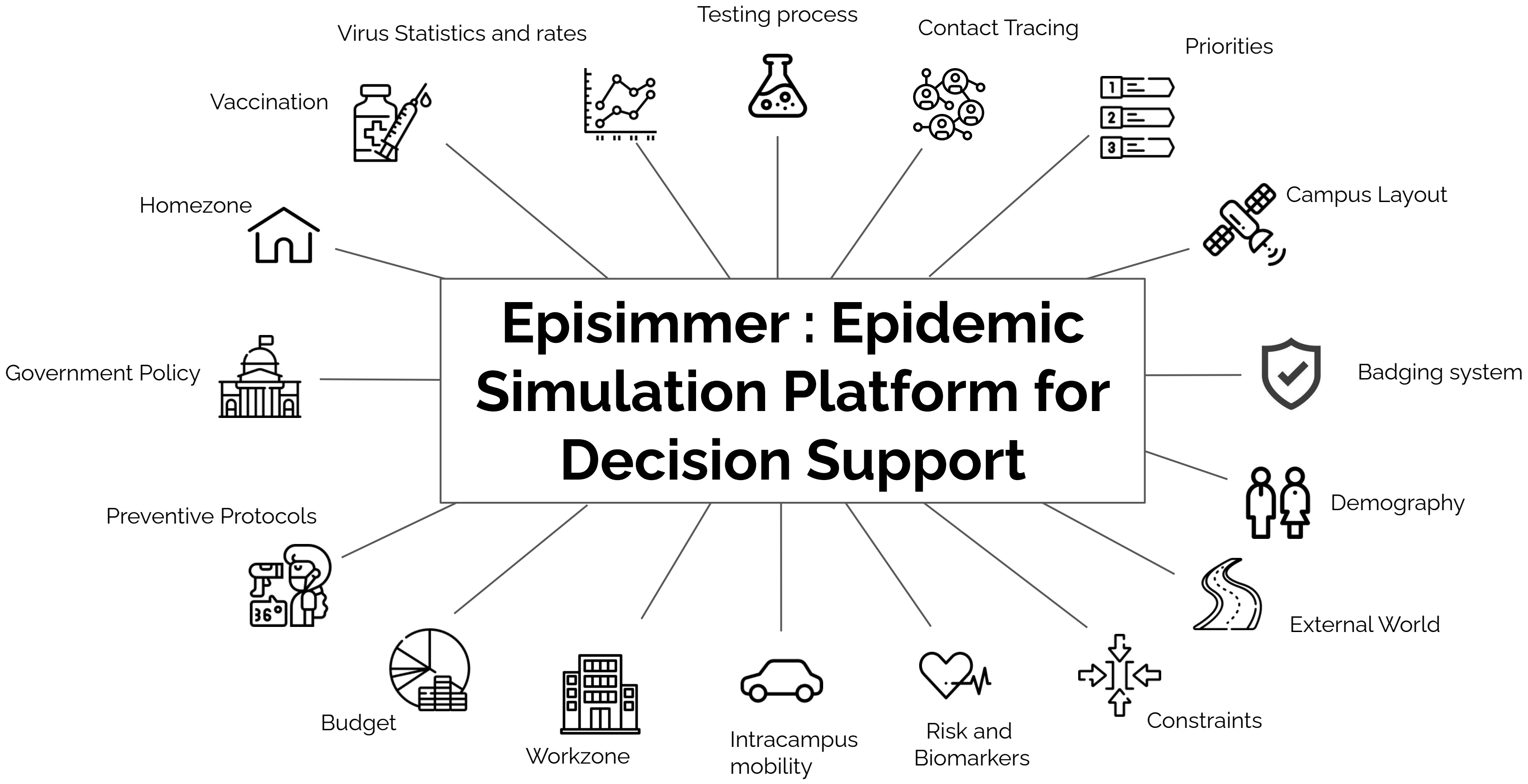
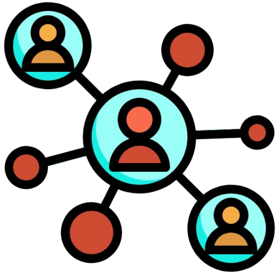


https://github.com/healthbadge/episimmer

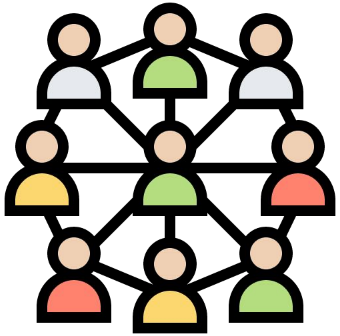
What is Episimmer?

Epidemic

Decision Support



Agent-Based



Community

Python

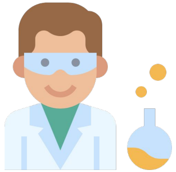
Overview

Uniqueness

Flexibility

Decision Support

Policy Recommender and Optimizer



Can be used by both Researchers and Policy Makers

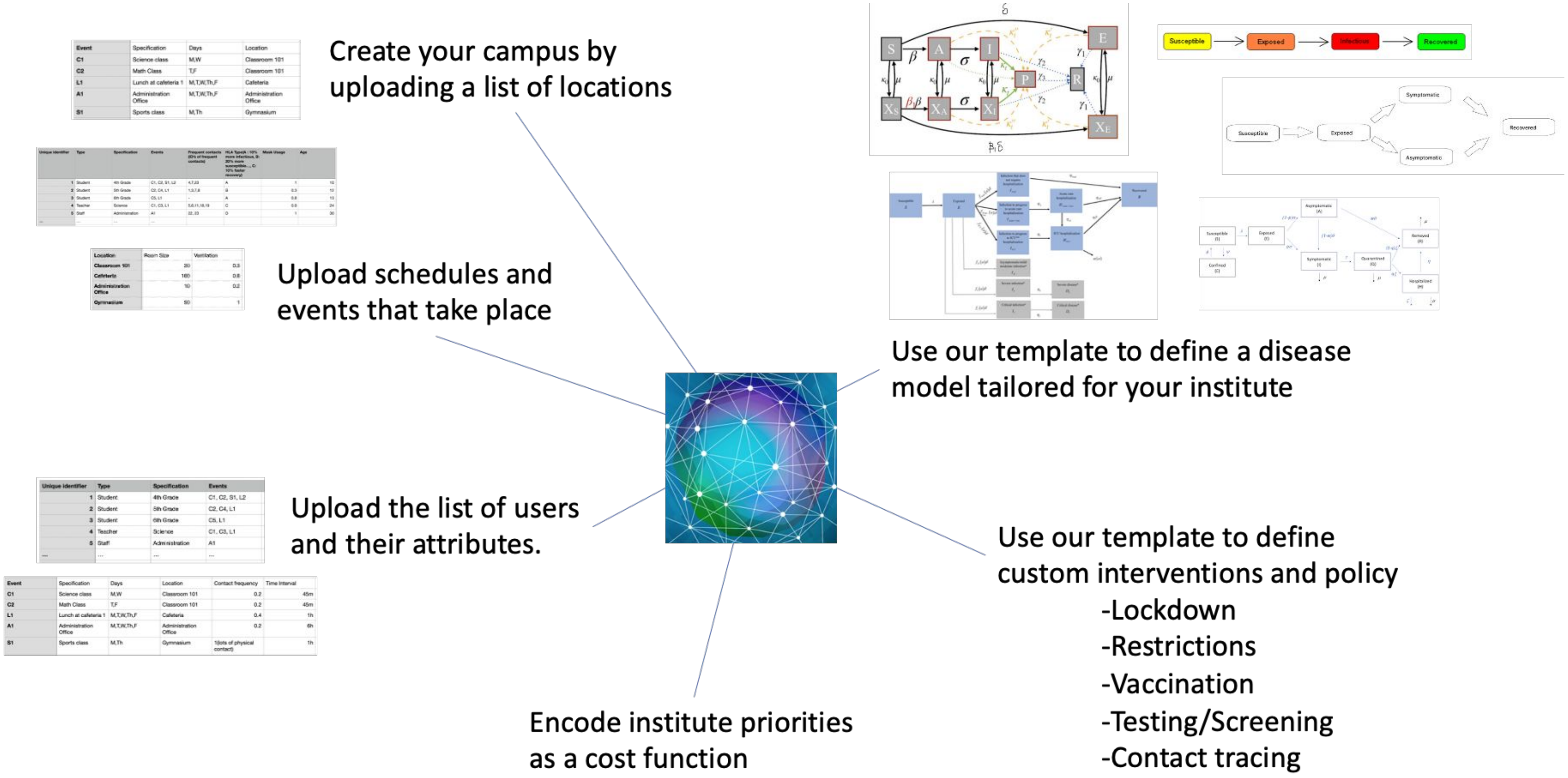
Capabilities

Compare Strategies

Experiment Ideas

Predict who and what is at risk

Scheduling events and interactions



Note : If any of these are missing, user can use default templates provided by Episimmer

Episimmer is built in layers

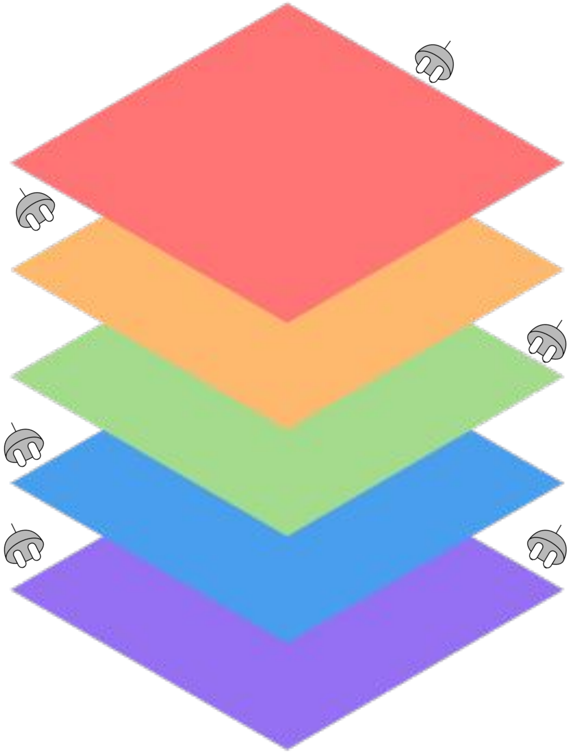
Layer 1 : Flexible Disease Model, Interaction Layer, Agents, Parameters

Layer 2 : Interventions and Policy

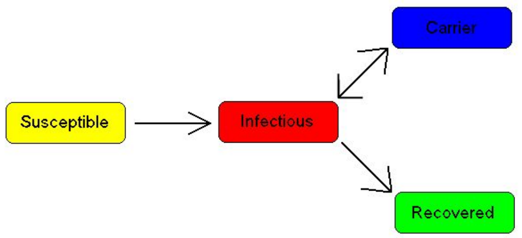
Layer 3 : Detecting risk and vulnerabilities

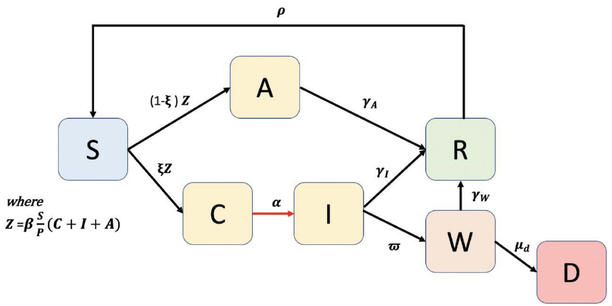
Layer 4 : Cost function and Optimization

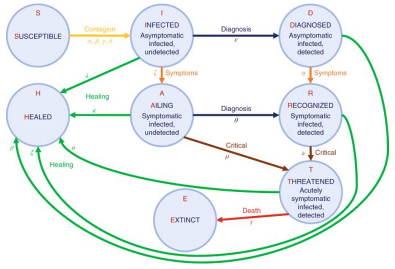
Layer 5 : Smart learning + Recommendation

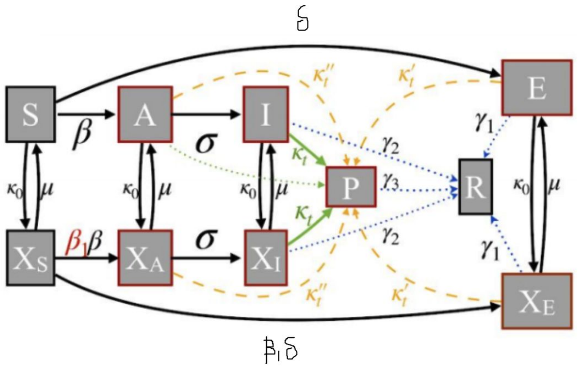


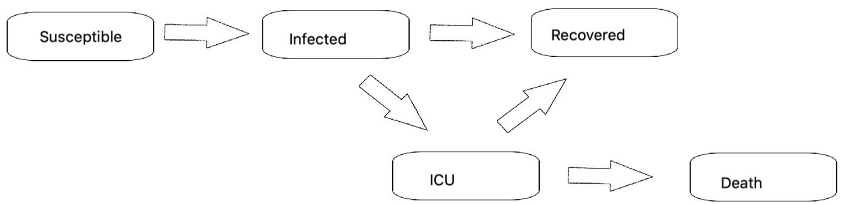
Disease Model





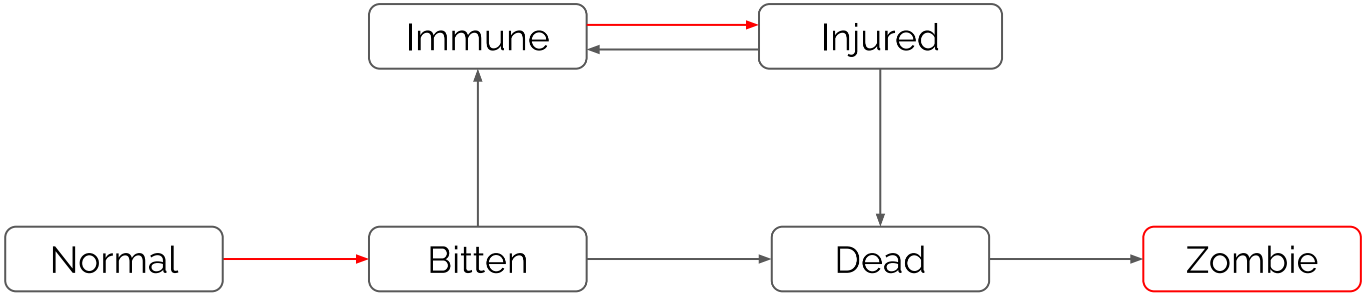






Episimmer is so flexible it can also model a Zombie Apocalypse

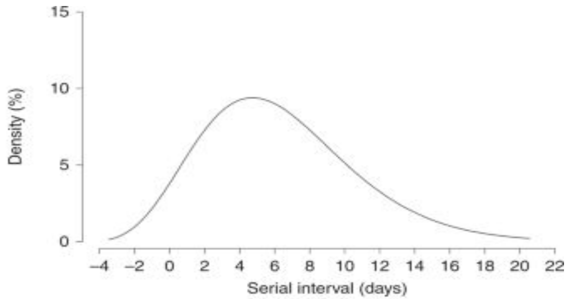
Assume as apocalyptic environment where people need to scavenge goods with zombies around a safe house.

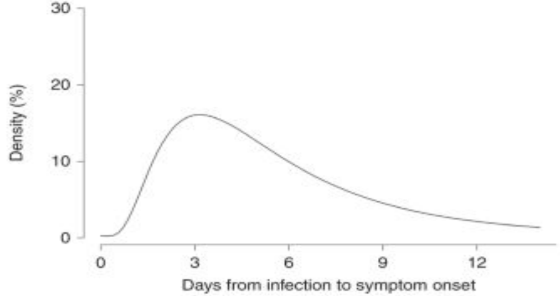


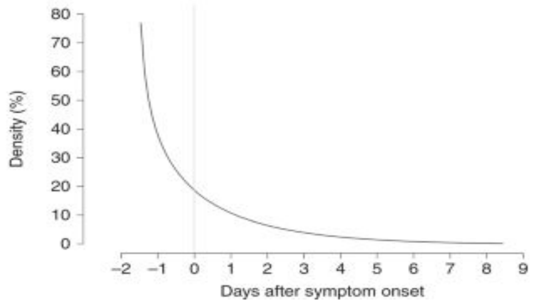
Click here for DEMO
For building a model

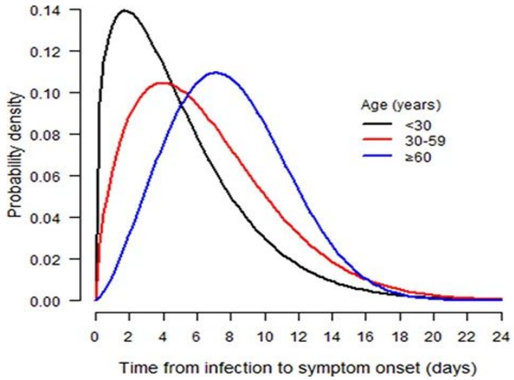
Disease Model continued ...

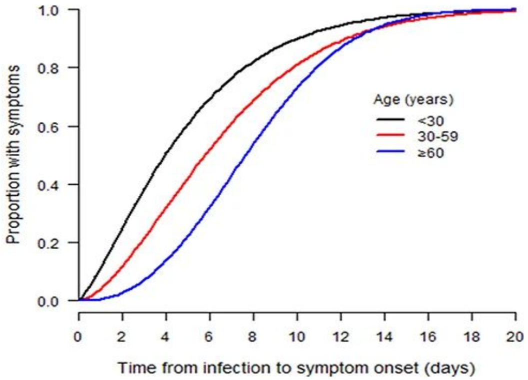
- Input can also be distributions from your government's official statistics.
- Distribution can additionally be over any attribute.











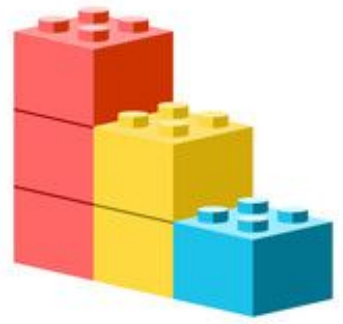
Interaction network

Episimmer is built for communities rather than open systems

Examples : schools, university campuses, industrial complexes, residential areas

You have 4 types of building blocks

- Location
- Interaction (fine grained)
- Event (more efficient but coarse)
- Random interaction event (structured uncertainty) - WIP



Best part is that you can use both simultaneously (Interactions and Events)

Additionally, the constructed networks can be static, dynamic or periodic.

Policy

Restricting

Vaccination

Testing

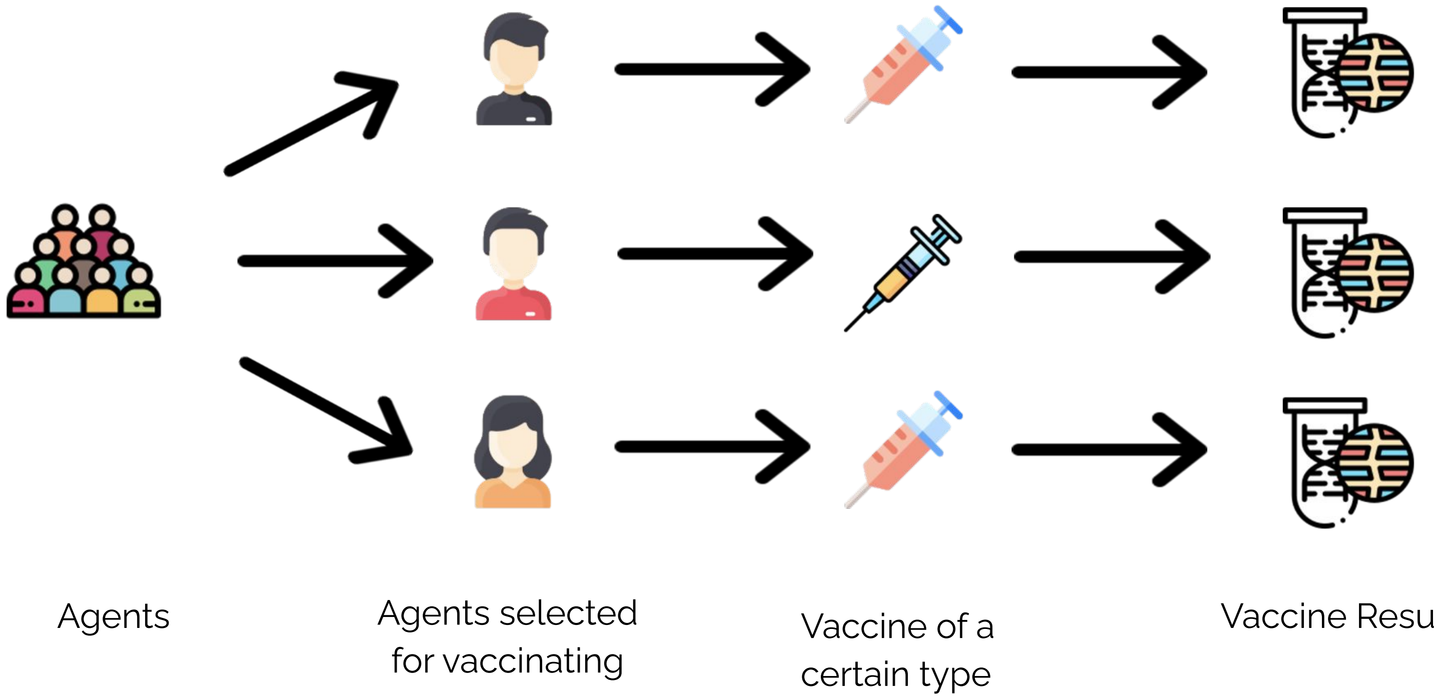
Contact Tracing

Any custom policy

Restriction and Lockdown Policy

- Complete vs Partial vs Limit(WIP)
- Flexibility for when it happens (real world only night curfew and weekend lockdown)
- Types :
  - Agent based
  - Event based
  - Location based

Vaccination Policy



Vaccination Policy

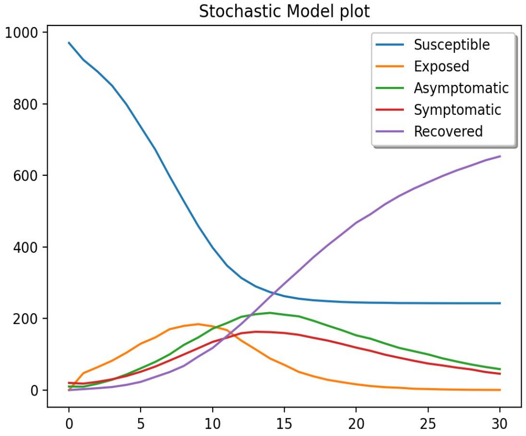
Things to keep in mind for vaccinations :

- Efficacy, Cost, Decay Rate
- Availability
- Different types of vaccinations
- Vaccination strategy (Random, Friendship, …)

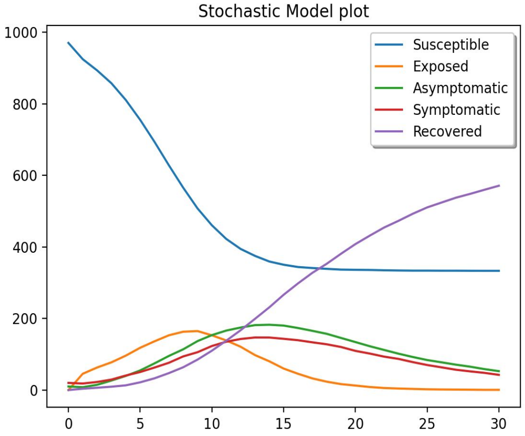
Choosing a vaccine

Assume a Budget : 300 units per day.

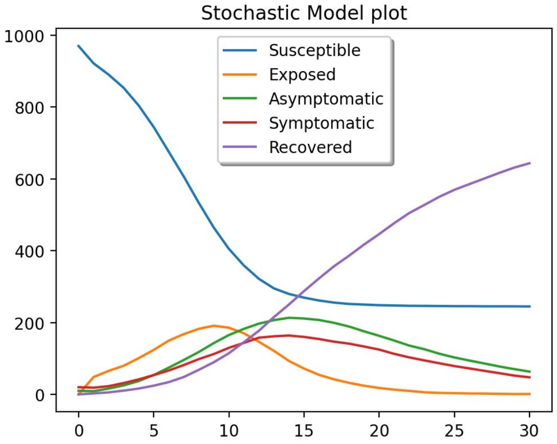
Vaccine Type	Cost	Efficacy	Quantity per day
A	10	95%	30
B	6	80%	50
C	4	50%	75



Vaccine A



Vaccine B



Vaccine C

Episimmer can easily test out custom strategies.

As simple as plug and play, easily experiment with custom ideas. A simple twist to vaccination using the Friendship paradox to give improved results. The same process can be used in testing when tests are limited.

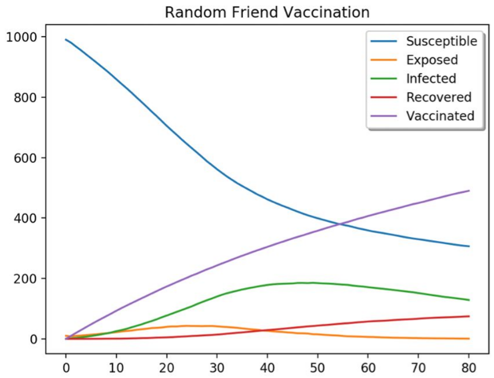
Process :

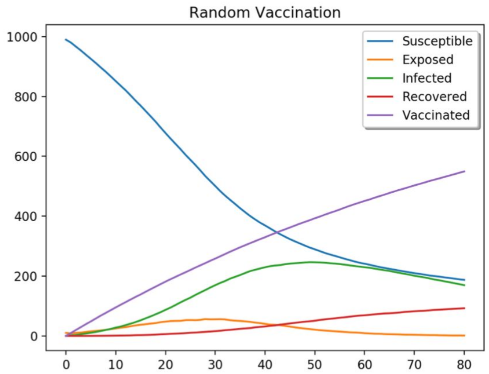
Repeat till vaccines completed

Pick a random person

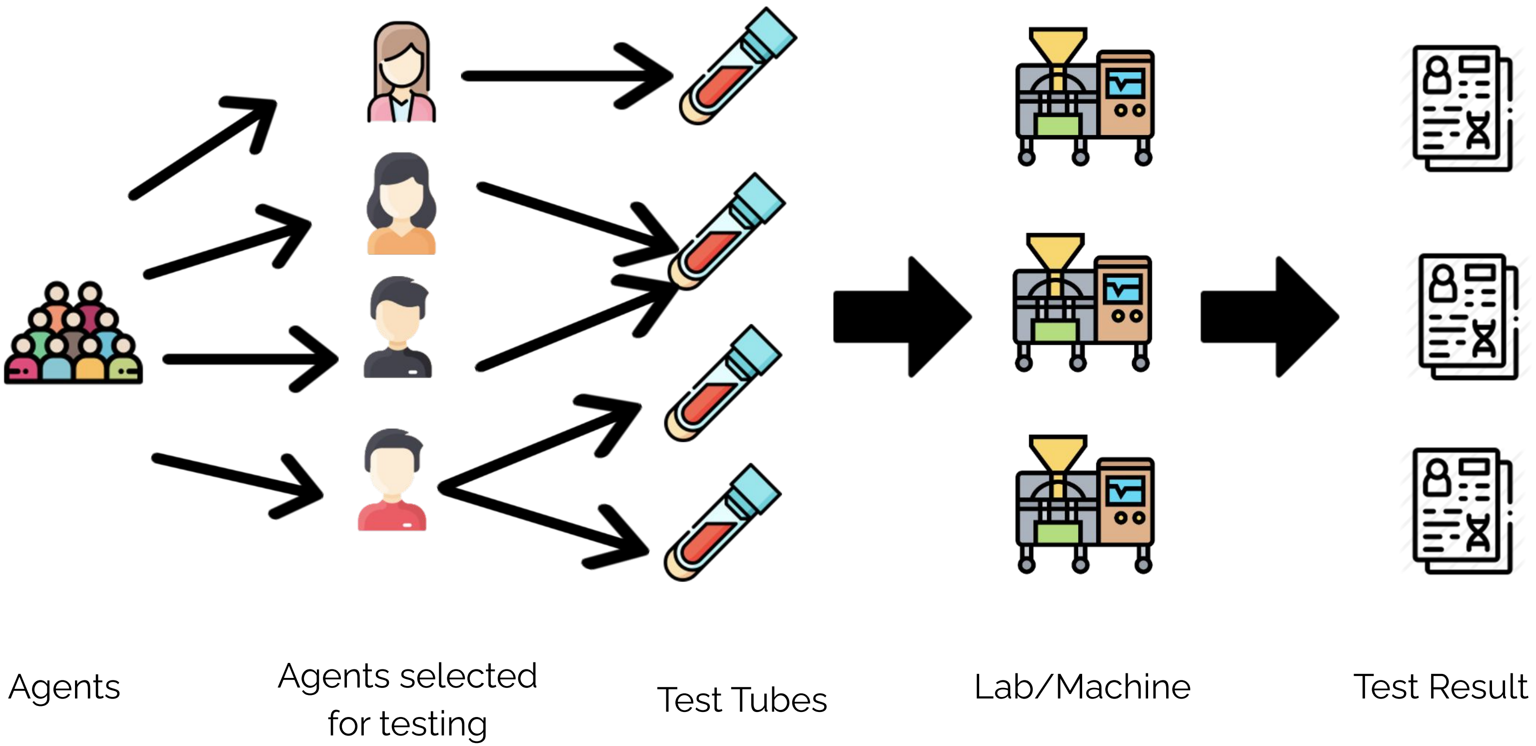
Ask them to identify a recent contact X

Vaccinate X





Testing Policy



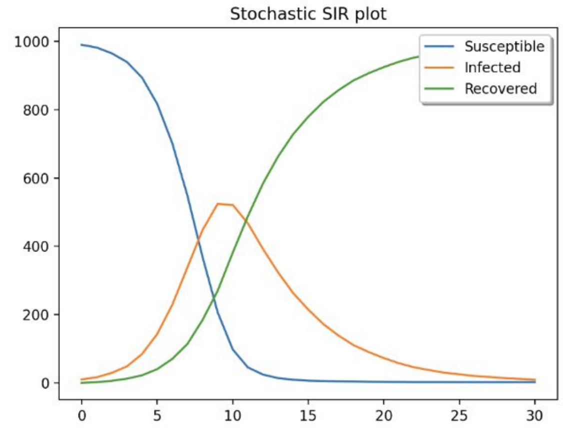
Testing Policy

Things to keep in mind for testing :

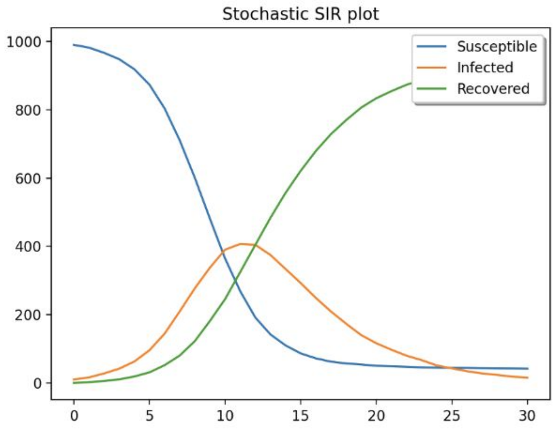
- Testing strategy
- Sensitivity (TP Rate), Specificity (TN Rate), Turnaround time and Cost
- Tests have two outcomes : positive or negative
- Test tubes and lab/Machines
- Agent - Test Tube Relationship

Group testing

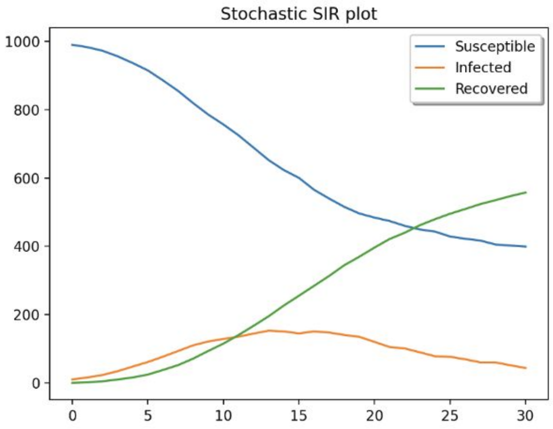
On testing positive, agents are quarantined for 10 days



No Testing



Normal testing
(1,1 Agent-Test tube relationship)



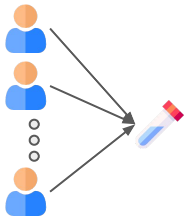
Group Testing
(5,2 Agent-Test tube relationship)

n,k Agent-Test tube relationship : n agents per test tube and k test tubes per agent

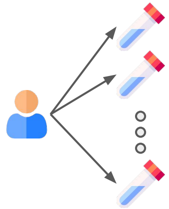
This is single step pool testing on a population of 1000 individuals.
Two step pooling will give enhanced efficiency at the logistic cost of getting individuals back in for the second time.

Type of Pool testing	1,1	2,1	3,2	5,2	5,4	6,4
Total Tests Per day	60	60	60	60	60	60
Number of agents tested per day	60	120	90	150	75	90
Total Infections	112	73	85	63	103	93
Total Quarantined days	305	691	380	402	329	312
Quarantined days for False Positives	0	357	43	112	6	12

The optimal pool will be a tradeoff between false positives and total infections.



n,k Agent-Test tube relationship : n agents per test tube and k test tubes per agent



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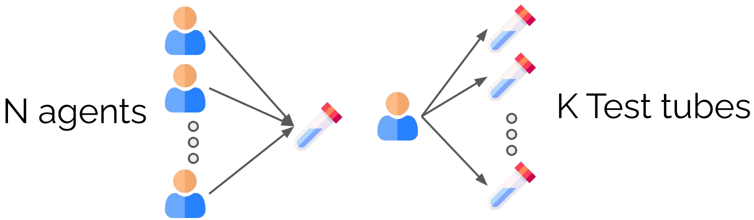
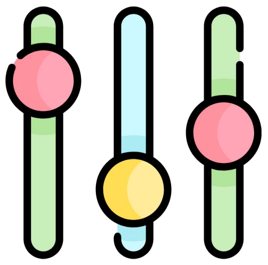


Decision Support

- Answer various questions posed by campus supervisors and researchers
- Test and compare custom policies and strategies
- Predict who and what events are at risk
- Recommend appropriate actions or policy

Communities are confused

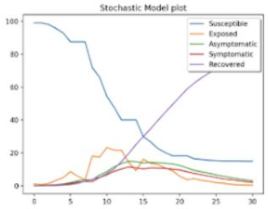


Need for personalization

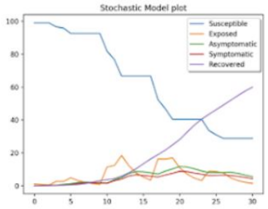
New area of research

Example questions one can answer using Episimmer

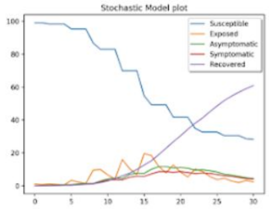
- What if we had offline classes on Monday and Wednesday.
- What if I have a testing policy every Tuesday and Thursday instead of Monday and Wednesday.
- What if I allowed visitors only on Wednesday
- What if I allowed first year students to enter the library every odd day and second year students every even day
- What if we make the entire class quarantine when a positive case is detected.
- If I need to have 10 labs classes a week. Which labs should I schedule on which day
- What if I sent the entire class home for two days once a positive case is detected.



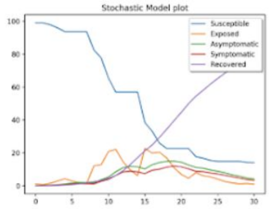
Saturday, Sunday



Mon, Tue, Sat, Sun



Wed, Thu, Sat, Sun

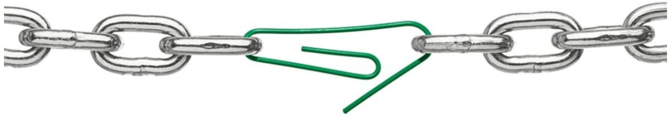


Fri, Sat, Sun

Vulnerability Detection

- Vulnerability Detection refers to finding vulnerabilities in the system that highly affect or are highly affected by disease spread.

- Vulnerabilities can arise from -
  a. Agents
  b. Locations
  c. Events
  d. Interactions



We focus on agent vulnerabilities.

Agent based vulnerability detection

Vulnerable Agents

Agents who are the most vulnerable.

Set of agents who are most likely to catch infection. Alternatively, ones most likely to catch infection the earliest.

Agent vulnerabilities

Agents who are the highest vulnerability in the ecosystem

Given a cost function, find set of n agents who on removal minimize the cost the most for an instance.

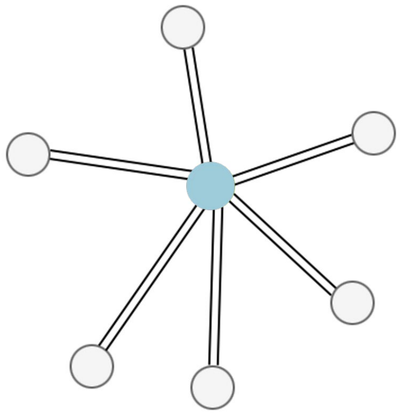
Vulnerable Attributes

Find most vulnerable agents based on a combination of attributes

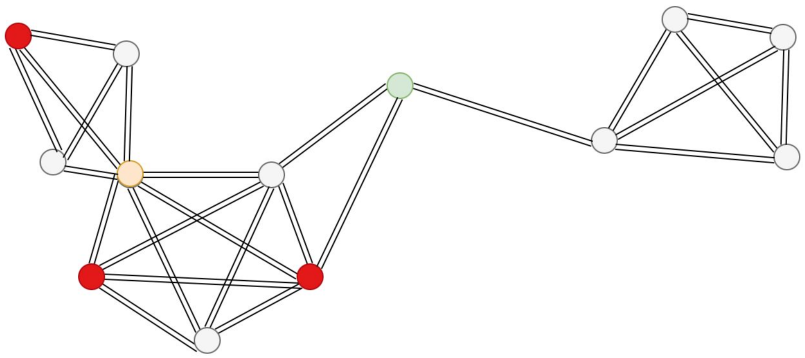
Attribute Vulnerabilities

Attributes which should not mix

Vulnerability Detection Example



Both most vulnerable agent and the agent with largest vulnerability



Infected Agents

Most Vulnerable Agent

Largest Agent Vulnerability

Algorithms for vulnerability detection

Vulnerable Agents

Monte carlo simulation

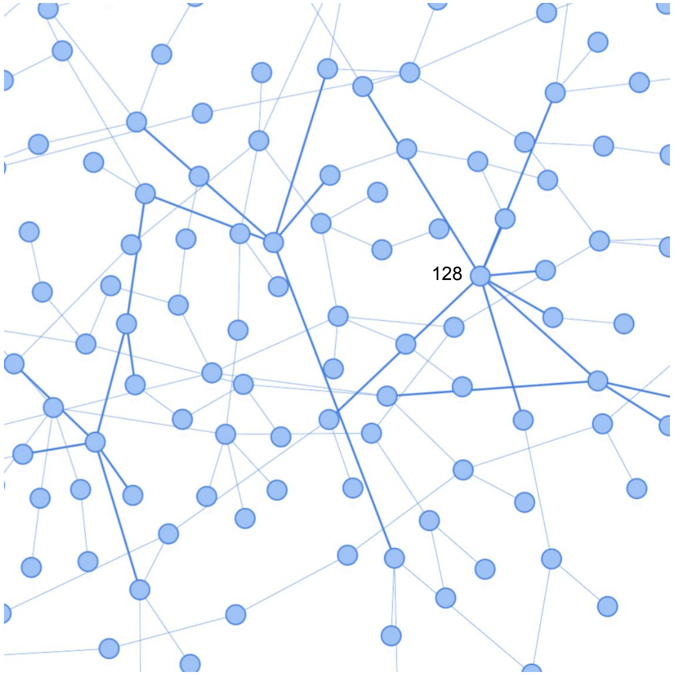
Exploring PageRank : Random Surfer Model + Teleportation

Agent vulnerabilities

Monte Carlo simulation for single agent

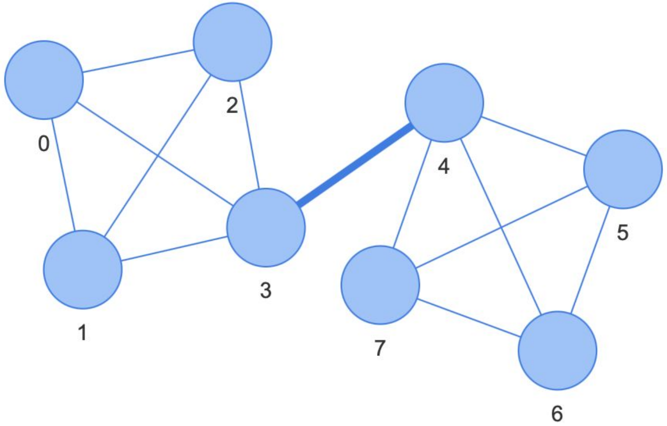
Exploring Multi-armed bandit solutions problem for single agent

Vulnerable agents with Monte Carlo simulations.



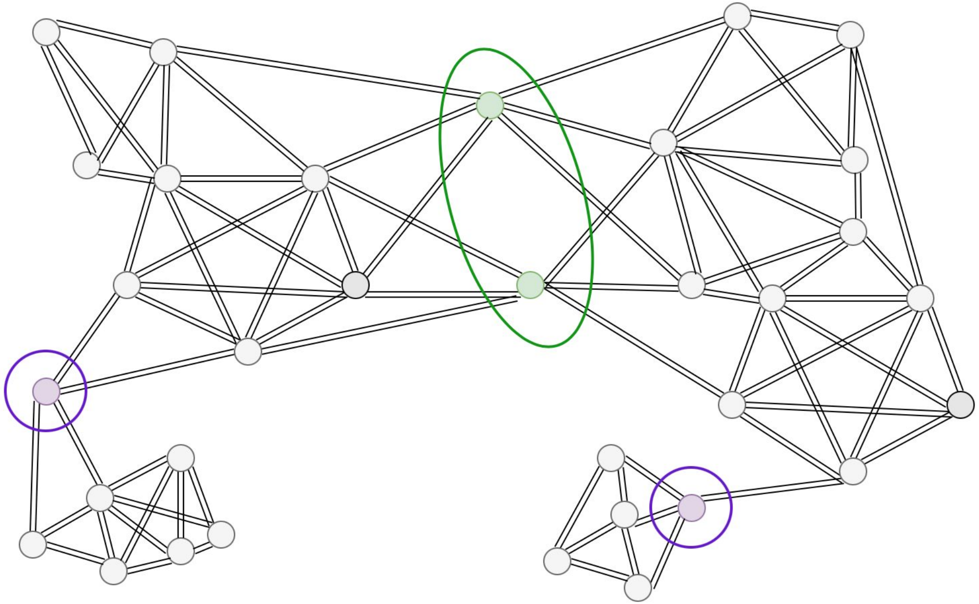
Higher score for agents that get infected early
128 is the most vulnerable agent.

Agent Vulnerabilities with Monte Carlo simulations



Higher score for agents on removal, cause less infections
3 and 4 are the largest vulnerabilities.

Finding agents vulnerabilities is not easy.



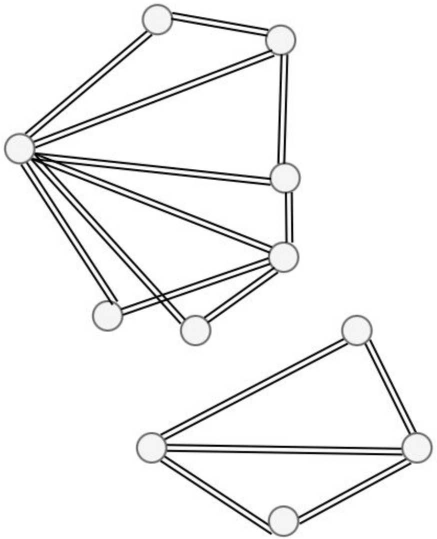
Rephrase the problem as follows.

Find vulnerability set of size k which on removal reduces the size of the pandemic the most.

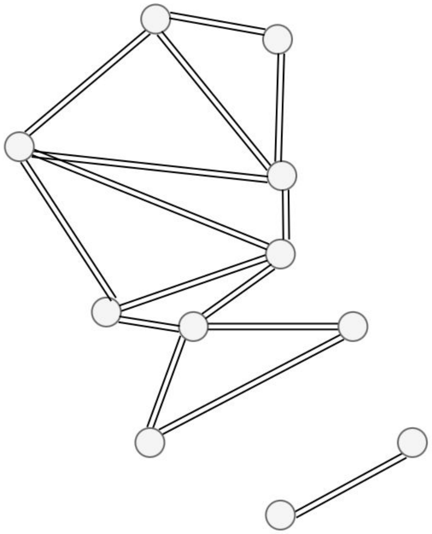
Monte Carlo => O(n^k)

This example shows a static graph to explain in a simple way while the real problem entails dynamically changing contacts.

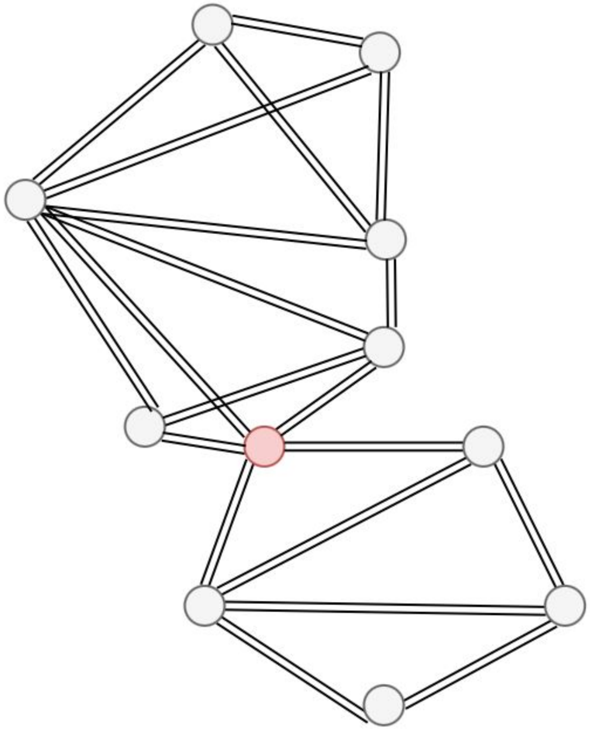
Additional complexity...



Odd Day



Even Day



In the real world universities or factories, we have weekly or daily periodic schedules.

Finding an efficient approximation algorithm or heuristic

- Efficiently for large static graphs
- Heterogeneous agents
- Dynamic graphs (real-time interactions with periodicity)
- Following disease dynamics
- Following enforced policies
- With multiple diseases or variants
- With varying parameters

Budget Optimization

Encode Priorities as a cost function

Freedom : Cost of restricting a non infected individual

Economic Loss : economic loss due to restrictions/quarantine

Health : Medical and health cost

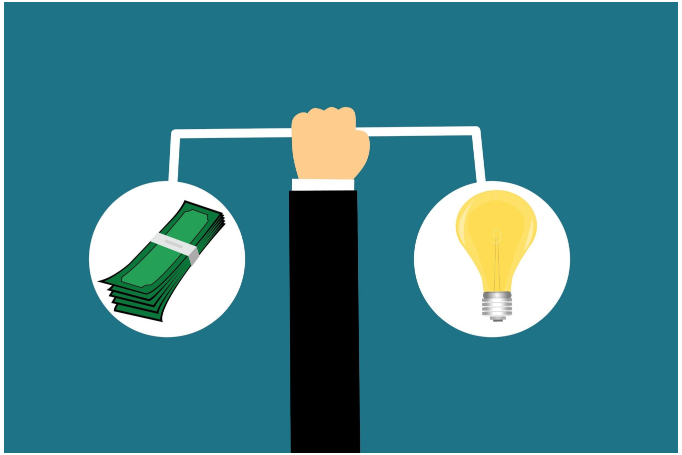
Risk : Variance in result, confidence threshold

Add constraints

Hard constraints on parameters and statistics that should not be violated.

Optimise Cost

Minimise the cost function without violating constraints.



Example for Budget Optimization

Given the following costs:

20 units per symptomatic individual

10 unit for 1 day of quarantine

4 units for test with 1% false negative rate

3 units for test with 5% false negative rate.

Given the following constraints:

At a given point in time the total infections should not exceed 5% of the population.

A cumulative maximum of 10 days of lockdown

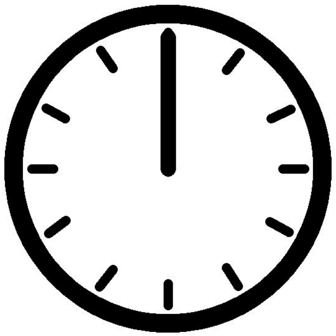
At least 1 day of the week is offline classes

Optimize:

We want to find the appropriate policy set consisting of testing strategy + quarantine strategy + lockdown strategy to minimize the cost ensuring the constraints are not violated.

To add in the future

1. Learning and Recommendation system
2. Utility for each agent + state dependent Behaviour
3. Side utility tools to more effectively feed into Episimmer
4. Practical templates for everything



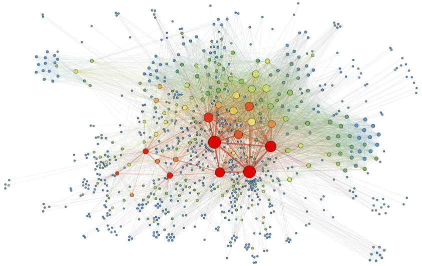
How Episimmer fits into our bigger picture

Preventive

Proactive

Decision Support and risk minimization

Episimmer : Epidemic Simulation Platform



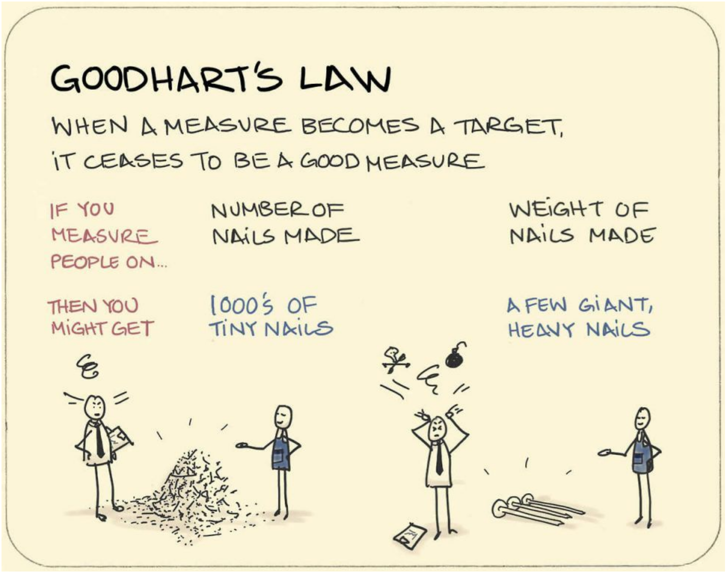
Enforce restrictions and real time intervention

HealthBadge : Badging System

YACHT

Problems with the bigger picture...

Privacy, Error free, Deception, Anomaly detection (Variants, contamination)



Example: Jevon's paradox, Cobra Effect

Better the system, more safe people feel and act differently. Safety systems should not encourage people to interact more.