

# Intellichain: A Blockchain Enabled Participatory Decision Support Framework

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## 1 Introduction

The future of evidence-based public health decision support depends on combining highly detailed contact network data and epidemiological surveillance. Therefore, the success of any decision making involving the public requires buy-in from all stakeholders. Specifically, in the case of the public health, data from the public is required as is their compliance with public health policy decisions. When decisions are made behind closed doors by unknown officials using unseen evidence, there can be a breakdown in communication leading to fallout and ultimately to poor uptake or acceptance of public health interventions such as vaccination campaigns. In order to foster trust between public health authorities and the public, the decision process needs to be open, transparent, and participatory in nature.

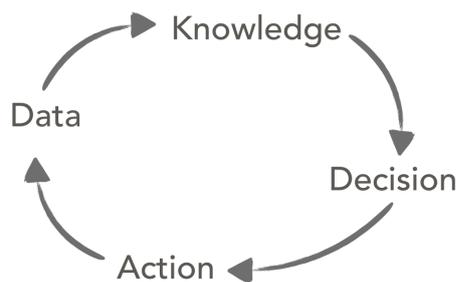


Figure 1. An evidence-based governance framework including generation and collection of data, leading to analysis and knowledge generation, which is in turn used for decision making. The loop is closed when decisions are put in to action, generating more data that can be used for further iterations.

Regarding the evidence-based governance model in Figure 1, the loop is only closed when decisions are put into action. In my public health research I found that often, the decision making process is not accessible to the public, and therefore public health messages are often difficult to communicate effectively. As a result, in too many developed and developing countries too many individuals disregard too many public health messages that they do not understand or trust.

## **2 Design**

For there to be trust between public health authorities and the public, the decision support process to be participatory and open. Specifically, the design of this platform will take into account the following principles:

- fair use of data and resources
- participatory and open to all stakeholders
- participants are fairly compensated for the use of their data
- governance and provenance of data is clear

It was noted that these ideals are the same as those espoused by Blockchain communities, leading to the idea that this technology can enable the transformation of the public health decision making process to be a participatory one. To these ends, Intellichain embraces open source and open data in order to engender trust in the decision-making process and ultimately compliance in the public through:

- Open Source Analytics and Simulation Code
- Data is open or at least can use anonymous open data
- Business rules for data analysis including modelling are implemented as smart contracts on a Blockchain in order to enable a participatory decision support platform for public health
- Computation and analytics are carried out in a participatory Blockchain network i.e. simulations are transparent and verifiable
- Advanced analysis and visualization capabilities to convey appropriate messages to decision makers and the public will be demonstrated.

In the following section implementation details will be presented that describe how the aforementioned principles informed the initial development of the prototype.

## **3 Prototype Implementation**

Intellichain was created using Blockchain technology; specifically Smart Contracts written in Solidity on the Ethereum platform and is paired with unique communication and knowledge translation capabilities. The platform is used to combine knowledge from a number of computational modelling publications to implement an Agent Based

Model, appropriate for modelling complex social system such as the spread of infectious disease. This modelling framework was specially designed for efficiency within a Smart Contract Blockchain environment, featuring minimal memory footprint, and pushing as much as possible off chain.

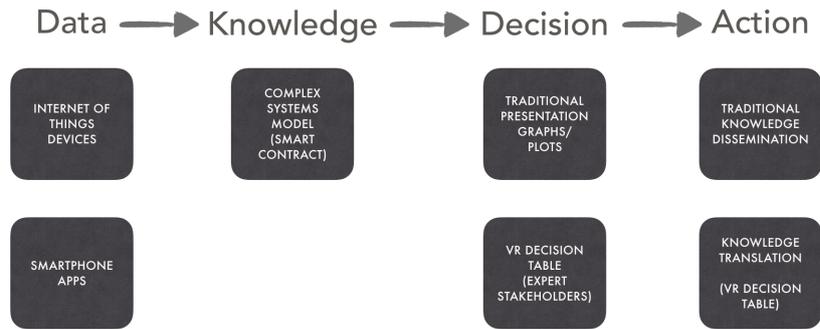


Figure 2. Data coming from devices including smartphones is used to parameterize analytic models executed on the Blockchain. Knowledge generated can be presented using Virtual Reality technology throughout the decision making and knowledge translation phase.

The evidence-based decision making process presented in Figure 1 is “unrolled” to illustrate corresponding Intellichain platform components. Data inputs into the system can come from web as well as mobile devices including smartphones and IoT devices. Data is anonymized and stored using a relatively simple mechanism within a smart contract, however, arbitrarily complex governance schemes concerning data provenance and governance can be designed. The implemented model ABM.sol represents a proof-of-concept ABM implementation to make it feasible to execute on a Blockchain network such as Ethereum.

To enable the conveyance of simulation outcomes in a participatory manner I have created the Virtual Reality “Decision Support Table” for data analysis and also for knowledge translation and communication with the public. VR represents an intuitive and explicit means of visualizing data and simulation outcomes, can be used for knowledge translation to convey the nature of simulation based modelling to stakeholders. Perhaps, most importantly, because this platform is by nature open source and open data it will foster trust in the decision making process and ultimately better outcomes with respect to public health measures.

## 4 Results

A sample ABM (Agent Based Model) contract has been deployed for use at Ethereum main network address: 0x203028e846f512ef3320c10f0d39739906e65797

It can be interacted with directly or using the ABI published on the github page, along with the solidity smart contract.

It was found that on the public Ethereum network with 10 agents, 3 time-steps were possible per block before the gas limit was exhausted. The gas limit is technically adaptive but it's difficult to carry out simulations when transactions are occasionally rejected or delayed due to gas limit. For these reasons, the initial prototype validation simulations were carried out on a test network.

A demonstration has been published to the Google Play store for Daydream compatible devices that permits users to experience a simulation carried out earlier on the aforementioned Ethereum test network. The simulation illustrates the important epidemiological principle of a super-spreader infecting several secondary cases early on in the outbreak who in turn infect others. log was imported into the VR decision table app. The simulation is relatively simple, but illustrates the important epidemiological principle of a super spreader early on infecting several secondary cases which in turn infect others

It's been observed that the time between blocks is appropriate for human beings interacting with the simulation to perceive the outcome of the present time step and decide, and act before the next block or simulation step. The current design awaits a transaction to initiate simulation of the each simulation step, rather than attempting a particular number of time steps per block, so any user interactions can be bundled with the request to simulate the next simulation step, therefore the simulation will essentially wait for participants to make a decision, with an expected network response time being approximately the block-time.

## 5 Upcoming Releases

The next version is in development will feature shared Virtual Tables experiences and interactions within a group of participants, and the ability to affect simulation outcomes as they are run on the Blockchain. On the data collection side, the benefits of a Blockchain network include the prospect of an easy way to compensate participants, and also, so-called zero-knowledge proofs may enable the collection of aggregate statistics in a population without revealing any information about individuals, safeguarding their privacy.

For deployment on public networks, some operations related to configuring and mediating the simulation could be permissioned to permit certain stakeholders access to control the simulation, while a wider audience can view. Also, individual Agents could be tied to a particular Ethereum account, corresponding to a mobile client, but presently this is not necessary and not implemented.

Design and implementation of a dedicated Ethereum-based Blockchain network with rules optimized for participatory data analysis and decision making applications is underway.

In the current iteration, the simulations were carried out on a test network, and the logs were imported into the VR client. This is for demonstration purposes of the platform and a new version of the mobile client is expected in March, please see <http://www.intellicha.in> for updates. The current mode has several advantages for demonstration purposes, however. The mobile client does not have to sync with a Blockchain, and the simulation can be sped up faster than the block-time for presentation purposes and the sake of the audience.

## **6 Concluding Remarks**

In summary, Intellichain represents a quantum leap in public health oriented participatory decision support, owing to its open design and advanced visualization capabilities. The code, data and outcomes are all open and the data and simulations are governed by smart contracts on a Blockchain. Experts and the public they serve have access to the same platform where ideas and outcomes flow freely.

It is my hope that in the future, there will be an increased call to open up data, code, simulations, and results. For links to the source code, an app download, and updates please stay tuned to

<http://www.intellicha.in>