DESIGN OF MULTIVERSE Agent Based Model

@EC\_GO May 8 2020

INTRODUCTION

This is an extension of the FIXED SPACE Agent Based Model called CovidSim, which provided parameters for simulating contagion-based epidemics within a fixed space, varying the lengths of time of incubation and asymptomatic infection, and the probability of contagion through movement by varying the Hazard Zone and mobility of persons.

The MULTIVERSE will accommodate a number of such Fixed Universes, which interact with one another through the movement of entities (persons) between them.

FUNDAMENTAL ELEMENTS OF THE DESIGN

Essentially, there are UNIVERSES (or spaces), and there are PERSONS, that move between the Universes. From these alone we propose attributes and mechanisms which will give this model sufficient power to simulate the dynamics of the communities we live in, within various contexts.

A UNIVERSE has the same dynamics of contagion (based on two PERSONS occupying overlapping space, given their Hazard Sizes), with three kinds of occupants:

* RESIDENT
* ATTACHED
* TRANSIENT and, in addition, an
* OVERALL MINGLE FACTOR

For example, a cruise ship or submarine is a UNIVERSE which is totally RESIDENT. A Long Term Care facility has mostly RESIDENTS, and some ATTACHED staff, and TRANSIENT visitors. An NFL game has mainly TRANSIENTS with some ATTACHED staff. An airport is mainly TRANSIENT with some attached staff. So the mix can be varied. Some places have more MINGLING than others: a conference reception would have a high mingle factor, a CRA payment office a low mingle factor. An airport would have a low mingle factor in terms of transients speaking or touching one another, but high if one took all common physical surfaces into account.

These are not the PERSONs. The PERSONs (in groups) must have the following characteristics:

* Roles (Fixed, Attached, Transient)
* Length of Stay
* Mingle Factor
* Itinerary

At a particular UNIVERSE, a PERSON might be a Resident, or be Attached, or be Transient; within that UNIVERSE, the PERSON has a specific Length of Stay, and from that UNIVERSE, the PERSON would follow their itinerary, which would have to be at times a choice (perhaps stochastic) of next destination. For example, after work at a meat packing plant, a PERSON might go to a communal shower and locker room, then to choice of {bar, gym, restaurant} 🡪 {ball game, bar, home} 🡪 {work, ER, clinic}

It is not necessary in this model to be specific about which bar, or which clinic. In fact, we do not need to specify “bar” or “restaurant” as much as needing to characterize a UNIVERSE/place by its characteristics of the ratio of population groups.

A PERSON may be a mingler in one context (working as a circulating food presenter at a reception, or nurse in ER), and a loner in another (library, home).

MORE FORMALLY

A UNIVERSE U has properties [F,A,T,M} F,A,T are ROLEs

* F = fixed resident %
* A = attached %
* T = transient %
* M = mingle factor

A PERSON p has properties:

* Roles R R(p): {F,A,T] = f(U) different States in different places
* Length of Stay L L(p): f(S(p), U) different Stays in places and roles
* Mingle Factor M(p): f(S(p), U) different mingling as function of U,R
* Itinerary list of (U[R,L,M], {Ui / Uj / Uk}, Ut, Uh)

We would not attempt to represent individuals uniquely but stochastically within groups that move from UNIVERSE to UNIVERSE. The attributes from CovidSim would of course still apply (uninfected, incubating, infectious, detected, Hazard Radius, risk factors, susceptibility).

DYNAMIC EXECTION

Within each UNIVERSE, the rules of contagion would apply as in CovidSim. At the start of an execution cycle, the new arrivals would be integrated into the Universe. At regular intervals (like punching the clock for shifts), the system would allow each UNIVERSE to deal with the PERSONs whose Length of Stay has been fulfilled, and a new destination determined according to the PERSON’s Itinerary.

The departures would be in the form of messages into the INBOXes of the UNIVERSEs in question. The system would then remove the departures from the UNIVERSE, and integrate the newcomers from the INBOX of that UNIVERSE.

The system would then permit the UNIVERSEs to execute according to their internal rules.

The Mingle Factor for a UNIVERSE is a general base for movement of the PERSONs, which would either increment or be a minimum of the Mingle factors for each individual PERSON. For example, residents in Long Term Care may not mingle much, but during meal-times and events, they do so, while the tendency for each individual might be low.

SETUP for Universes and Population

This may be time-consuming, if the distributions are to have some approximation to the reality contexts being modeled. Nevertheless, we must first define the UNIVERSEs and their general characteristics, in terms of mixes of Fixed, Attached, Transient and Mingle Factors (and here we can add names to bring some reality to these abstract spaces).

Then we have to choose the population in terms of numbers and roles as they move from one Universe to another. This scale of this modeling might be challenging. For example, do poultry workers just mingle in the workplace and leave, or do they move to a common bath and locker room facility and then leave?

For each group of PERSONs (drawn from the total population being modeled) we have to define which groups have some concrete identity in our planning, so we can plan their itineraries in terms of the UNIVERSEs they move to, and in those what Roles they play (they could move to the same UNIVERSE under a different role – for example, a flight attendant could be an airline passenger in the same simulation cycle).

This modeling of the Multiverse and its populations can be as micro-managed as one has the patience for, but the necessary level of detail should be driven by the questions being asked. If a detail is not necessary for the study, it should not be included. Simplicity is clearly going to be the mother of invention, in complex modeling systems such as this.

There can be inconsistencies in terms of time….could a group of PERSONs go to an office or manufacturing class Universe for 23 days and not leave? Well, the workers in an acrylic plant in Pennsylvania did exactly that, in order to produce the base materials for PPEs, in April.

If the inputs and outputs don’t balance, either the system is incorrectly programmed, or death stalks through the ghost in the machine.

STATISTICS

So what is going on in this simulated MULTIVERSE? The question is to ask how the epidemic is going in the complex UNIVERSEs? What does shelter in place mean in this model? It means that PERSONs become Fixed in an abstract space called “HOME’ with some mingling within but overall low, while the population put into circulation would be low.

Since the total uninfected, incubating, infected, and detected are carried by PERSONs, they can be cumulated at any time for the MULTIVERSE and for each UNIVERSE. The itineraries for each group of PERSONs (or stochastically, everyone), can be changed at any execution by the SYSTEM to implement a new policy of shelter in place, or of more testing (which shortens the periods before detection), or of the vaccine which changes the susceptibility, or closing down places (which removes certain UNIVERSEs in the abstract sense) or of opening up (which adds a UNIVERSE with characteristics to the itineraries).

It is clear that the system will have to be able to change all itineraries (much to the dismay of Republicans, but we can build in resistance too). So we want more people to go to mingle places – change their itineraries to make a certain % of PERSONs in age groups to visit two high mingle places before going to the low mingle HOME place for several cycles.

The fundamental tallies are going to be the numbers uninfected, incubating, infectious, detected at various points, the travel movements and the compositions of the UNIVERSEs as they change at each clock punch, and something we have not modelled – deaths and hospitalizations.

DEATHS and TAXES

We could move all detected to two rooms by adding in the function f(CoronaState🡪Detected Universe) and examine those detected in the Universe to send them to the Detected Universe.

The Detected UNIVErSE would be a Low Attached (staff) and High Transient (the patients) one, with the patients stochastically leaving after so many cycles to {Hospital U, ICU U, Death U, Home U} and from each of these we could have more stays and departures.

Perhaps we don’t need primitives except for the new departure-based-on-coronaState, and the rest can be modeled by the elements already designed. Cruise ships, quarantine camps, isolation, home shelter, parks, offices, construction sites, government agencies, can all be modeled using these design elements.

VALIDATION

It is going to be very difficult to use this as a predictive tool in terms of making a statement about excess deaths of so many people in Penticton if we open the Starbucks there.

This tool is intended to be an analytic model that shows effects in the sense of pushing on a lever and seeing an object rise at the other end of the fulcrum. It is intended to model effects, not predict numbers.

The future is never going to sit still and obey numbers that come from the past. However, if we had a model that reasonably allows us to state that if we had these kinds of spaces, and this kind of circulation of PERSONs, and they were to change, how would the needles move, and relatively speaking, how large or small are the effects?

These are the questions that the Covid Multiverse Agent Based Model hopes to address.

It is going to be tricky – if you open a football stadium with a mix of 90% transient and 10% staff, and you send a group of 15 PERSONs from HomeU to StadiumU, what if you forgot to send any P(transients) to it? You could choose to do that and simulate a no-audience game, or you could simulate a financial disaster (what if they gave a party and no one came) or you just plain forgot the population equations, or you implemented a free will-fear factor and PERSONs chose to stay home!