A Pandemic Digital Global Architecture

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Abstract. This paper is a proposal for a global IT health system. As a paper, it is concerned with the high-level definition of the architecture of such a system. If designed and deployed correctly, a system that will be of benefit to the world when faced with a pandemic. Therefore, this paper is not written in the style of a scientific research document with details about findings and conclusions. Instead, its focus is on proposing an architectural model and the beginning of designing and implementing a Global Health IT System that can benefit everyone.
It is a paper that is focused on concepts and does not discuss in-depth detail. How-ever, that detail is undoubtedly considerable and necessary as the proposed system development and deployment proceeds.
This paper defines a model for politicians, social specialists, medical experts, and IT computer science experts. A model they can have in their minds to begin a significant change to how risk can be managed. A change to how our global society acts and reacts when faced with the threat of a pandemic.
This paper aims to inform key international decision-makers that Computer Science can play a significant part in controlling a pandemic. And begin the definition of the system solution to do this. This paper is a signpost to what must be done.

Keywords: Pandemic Digital Global Architecture · Pandemic Dashboard Information System (PDIS) · Pandemic Status, Pandemic Outcome · Global Health System.

1 Introduction

The Covid-19 pandemic has shaken the foundations of societies everywhere. It is a major medical, economic, and social challenge. It is also a Computer Science challenge; how Information Technologies (IT) can provide insight into the pandemic's state. Examples of such a system can be found in [3, 4]. These IT systems are global, and transaction driven and are examples of how IT systems can operate instantaneously and continuously.

Today, IT systems are essential in dealing with the pandemic through appropriate medical and social actions. The success of these systems is critical. The preparedness of nations to have IT systems ready for execution was not ideal when the Covid-19 pandemic appeared. Time to react to a pandemic is key in dealing with it efficiently. This paper assumes components of the IT system proposed, whether hardware, software, or skills, can be brought together by the disciplines of Computer Science into a real-time operational system. What is needed is the realisation of the need for such systems and the political, social, and financial push to meet the challenge. In short: **we have the technology; we need the sponsorship**.

2 Background on Readiness

In dealing with the Covid-19 pandemic, the UK had many IT systems collecting, analysing, and reporting on the pandemic's state . The UK is used as an example; other nations may have better or worse systems that they employed. There is no global system, thereby no global focus on what is happening.

During the start of the Covid-19 pandemic, there was a time lag in collecting and analysing the critical data needed to take swift and corrective decisions to control its progress. There was confusion about what the data told the medical experts and the politicians. Information was inaccurate, late, and came from too many sources. One of the most annoying and sometimes dangerous outputs of IT information systems is misinformation.

The technology components for an effective IT system, the hardware and many software components were available. The overall system and the processes to execute them were not. Over time a potpourri of systems was refined into one apparent system with consistent inputs and outputs. Time was lost, and actions derived from the information available were not optimised. Thereby solutions were not optimised.

3 What is needed?

3.1 Status and Outcome Trusted Information

When a pandemic is or is about to happen to a region, precise information is needed with various degrees of granularity. There are two key questions to answer:

1. Where are we with the pandemic?
   - The Current Status. What is happening, and at what stage of the pandemic are we today?
2. Where are we going with the pandemic?
   - The Possible Outcomes. Where will we be within a prescribed timeframe like days, weeks, months?

With timely and accurate answers, medical and social containment measures can be determined and put into action. However, the answers to crucial questions need to be produced in real-time to achieve maximum effect. Any timeliness lag of information means a lag in the effectiveness of the measures to combat the pandemic. The ultimate design point of a pandemic digital system must therefore be real-time. When any pertinent event occurs, the relevant data is collected, analysed, and the derived information reported. This is probably a goal that cannot be achieved in the early life of the system, but any variance from real-time must be as small as possible.

Of particular focus is the rate of transmission of a virus. A pandemic can spread very quickly, locally, or globally. For example, the Covid-19 pandemic was generally identified in Hunan, China, in late 2019. Some two months later, the virus was global. In the UK, what is known as the English variant was identified in September 2020. It spread throughout the UK and many other countries within weeks with a surprising speed after the experiences of other variants. For references illustrating that there is a time before a variant is detected, but very quickly it is transmitted see [2, 9].

The message is that a pandemic can spread and snowball very rapidly. So, the IT system described here to deal with a coming pandemic must be architected to collect input data and output information in real-time. We can, for this paper, entitle such a system as:

The Pandemic Dashboard Information System (PDIS)

3.2 The Skills Needed

From the outset, it must be realised that considerable and varied skills will be needed to create and operate a PDIS. Essential skills are shown in Fig 1. Without the correct mix of these skills, the appropriate system will not be of value.

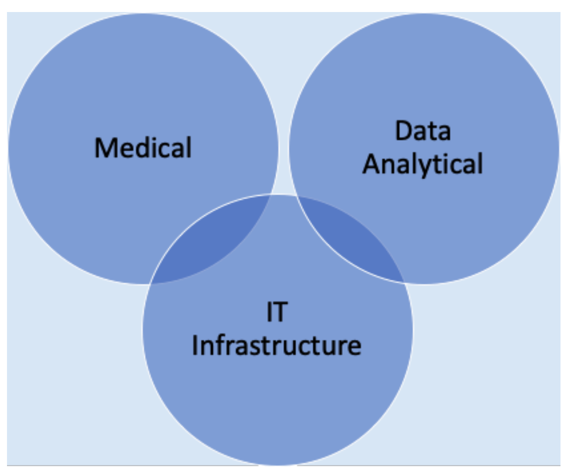

Fig. 1. The Skill Set

- Medical skills to define the requirements of what must be collected, analysed, and in particular reported. The experts possessing these skills know what they want.

- Where are we with the pandemic?
  - ∗ What has happened? When did it start and how did it grow?
  - ∗ What is happening? How is it growing with regions and between regions?
- Where are we going with the pandemic?
  - ∗ What could happen? What course could it take from today?
  - ∗ Is it spreading like a past pandemic, or is its spreading in a novel way? What patterns can we see and extrapolate?

– Data Analytical skills to define the base data and how it will be analysed for the medical experts. There will be a need for analysis tools, including Artificial Intelligence (AI). The system must learn and improve.
- What programming functions do we need to transform the data into information?
  - ∗ What tools do we have to be able to provide the crucial information to the medical and social experts?
- What mathematics do we need in the analysis programming?
  - ∗ The most suitable mathematics must be chosen. The choice will need exceptional skills. Simple extrapolations based upon base assumptions will not be sufficient.
  - ∗ There must be a consideration of the Dynamic Complexity of the problem to be solved and associated mathematics [10]. The assumption must be that new pandemics may not behave like past pandemics. Even when the behaviour of a pandemic is understood, there must be an assumption that the known behaviour will change.
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– IT Infrastructure skills to architect, design, and manage the infrastructure. The PDIS will be a very complex IT system. that must handle sudden input peaks and varying output demands. It will operate 24*7. Key challenges will come from such questions as:
- How do I design, develop, and deploy, in phases, the system?
  - ∗ It will have hundreds of thousands, perhaps millions upon millions of components.
  - ∗ It will have to handle sudden input peaks and unexpected demands for output information, what we might call an Information Pandemic.
  - ∗ The infrastructure will start minimal and proliferate as new points of input and output are added. And, new functionality, especially concerning output information, is asked for by the experts.
- How do I design, develop and operate it to be 24*7?
  - ∗ The absolute best Computer Science IT architects will be needed to specify the system. The best technology enterprises will supply these along with academia.
  - ∗ There will be considerable component redundancy.

4 The Pandemic Dashboard Information System (PDIS)

4.1 The Purpose of the PDIS

The purpose of the PDIS is to provide information to a nation's medical, social, and political factions, a group of nations and especially the international scene when a pandemic threatens and is becoming global.

The foundation or basic Architectural Building Blocks of the PDIS are Data, Information, and Infrastructure, as shown in Fig 2 below. Data is collected and stored by the system and transformed by analysis into information. For example, experts require information to understand how the pandemic in question progresses and can be controlled.

The infrastructure hosts and operates the system; it is, therefore, a shared international infrastructure with some central nodes like server farms and datastores in centres and many, many distributed nodes. In the extreme, in some years' time, the endpoints could even be microchips, or their descendants, attached to people so that their individual states like positive or negative concerning infection can be monitored instantly. There will be two operational phases:

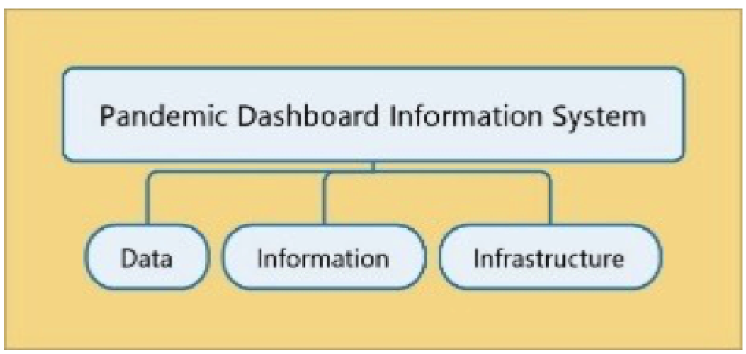

Fig. 2. The Basic Building Blocks

4.2 Operational Phase 1. Regular Monitoring and Predicting

This will be the normal state of the PDIS when it runs in silent mode. The system observes the global scene where viruses have been reported and are becoming candidates for a pandemic. The system predicts how a local outbreak might spread to become a major pandemic. Prediction is based on known, experienced before patterns and advanced mathematical analysis of unseen and unknown patterns, probable and improbable patterns. Complex predictive analysis methods having generated such patterns[1].

[1] Prediction is very difficult, especially if it's about the future! Niels Bohr, Nobel Laureate

The Key Questions to be answered are:

- Where are we with the pandemic?
- Where are we going with the pandemic?

4.3 Operational Phase 2. Pandemic Reporting

This will be an operational phase when a nation or region is close to declaring a pandemic or is subjected to a pandemic state. There will be four main activities:

1. Collection of data from specific areas.
2. Standard Analysis, based upon routine reporting of base metrics.
3. Special Analysis, as required by experts to investigate special conditions.
4. Reporting, to experts.

The PDIS will predict how a possible pandemic will behave over time. A model for this type of operational analysis may be weather forecasting (cf. [7]).

4.4 Data

Data is collected and stored by the system, and parts of it are continuously analysed. The data can be categorised into four main sets:

1. Static Data, that defines the basic parameters like geography and the basic metrics of the system.
2. Personal Data, which is enough to define individual cases etc.
3. Infection Data, to identify the intensity of infections.
4. Technical Data, as needed by the applications of the system.

Data will be stored in datastores consisting of databases with appropriate indexes. It will be collected, if possible, in real-time and time-stamped. All data will be duplicated synchronously as a minimum.

A complex data analysis engine is at the heart of the PDIS, and its components are analysis tools. All data, when transmitted or stored, will conform to accepted international standards. Some tasks will have consistent execution profiles that will not change. Others will be ad-hoc tasks.

Data collection endpoints should include individual personal devices, testing facility systems, medical systems, vaccination facilities.

Data and associated information on past patterns of a pandemic will also be needed for projected outcomes. Still, there will always be some unexpected or never-before-seen outcomes as happened with the Covid-19 pandemic. Historical data will be analysed and reanalysed to reveal unknown information and patterns that we not detected previously. Academic programs and projects will be ideal for this set of tasks.

All data elements, particular personal case data, will be held securely and not open to general/public access. Data will be depersonalised wherever this is possible.

4.5 Information

The information produced by the PDIS will be of two types:

- Standard Regular Continuous Information, which is as close as possible to real-time information. It has been predecided as being the core information that the PDIS will produce and output. This information will be provided continuously or at regular predetermined intervals.
- Ad-hoc Irregular Information is to answer specific queries resulting from requests by experts to abstract particular information pertinent to their view and assessment of the pandemic. Such information will require advanced analysis tools and a close working relationship between medical/social experts and analysis experts.

4.6 Infrastructure

The infrastructure will have internationally distributed components that collect and assemble data and central components that store and analyse data. There must be no single point of failure of the total system. Some components will be owned and operated nationally, and some will be under international control.

All interfaces within the system will be defined and prescribed through standards. Where standards for data formats already exist, these will be used. Where they do not they will be specified and mandated. In addition, all interfaces will be secure to prevent unauthorised data extraction or malicious activities on the system.

Standard network Internet protocols and transport channels will be used. Special high-throughput data pipes will connect the main centres. The encryption of data will be standard.

5 Key Design Points

5.1 Timeliness

The assumption is that a virus can spread rapidly. The Covid-19 pandemic has shown that variants appear and spread more rapidly than their predecessors. The designation of a pandemic is a social-political decision based upon expert medical advice. It is not an IT decision. A central design point of the PDIS is that it must report in real-time or near real-time (say within minutes). Thereby a pandemic can be immediately declared after it is initially detected. It can then monitored and measured.

The PDIS is a health warning system and must be seen as an Early Warning System. A system that reduces the risks inherent in disasters by quickly providing information, so there is time for preventative actions (see e.g. [11]).

5.2 Ownership, sponsorship, and funding

A PDIS should be a national function and be part of a national or region's Risk Management. There are many examples of national risk management systems (see, e.g. [6]). Each nation or region has to decide how the system is funded. In addition, the PDIS must be seen as an international system and be formally supported. For example, it might be sponsored by The World Health Organization (WHO) [8].

The PDIS should be an essential national or regional asset. It must be part of the nation's prime Risk Management, The Pandemic Risk Management component. Unless such a discipline originating from a system like the PDIS is part of both international and national risk management, the recurrence of another pandemic after the Covid-19 pandemic could bring about similar or worse social and economic effects.

In the section of this paper, The High-Level PDIS Architecture Model — The Phys-ical Components, which follows reference is made to existing global financial system models [5, 1]. The Business Model for these systems is based upon them being user-financed. The PDIS will, of course, be politically/socially financed.

Unless the population sees the need for the PDIS and trusts the system's continuous data collection, and output information, it will not succeed. Without formal international recognition, there will be no global pandemic single system image. Instead, each new pandemic will be treated as a surprise like the Covid-19 pandemic has been.

6 The High-Level PDIS Architecture Model

6.1 Functional Components

The PDIS will have the following Functional Components. The interrelationship of these is shown in Figure 3.

1. Data, and its collection and storage.
2. Execution Mode, the running state in which the data is analysed.
3. Information, outputs that guide the experts and warn of a potential pandemic and the state of an existing pandemic.
4. Infrastructure, on which the system executes.
5. Skill Sets, by which the system is designed, deployed, and operates and is continuously improved.
6. Sponsorship, by which the system is created, funded and controlled.

The system components, wherever possible, will work in a synchronised real-time mode. Input data will be processed as a series of transactions that events have generated. As many current states of the pandemic as possible will be analysed in real-time or near real-time. Information will also be generated and presented as near as possible in real-time.

There will be a set of preset triggers. Then, when one or more of these are exceeded or receded, this can be reported to those experts responsible for medical and social decisions. So, that a pandemic can be declared – it's going to happen, or undeclared – it is not going to happen, or it's over.

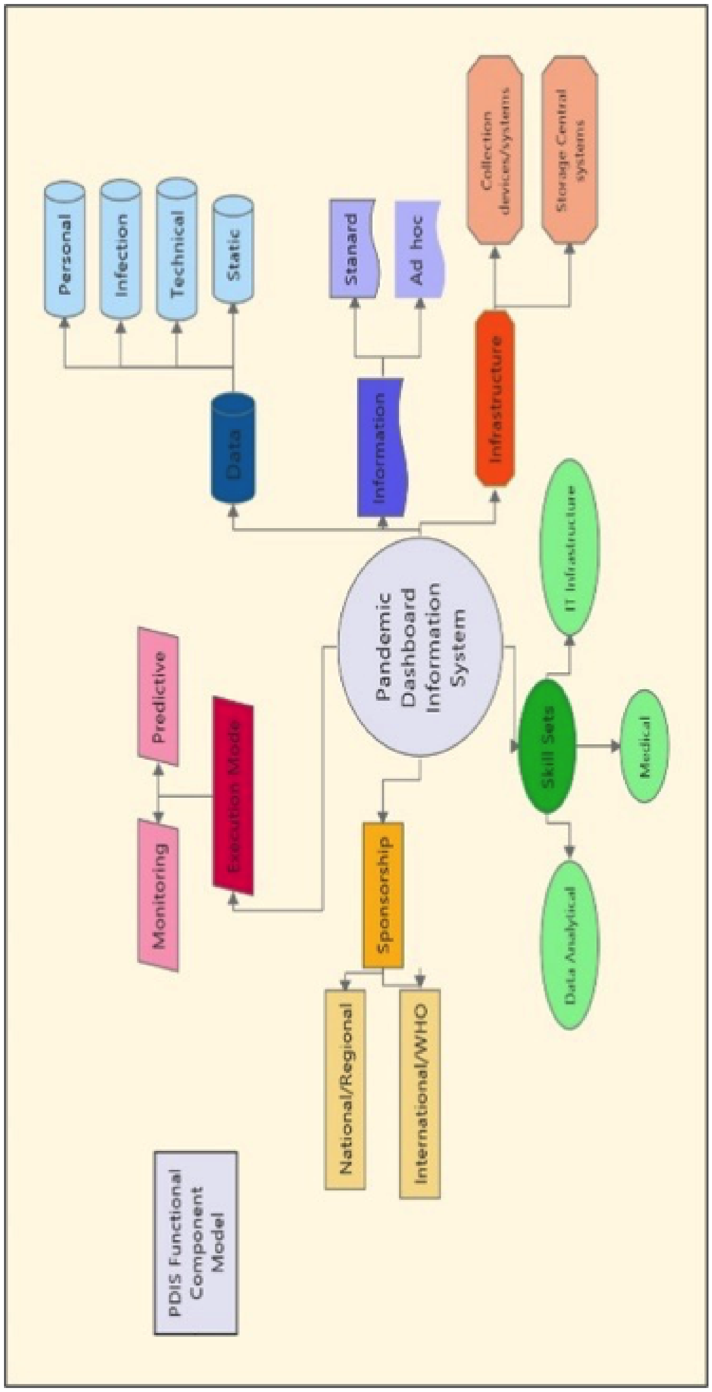

Fig. 3. The Functional Components of the PDIS

6.2 The Physical Model

The physical model of the PDIS will be a set of interlinked IT node systems that exchange data and information about the pandemic and how its state is changing. Queues will inevitably form at some sub-system nodes. The overall model is like a global credit card system or a global payments system (for examples of real-time global financial systems see [5, 1]). The financial world has long exploited and refined such IT models with 24*7 operations, high security and instant responses to requests and data transmission. Some of these systems have existed for 50 years or more and prove that the likes of the PDIS real-time system can be built and successfully run.

7 Key Desisions

A set of primary and Key Decisions must be made to begin and then get the PDIS into operation.

The PDIS will evolve as a global operational system. It will not suddenly happen but must not take to years to begin to happen. It must have a phased implementation to provide some benefits reasonably short, say three years. A long project that does not deliver early benefits will soon lose sight of the goal. The goal is to reduce the risk of a new pandemic. The first version will be limited regarding the data it collects, the analysis it does and the information it provides. But it must make the earliest possible contributions to the social and medical challenge of dealing with a global pandemic.

The following high-level chart (see Fig. 4) shows the Key Decisions and activities that must be made. These involve political, social, medical and computer science participants.

A fundamental assumption is that there is political and social willpower to have the PDIS for the international benefits. This must be proven and transcribed into a program to deliver the PDIS.

Plus, there is an assumption that medical and computer science expertise is needed to design and develop it and make it work. This paper states as a basic tenet that Computer Science expertise does exist if applied to the task with rigour. So do the IT components.

8 Conclusion and Proposal

The speed at which the Covid-19 pandemic grew caught the world by surprise. In the middle of 2021, there is still a degree of surprise on how the same pandemic regrows in waves.

Computer Science played a vital part in how the pandemic was, and is, measured, reported, and actioned. However, specific and focused IT systems were slow to become operational. Often giving inaccurate outputs and a fragmented view of the pandemic both globally and regionally. The PDIS is a proposed architecture for what we can call an international Pandemic Defense system and

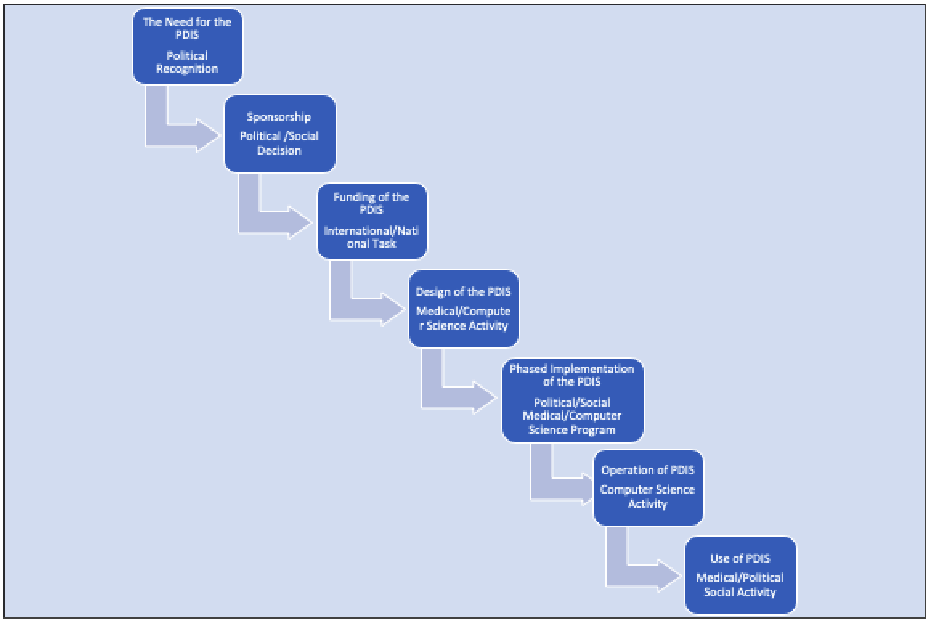

Fig. 4. Key Decisions and Activities

a set of national Pandemic Defense systems that are up and running in time for the next potential pandemic.

The world must have an operational system that can measure and predict the risks of a pandemic growing and happening. If a pandemic does occur, the PDIS is an up-to-date instrument, a social tool, that measures and informs of a pandemic's progress in near real-time. Without the creation of PDIS's the world will again be slow to use both the skills and components of IT to measure the degree of a pandemic's challenge. The use of IT will be fragmented. At the start of the 21st century, we have the components to design and deploy the system. There is a singular message:

Computer Science has the technology; we need the sponsorship.

Finally, it's interesting to reflect that had the Covid-19 virus appeared in, say, 2010[2], it would have taken years for appropriate vaccines to have been developed. Vaccines capable of combating the virus.

In 2020 it took months because the medical world was prepared. The vaccine research world was ready, but the global pandemic information system was not in place. The political, social, medical, and computer science world needs to be prepared for the next pandemic virus.

[2] It became public in 2019 it may have been around in some variant form in some creature for many years.

References

1. CLS – trusted market solutions - settlement, processing and data – CLS group. https://www.cls-group.com/, accessed: 2021-07-09
2. Covid-19 (coronavirus disease 2019). http://verywellhealth.com/, accessed: 2021-07-09
3. Covid symptom study. https://covid.joinzoe.com/, accessed: 2021-07-09
4. Data related to coronavirus (covid-19) – office for national statistics. http://ons.gov.uk/, accessed: 2021-07-09
5. Everywhere you want to be – visa. https://www.visa.co.uk/, accessed: 2021-07-09
6. Uk government risk management advice and system guidance. https://www.gov.uk/government/publications/management-of-risk-in-government-framework/, accessed: 2021-07-09
7. Weather forecasting – practical applications. https://www.britannica.com/science/weather-forecasting/Practical-applications/, accessed: 2021-07-09
8. Who – world health organization. https://www.who.int/, accessed: 2021-07-09
9. Anderson, R.M., Hollingsworth, T.D., Baggaley, R.F., Maddren, R., Vegvari, C.: Covid-19 spread in the uk: the end of the beginning? The Lancet **396**(10251), 587–590 (2020). https://doi.org/https://doi.org/10.1016/S0140-6736(20)31689-5, https://www.sciencedirect.com/science/article/pii/S0140673620316895
10. Abu el Ata, N., Perks, M.J.: Solving the Dynamic Complexity Dilemma. Springer (2014)
11. Khankeh, H., Hosseini, S., Farrokhi, M., et al.: Early warning system models and components in emergency and disaster: a systematic literature review protocol. Systematic Reviews **8**(315) (2019)