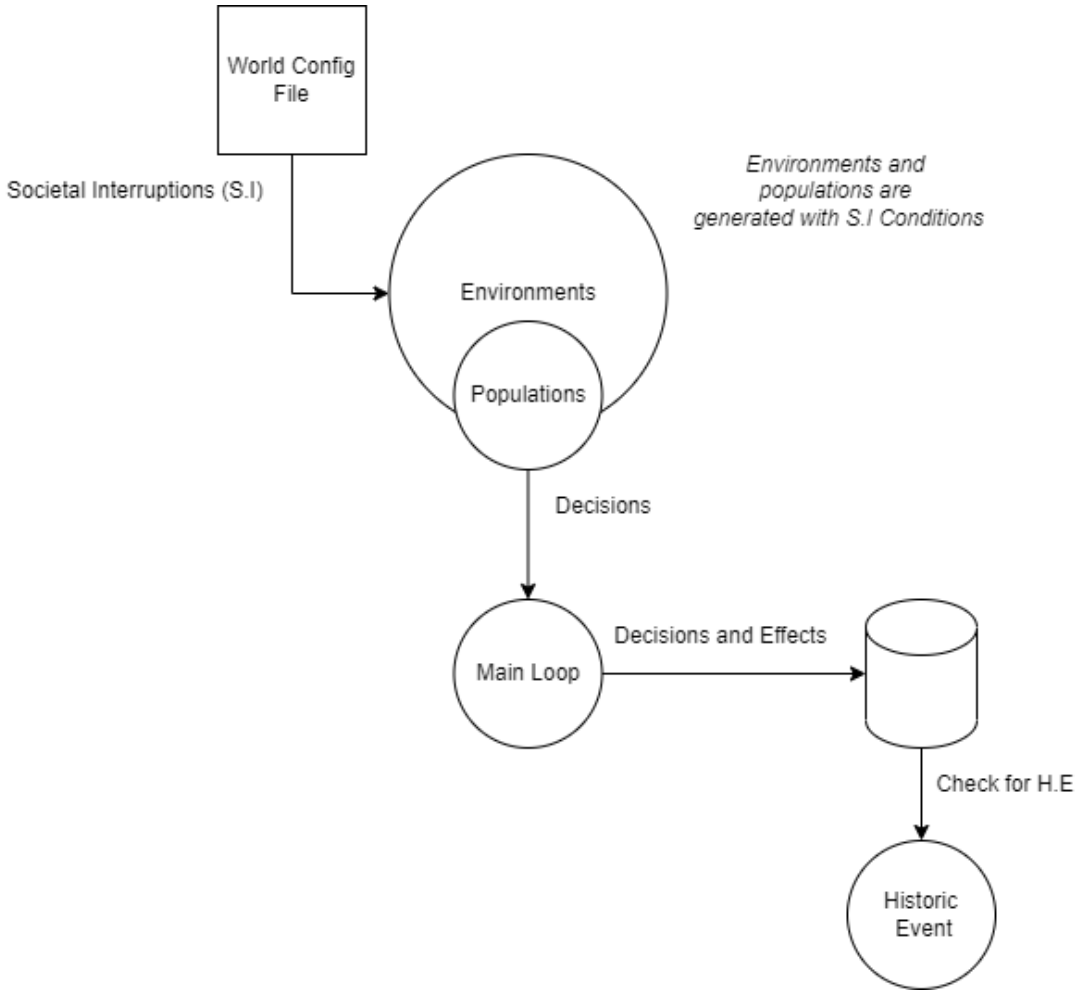
A societal interruption (S.I) is an event that can randomly occur to add unexpected changes to the simulation. Each S.I has specific **Environmental Conditions** associated with it that will determine how individuals in specific environments are affected by the given S.I.

Examples:

1. **RECESSION**
   a. Conditions
      i. "UnemploymentRate": 0.10,
      ii. "StockMarketPerformanceDecline": 0.22
2. **PANDEMIC**
   a. Conditions
      i. "MortalityRate": 0.10,
      ii. "PopulationInfected": 0.08,
      iii. "NewCasesPerDayByPopulationPercentage": [0.01, 0.03]
         1. *1% - 3% of the population gets infected each day.*
3. **CIVIL_WAR**
   a. Conditions
      i. “”:

These conditions are applied to the simulation through the WorldConfig.json file. After a specific S.I has been set for the simulation run, the **Adaptation Engine** will be responsible for making the population choose decisions to counter the effects of the S.I and eventually become immune to it. (If the same S.I returns the population will know how to handle it, i.e. A world state is logged to a database with successful responses to S.Is).

11. Main Flow



The main flow of this simulation will be decided by the current Societal Interruption (S.I) that is applied to the world state in the World Config file. That S.I will have associated conditions that will be applied to specific environments and a percentage or all of the population. These conditions will affect how those individuals make decisions in their environment. All of those decisions should eventually lead to a **corresponding Historic Event (H.E).** As the decisions are made they are logged to the database for **post analysis.**

For the society to achieve a state of Utopia, they have to experience multiple S.I's to learn from them and achieve all three H.E's.

- S.I to H.E mapping
    1. Recession ⇔ First World Country
    2. War ⇔ Social Equality
    3. Pandemic ⇔ High Quality of Health

1. After many recessions, the economy will evolve enough to improve GDP/GNP/ etc.
2. After multiple wars, societies will develop a framework to better communicate and understand each other, which will lead to greater compassion and less conflict.
3. After multiple pandemics, the society will evolve health care systems and sanitation standards and norms to lead to higher quality of health.

Process for updating the **Global World State** variables.

- Example:
    Constantly add to businesses earnings and combine all business profits to calculate GDP for "First World Country" thresholds.

12. User Interface Mocks

- **Interactive mode**: When you want to change values in the simulation at run time, what mechanisms do you need to design to make that happen?

13. System Logs & Database

- Will use **MongoDB** (To get M experience from MERN)
- Come up with a mongo schema or find standards
- Study database design and what makes Mongo special compared to the other database options available today.

Extra Notes:

- Make this design S.O.L.I.D
    - https://www.digitalocean.com/community/conceptual_articles/s-o-l-i-d-the-first-five-principles-of-object-oriented-design

- What directory structure should you use for this project? *(adapters dir, entities dir, data managers dir, etc ??)*

- When does it make sense to build a module?

- Should the Adaptation engine be designed as a module because it has the potential to become a full ANN component using TensorFlow or something else?

- *Secret Sauce*
    - Make this simulation scalable to be able to model the entire world and all necessary variables.
        - 1. Can predict / model future events
        - 2. Prevent bad events and help create good ones
    - New compression algorithm:
        - For modeling astronomical amounts of data and variables
            - 1. Fractals
            - 2. Recursion

- How to make this simulation truly Event based?

Research:

Social Prediction

https://journalofchinesesociology.springeropen.com/articles/10.1186/s40711-021-00152-z

YANSL

https://www.informs-sim.org/wsc97papers/0078.PDF

Object-oriented modeling and simulation

https://dl.acm.org/doi/pdf/10.1145/167293.167321

https://downloads.hindawi.com/journals/mse/2016/1756124.pdf

https://www.researchgate.net/publication/258122737_Simulation_in_Sociology