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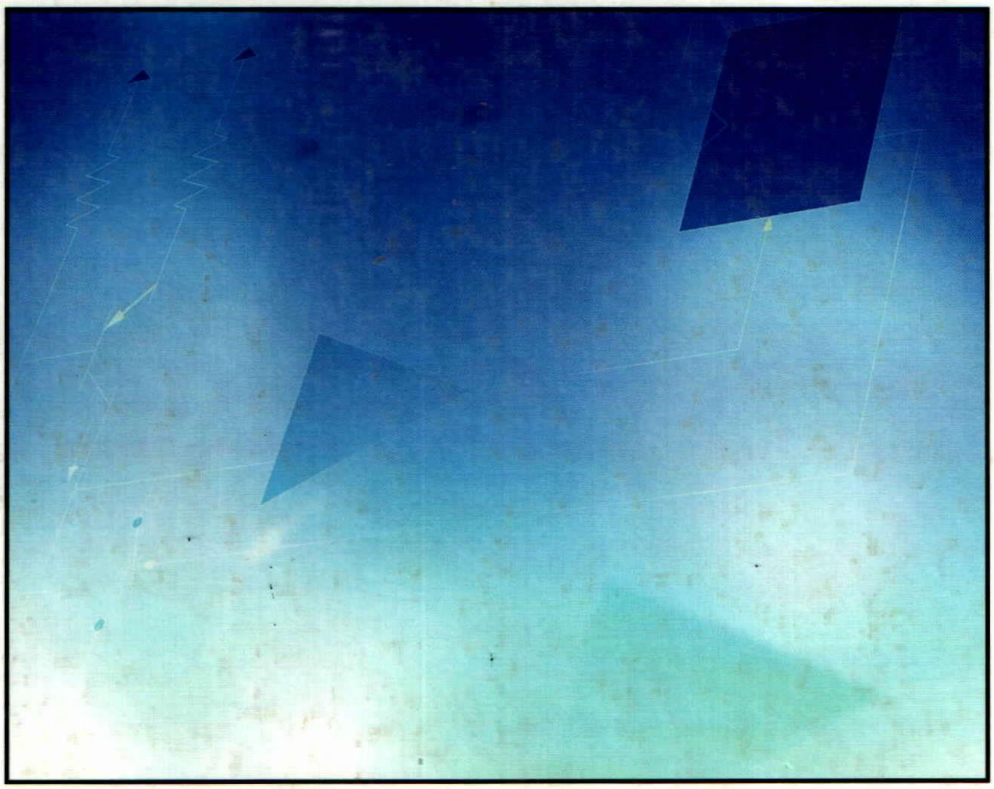
Systems Thinking and E-Participation

ICT in the Governance of Society



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Chapter 6
E-System for Public Health in India:
Towards an Architectural Framework Incorporating Illiteracy and Linguistic Diversity

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ABSTRACT

Public health stands for the study and practice of those activities and initiatives that result in the prevention and reduction of incidences of illnesses and diseases in the population. The application of Information and Communication Technologies (ICT) can considerably facilitate Public Health project initiatives. In spite of the huge benefits of using ICT in Public Health, it can also pose considerable challenges in certain populations, pertaining to the access and comprehension of information shared through modern technology stemming from a range of issues such as illiteracy, demographic and linguistic diversity, differing economic strata of people, and differing priorities. In this chapter, after presenting a discussion on the issues faced by the public and relevant systems thinking approaches that may enable addressing the same, we propose a visionary architectural framework for ICT in Public Health through the eye of systems-thinking. We have called this framework e-System for Public Health (ePH). The understanding draws heavily from the Indian context as the country presents an interesting array of the challenges that we have mentioned above.

INTRODUCTION

Public health stands for the *study and practice of those activities and initiatives that result in the prevention and reduction of incidences of illnesses and diseases in the population*. The application of Information and Communication Technologies (ICT) can considerably facilitate Public Health project initiatives. In spite of the huge benefits of using ICT in Public Health, it can also pose

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considerable challenges in certain populations, pertaining to the access and comprehension of information shared through modern technology stemming from a range of issues like illiteracy, demographic and linguistic diversity, differing economic strata of people, and differing priorities. ICT may still be relied on to overcome such challenges, for the delivery of Public Health information in a variety of formats, forms, and languages in a range of tools as user-interfaces for access of the general population, if fostered and supported by the public sector.

When complexity is high and the range of interrelationships between various elements is varied and diverse, it is important that any Public Health initiative be able to capture different co-existing factors that influence success, consider the inter-relationships between different elements in the environment, and understand how, because of the inter-relationships, the system as a whole transforms and evolves. In order to appreciate this, we have resorted to taking a systems perspective in evolving the architectural framework.

After presenting a discussion of the systems thinking approaches and the issues faced in public health, we propose an architectural framework for ICT in Public Health through the eye of systems thinking with a futuristic vision. Hereon, we will call this e-System for Public Health (ePH). The understanding draws heavily from the Indian context as the country presents an interesting array of the challenges that we have mentioned above. Furthermore, rather than being drawn from existing ICT, our proposed approach is visionary and forward-thinking in terms of what we want to see in future ICT in order to enable the ePH. The country is also on the verge of significant change in terms of ICT in public services and related e-governance initiatives. The framework that is proposed will not only be relevant to India, but learning from this can also be inferred for other countries with a similar environment.

We will first elaborate what we understand by Public Health and discuss the challenges in terms of diversities that are posed by India as a country. We will then elaborate why, as a result of this, systems thinking and approaches can lend a perspective to work towards an architectural framework for ePH in India. We then consider how this can be woven into the e-governance framework of the country, and finally, touch upon some of the challenges of the ePH that need to be considered during its implementation.

WHAT IS PUBLIC HEALTH?

We have defined Public health as *the study and practice of those activities and initiatives that result in the prevention and reduction of illnesses and diseases in the population*. What accounts for rectification of diseases when there is an outbreak, does not represent Public Health; rather, the process of designing and implementing initiatives that will result in the prevention of such incidences in the first place will account for Public Health. These may include educating the public and raising their awareness of health and disease specific issues, and implementing health and hygiene initiatives. Hence, Public Health does not mean treatment. Public Health can therefore be classified as being proactive rather than being reactive, and being preventive rather than being curative. Dasgupta (2005) notes:

Public health services are architecturally distinct from medical services. They have as a key goal to reduce a population's exposure to disease, for example through assuring food safety and other health regulations; vector control; monitoring waste disposal and water systems; and health education to improve personal health behaviors and build citizen demand for better public health outcomes (p.1).

Public health normally consists of community-wide health and welfare initiatives that are ideally facilitated by the government, and in certain

cases supported by Non Government Organizations (NGOs), international bodies and self-help groups.

CONSIDERING THE CASE IN FOCUS

It is understood that Public Health and ePH initiatives exist in developed countries with a certain degree of maturity, given the ready availability of funds and the relative homogeneity of the population. Our interest is in evolving an ePH architectural framework for a geography that may pose challenges of a very different kind in terms of its socio-economic inequality and cultural diversity. Such a situation will present its own uniqueness. The country that is considered here is India, due to the uniqueness it presents in its diversity.

India has a population of over one billion people according to the Census of India (2001). The population is spread over an enormous landmass spanning over 3,287,263 square kilometers that includes mountains, deserts, swamps, rainforests, valleys, and plains, nurturing a rich and equally diverse eco-system. The massive population harbors a huge array of languages and dialects, and it follows different faiths. While the number of languages used in India can be identified to be over one-thousand, twenty-two of these languages are recognized by the Indian Constitution. The majority of the languages stem from two families: Indo-Asian and Dravidian. The former is spoken by about 70% of the population and the latter is spoken by about 22% of the population. The rest of the languages stem from families like Dardic, Tibeto-Burman and Austro-Asiatic families (Languages of India, 2008). The primary religions to be found in the country are Hinduism, Islam, Christianity, Zoroastrianism, Judaism, Buddhism, and Sikhism. A majority of the population follows Hinduism, followed by Islam and Christianity. Furthermore, Hinduism has numerous sects and sub-faiths that yield different levels of influences and beliefs.

This diversity of India is no less reflected in its economic scenario. An aggressive growth rate, rampant industrialization, unprecedented technological innovation, and heightened Foreign Direct Investments (FDI) have created a class of people that has immediately and directly benefited from the situation and who lead a lifestyle that is extravagant, elitist, and indulgent. There is another class of people that has been completely left out of the benefits of economic prosperity, who live a life of severe deprivation. Whereas India's 40 wealthiest men are worth more than $351 billion according to Forbes (Sappenfield & Chopra, 2007), the United Nations Human Development Report states that about 34% of the population in India still continues to live below $1 a day (HDR, 2007-08).

It is worth noting that the current health scenario in India is quite dismal, contributed significantly by the lack of any coordinated public health initiative. This statement can be substantiated by information that we have collated from Garai & Shadrach (2006) who share the following unwelcomed information for India:

- Lack of adequate medical attention results in one maternal death every five minutes
- An existent infant mortality rate of 70 per 1000 live births
- The highest number of cases of HIV/AIDS outside of South Africa, with 5.1 million people infected
- Incidences of non-communicable diseases on the rise with 25 million cardiovascular patients, 2.4 million cases of cancer, and 25 million diabetics
- It is estimated that 24.7 million deaths are caused every year due to water contamination, poor sanitation and poor hygiene
- A serious lack of proper sanitation and toilets in rural areas

Demographic, economic, and linguistic diversity, coupled with a lack of coordinated efforts,

give rise to a situation where the population has varying degrees of understanding of health-related issues due to varying literacy levels, and varying kinds of access to public health facilities. This may give rise to a situation where the access and use of any ICT enablement in Public Health gets restricted only to the literate and privileged sections of the society. Therefore, our interest is in working towards an ePH architectural framework that will benefit the underprivileged sections of the society. This can also be used to directly inform the e-governance agenda of the Indian government.

REQUIREMENTS FOR EPH DESIGN IN CURRENT CASE

An ePH architectural framework can be considered that would enable holistic information availability of a defined range of health-related topics aided by user-friendly interfaces, enabled by effective ICT. An ePH approach will need to deal with the scale of health related information that needs to be shared and the various media by which this needs to be provided. The common ways by which ICT supported Public Health initiatives have been implemented or conceptualized in India include the following (Garai & Shadrach, 2006):

- Disease specific websites
- Online training to paramedics & nurses
- E-learning packages like interactive web-based portals and CD-ROMS
- Knowledge gateways for personalized counseling services
- Virtual knowledge communities for sharing of information and experiences
- E-consultation of sensitive conditions like HIV/AIDS
- Online repository of latest medical journals and periodicals

However, it is crucial to note here that where the level of complexity and diversity is exceedingly high, there will be a requirement that the ePH architectural framework has the following qualities:

Inclusive

The ePH needs to be inclusive so that it caters to the requirements of the underprivileged sections of the society. For instance, a significant population of India remains non-literate yet they must still have access to Public Health information. A traditional ICT approach is not suitable for this population. Rather, there may be a requirement to develop a text-free User Interface (UI) for this population (Medhi, et. al. 2005; Medhi & Kuriyan 2007). Even within non-literate users, there is a cultural difference between different religious communities in understanding information. It was found that while non-literates among Hindus expect time to flow from left to right, the non-literate Muslims expect this in the other direction, although they do not have any knowledge of Arabic script (Donner et. al. 2008). In other words, the ePH needs to be outlined in such a way that it is able to take into consideration various requirements and sensitivities in the design and implementation phases, so that the system is inclusive in nature.

Dialectic

In a climate that is diverse, it is very common to have diametrically opposing viewpoints and apparently opposing ideologies about how the ePH needs to be developed. We may take the example of sex education in schools in India. Earlier in 2008, the health ministry proposed to introduce compulsory sex education for schoolchildren to increase awareness of sexual health and reduce incidences of sexually transmitted infections. However, this attracted tremendous resistance from a section of parents, who believed that sex education would infringe upon the morality of

their children. The debate today is struggling to achieve a balance between rationality and morality in the country. The ePH is required to be designed considering such diametrically opposing ideas and approaches rather than trying to discount the same. Public participation should be dialectic and be able to arrive at a consensus, if not agreement, in order to have the ePH that is able to address the differing needs and belief systems of the society. Dialectic debate is the process in which opposing ideas are put forward in front of each other by their proponents and dialogued about to arrive at an agreement. The value and contribution of dialectics in the evolution of human thought has been extensively documented in social and management theory (Stump, 1989; McTaggart, 1964; Eemeren, 2003).

Adaptive

Technology is changing rapidly and so are requirements of and expectations from technology. What is therefore required is an ePH that has the ability to be adaptive to change and innovation. This can only be achieved by avoiding an ePH architecture that is rigid and straight jacketed. Architecting ePH needs to be able to make provisions of a system that is able to appreciate and address the variety in the environment. This should be designed in the line of a complex adaptive system that can change and shape itself according to the demands of the environment, so that control and order become emergent, rather than pre-determined (Dooley, 1997).

Evolving

Adaptiveness is the prelude to evolution. An ePH should be able to adapt to differing requirements in a continual manner, but at the end of a particular time span, the resultant character of the ePH should be qualitatively different from and superior to what it was when it started. This is important because pubic health requirements can themselves change over a period of time. For instance, in India, plague was an issue of severe public concern in the 1990s. However, the concern gradually moved to HIV/AIDS a decade later. Currently, there are other forms of illnesses such as Avian Flu and Severe Acute Respiratory Syndrome (SARS) that are capturing the attention of the public and the policy makers. The way the ePH will have to address these differing health requirements needs to evolve as the quality, quantity, sensitivity, and modes of delivery of the information (pertaining to the different demands) will also change.

Robust

It is important that in spite of the ePH being inclusive, dialectic, adaptive, and evolving, it needs to be robust with the ability to withstand the test of changing times and demands. The challenges that this will give rise to are the ability to be robust yet flexible, to be system defined yet adaptive, and to be specification-centric yet evolving. However, robustness in this case is understood not from negating its counterpoints, be it inclusiveness, dialectic, adaptiveness or evolutionary, but by being able to derive its strengths from these negations.

People Sensitive

Any ePH must be people sensitive; this means that it must be able to absorb the dynamics involved in people-machine interactions within the existing socio-political framework. With new technological provisions, an ePH may seem like a liberator. However, the environment within which this architecture needs to be managed may have acculturated and ingrained logics of working that may be averse to the use of ICT as well. Conventional planners and practitioners may be highly conservative about the way they have been doing a particular job for quite some time, and they may not want to bring about changes in their working patterns. Hence, the framework should

also be able to absorb such resistances. Change management can appear to be a challenge, and innovation acceptance, a threat to established practices. The analysis and understanding of the human element is of utmost importance in considering the successful introduction of new ICT systems. Unfortunately, planners tend to pay more attention to the technology element rather than the people element.

From the above discussion, we arrive at the understanding that an ePH for a diverse population with challenges around language, literacy, poverty and deprivation, needs an approach that is able to encompass these factors and look at the process of working towards this framework in a holistic and systemic manner. This holistic and systemic approach will not only be required in the conceptual stage of working towards the ePH architectural framework, but also in its planning and implementation. Together with this, a range of different approaches will be required to take into consideration the pluralism of elements that exist in interplay within the system and how they can be integrated to make further application-sense for the target population. Considering these factors, we have expressed a bend towards the Critical Systems Thinking perspective that we will elaborate on in the following section.

CRITICAL SYSTEMS THINKING AND APPROACHES

Descending from the Greek verb *sunistanai* the word 'systems' originally means "to cause to stand together" (Senge, et. al., 1994). Systems thinking involves appreciation of the collective character of elements, enabling a macro view beyond micro sub-systems and activities, advocating the idea that the whole is more than the sum of its parts. Chowdhury, et. al. (2007) note that "The central idea behind systems thinking is that organizations are constituted of sub-systems, or elements, that are in interrelationships with one another, and that exist within a boundary. What are important are not the elements per se, but the interrelationships between them, because it is the nature of the interrelationships that give character to the system" (p.10). Systems thinking therefore, lends the idea that in order to understand the complexity of social systems, we need to assess how different sub-systems are organized within a particular system and attempt to gauge how this can result or is resulting in a larger system that is qualitatively different from the sum of its parts. Therefore, elements are to be looked at as a whole from the beginning, rather than looking at them in isolation; therefore, there is a direction to gauge for emergent patterns, complex relationships, and unobvious interactions.

Critical Systems Thinking (CST) is a specific area within systems thinking that inspires the inclusion of diversity and pluralism in approaching and understanding situations with human betterment as its core concern. This involves the ability to take into consideration different, and sometimes differing, worldviews, challenging preconceptions and boundaries that people create in their thought processes and the ability to be empathetic to situations. Churchman (1971) also refers to this as the "sweeping in" of ideas and factors in the intervention process.

According to Midgley (1996), there are three fundamental commitments of CST:

- **Critical awareness:** Examining and re-examining taken-for-granted assumptions, along with the conditions that give rise to them
- **Methodological pluralism:** Using a variety of research (or intervention) methods in a theoretically coherent manner, becoming aware of their strengths and weaknesses, to address a corresponding variety of issues
- **Emancipation:** Ensuring that research is focused on "improvement", defined temporarily and locally, taking issues of power (which may affect the definition) into account (p.11)

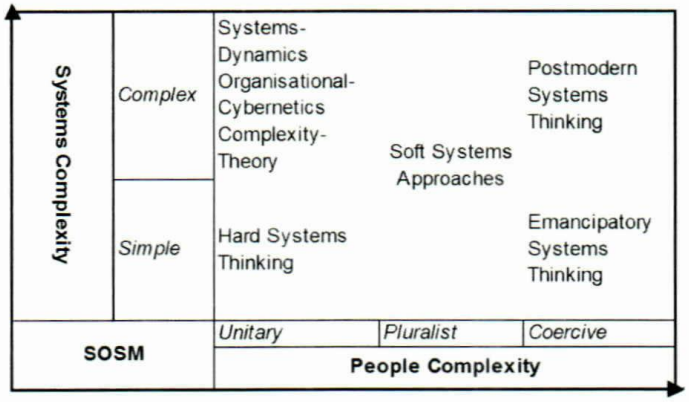
CST can therefore be considered as a step ahead within systems thinking where holism is regarded as a characteristic to be derived from a critical understanding of the stakeholders who form part of the system and who take a proactive approach in improving their situation within the system.

Apart from systems thinking being a perspective, it has also inspired a range of approaches, methodologies, and techniques that have been extensively used in real world situations to define and resolve complex problems and arrive at viable solutions and alternatives. Methodologies and techniques, inspired by systems thinking, have undergone significant changes over the years (Clarke, 2001) since the 1950s to the present time. These changes stem from formulating and applying techniques and methods from a positivism-oriented hard systems approach, to where the thrust had been on an interpretivism-oriented soft systems approach, to where the interest has leaned towards a postmodernist-oriented critical systems approach[1].

There has been a significant amount of work done in the field of demonstrating which methodologies and techniques are applicable to which situation (Jackson & Keys, 1984; Jackson, 1990; & Jackson, 1995). Jackson (1995) argued that depending on the system (or context) and the people complexity of the situation under consideration, different approaches and methodologies may need to be adopted. He concluded his understanding in a framework that he named the System of Systems Methodologies (SOSM), which is depicted in Figure 1.

In the SOSM, the x-axis indicates people complexity. A *Unitary* context implies that there is a pre-existing agreement on the end result and there need not be any requirement of a detailed discussion about the same, or any intervention for systems design. Participants have similar values, belief systems, and interests. They share a common purpose and are involved in decision making to reach a particular defined objective. A *Pluralist* context would indicate there is some difference between the participants on what an end result of any intervention or systems design may be; however, these differences can be overcome by engaging the participants in a collaborative exercise, wherein the differences can be explored and a resolution arrived at. There is normally no hidden intension or agenda of the participants; whatever

Figure 1. SOSM (adapted from Jackson & Keys, 1984, Jackson, 1990 & Jackson, 1995)



difference of opinion exists, they are highlighted with the desire of reaching a consensus. A *Coercive* context would indicate a situation where participants have different agenda and intentions that are influenced by different worldviews. Hence, such a situation is intensely political and outcomes are determined by a wielding of power and related influences. Reaching a consensus or agreement in such a situation is challenging and involves highly critical thinking to be able to infer unstated truths and be able to look beyond the obvious.

The y-axis indicates system complexity. A *Simple* context implies that elements in the environment have a straightforward relationship. Constituent elements that have identifiable interlinkages and deviances in one element result in easily inferable deviances in the following element in the value-chain. A simple system tends to remain stable over time and relatively unaffected by how each sub-system operates. A *Complex* environment, on the other hand, indicates the existence of a wide range of elements and sub-systems organized and in interaction in such a way that its relationship is not easily identifiable and comprehensible. Deviances in the system may be a result of a deviance in functioning or in the relationship between a wide range of elements, or the reasons may not be traceable at all. Complex systems do not remain intact over time, but they adapt and evolve because of their own action and the action of the larger context in which they operate. It is important to note that environmental complexity may not be dependent on the number of elements or people involved. An arrangement where there are few elements or people may be organized in a complex manner, therefore resulting in a complex environment. On the other hand, there may be a large number of elements or people organized in a very systematic process-based manner, therefore resulting in a simple environment.

Jackson (2003) notes that combining the two axes in the SOSM-framework leads to six ideal-types that can be described as "stating logical extremes that can be used to construct abstract models of general realities" (p.19). These are simple-unitary, simple-pluralist, simple-coercive, complex-unitary, complex-pluralist, and complex-coercive. Specific methodologies and techniques may be associated with each of these ideal typical situations by understanding which systems approach may be appropriate for which situation. For instance, hard systems thinking and approaches are deductive and formalistic; they carry the opinion that situations can be approached by esoteric mathematical and unitary methods. These approaches became popular in the post-war period that was focused on rapid rebuilding and reorganizing structures that could deal with limited resources to be deployed within a specific space and time. These approaches worked for the situation, and they therefore emerged during this period (Jackson, 2003). However, as time passed, higher complexities started emerging in societal and organizational systems, for which, dealing with these hard systems approaches was not only insufficient, but it was also inappropriate. This resulted in the need for approaches and methodologies that could take into consideration a range of different factors and people-issues during an intervention. These approaches would help in understanding the deeper structural relations in real world problem situations to enable organizations to adapt and evolve with internal and external contingent factors on them. The approaches and methodologies that emerged because of this were labeled later under the banner of 'soft systems approaches'. The advent of soft systems thinking has a great deal to contribute as we move towards the right hand side of the horizontal axis of SOSM. Soft systems approaches enabled the realization that worldviews are not always the same and differences are inevitable in the dynamic situations that organizations find themselves in. Methodologies influenced by soft systems thinking offered the possibility to facilitate divergent worldviews into agreement in an atmosphere of constructive debate and discussion. These approaches encourage the accommodation of crucial

factors like values, beliefs, and human feelings. Moving further towards the right in the horizontal axis of the SOSM-framework, there is an indication of the coerciveness in human relationships, including situations of hidden or negative power dynamics, imposition of ideologies, and the idea of might having the right. The interest of the interventionist in such situations is to appreciate and unearth different dynamics in play and explore how, because of their intervention, there may be an improvement in the situation. To deal with such situations, methodologies that encourage an emancipatory[2] and postmodernist outlook can be of assistance to the systems practitioner. These enable looking at the same situation from different perspectives, appreciating opposing agenda, and creating a platform where it can be recognized that there is no one best way to do things. These approaches indicate an interest toward exploring those hidden agenda that are inherent in the design and deployment of complex systems.

CRITICAL SYSTEMS THINKING AND EPH

We believe that for the ePH to be successful in the Indian context, it needs to be positioned within a multi-contextual situation considering social, political, economic, demographic, and cultural factors. Therefore, architecting an ePH framework will entail that the above elements are considered, not in isolation, but in interaction with one another. Any ICT infrastructure will need to be able to capture and address factors that are over and above those that are directly lifestyle- and illness-related, towards those that are inherently related to the multi-dimensional factors mentioned above. As Midgley (2006) observes, "the whole concept of public health is founded on the insight that health and illness have causes or conditions that go beyond the biology and behaviour of the individual human being" (p.466). Architecting effective ICT for public health will need to adopt approaches that are able to recognize interrelationships between elements stabilize difference of opinions and emancipate, to whatever extent possible, the voices and opinions of those sections of society that are easy to be ignored or overlooked. Therefore, it is important to approach the architectural framework design of an ePH for the Indian context from the standpoint of Critical Systems Thinking. In the context of Public Health, Leischow & Milstein (2006) note:

Equally important (to considering directly health-related aspects) is an emphasis on relating different types of structures that shape our lives, including the biological systems of our bodies, the organizational systems in which we work, and the political systems with which we govern public affairs. Although there is no single operational method for identifying and interpreting these relationships, there is, in fact, a common architectural orientation recognizable as a systems approach: it is a paradigm or perspective that considers connections among different components, plans for the implications of their interaction, and requires transdisciplinary thinking as well as active engagement of those who have a stake in the outcome to govern the course of change (p.403).

A range of systems approaches and methodologies have been used in various ways in Public Health, research planning for healthcare, and intervention and policy formulation for healthcare. The methodologies and techniques used include System Dynamics, Critical System Heuristics, Soft System Methodology, Strategic Assumption Surfacing and Testing, and Interactive Planning and Strategic Choice (Cohen & Midgley, 1994; Sudhir et. al., 1997; Maani & Cavana, 2000; Fahey et. al., 2004; Chowdhury, 2006; Chowdhury, Clarke & Butler, 2007; Chowdhury & Nobbs, 2008)[3].

Considering our discussion on the socio-economic diversity of India and the factors that interplay therein, we have placed the Indian context under consideration in the complex-

coercive space of the SOSM (System of Systems Methodology)-framework. This directs us towards considering a postmodernist approach in the architectural framework design for ePH that will appreciate the diversity the system will deal with. A postmodernist systems approach will encourage appreciating the diversity of factors that interplay beyond the surface level and consider how an attempt can be made to reach out to the benefits of the subaltern and deprived sections of the society. In this light, we focus on proposing a visionary architectural framework, rather than being tied by what is possible within the current ICT systems such as the ones proposed as of date.

EPH AND E-GOVERNANCE

Kanungo (2004) defines E-governance as "the application of information and communication technologies to transform the efficiency, effectiveness, transparency and accountability of informational and transactional exchanges within government, between government and government agencies of national, state, municipal and local levels, citizen and businesses, and to empower citizens through access and use of information". E-governance can contribute immensely for both the government and citizenry. Das & Chandrashekhar (2006) talk of how e-governance can contribute towards governance, public services, and management. They highlight the advantages in the following classifications:

Governance
- *Transparency*
- *People's participation*
- *Promotion of a democratic society*

Public services
- *Efficient, cost-effective and responsive governance*
- *Convenient services to citizens and businesses*
- *Greater citizen access to public information*
- *Accountability in delivery of services to citizens*

Management
- *Simplicity, efficiency, and accountability*
- *Managing voluminous information and data effectively*
- *Information services*
- *Swift and secure communication (p.4)*

The Government of India introduced the National e-Governance Program (NeGP) in 2006 with the vision to make "All Government services accessible to the common man in his locality, throughout his life through One-stop-shops (Common Service Centers) ensuring efficiency, transparency, and reliability at affordable costs to meet the basic needs of the common man" (NeGP, 2006). However, we have not come across any conceptual deliberation on how this vision can be translated into action in the realm of Public Health. We therefore believe that the ePH we propose can serve as an important step towards crystallizing a conceptual integration of the Public Health dimension in the country's e-Governance framework.

In the next section, we discuss the architectural dimensions for our envisaged ePH framework, considering a range of interplaying factors. A Critical Systems Thinking (CST) perspective has resulted in our consideration of a diversity of variables, directly affecting those factors that can result in the betterment of the situation of the disempowered and underprivileged.

EPH: SYSTEMS DIMENSION AND CATEGORIZATION

With the above background and in order to present an architectural framework for the ePH system, we are now ready to propose our thoughts on an architectural framework for ePH. In order to do

that, we first identify the following important primary dimensions:

Population Factor

While the ePH system is meant for all citizens, there are certain aspects about the Indian population that must be taken into consideration. Consider that the top 5% (Farrell & Beinhocker, 2007) of the population (the middle class) is highly educated and has either access to computers easily or own a computer with an Internet connection. This group already has the knowledge and resources to know what to look for in terms of understanding about a particular public health need. In fact, this group is well versed in the English language and can use any popular search engine such as Google or Yahoo to search for information about any public health issue. Thus, in our systems consideration, we assume that this population group is *not* the primary target for the ePH in India. In other words, the target population group for this ePH system is the lower middle to lower strata of the society. In the context of India, this group can be further divided into different categories by considering the following factors: language, demography, and literacy.

Mode of Access to Information

There are various modes of providing information about public health to citizens: TV, print medium (e.g., newspapers), billboards, the Internet, and Mobile Phones. India uses billboards to make its citizens aware of a particular public health concern (e.g. HIV-AIDS). Furthermore, TV and the print medium (newspapers) have also been commonly used over the years for the same purpose. Two of these media (print and billboards) assume that the target group is literate. Three of these media (TV, print, and billboards) do not fall under our consideration. In other words, we focus primarily on the following two modes for access to ePH: the Internet and Mobile phones.

Internet access from desktop computers is now available in many places, including in rural areas where this access is available at community centers through the effort of the National Informatics Centre. Besides such Internet access, the mobile phone is an important component of the ePH system for India. There are four primary reasons for this: (1) the newer mobile phones have a number of capabilities such as a multi-media display; (2) due to infrastructure limitations of wired phone connectivity, the mobile phones have made inroads to the remotest parts of the country, even in places where the availability of electricity is limited. In many rural areas in India, the wireless base stations for mobile phone services are routinely powered by diesel-powered generators; (3) From a communication technology point of view, the infrastructural side of providing mobile phone services is moving toward the Internet protocol (IP) technology, to be in common with the wired Internet; (4) Web access is already available on many mobile phones, albeit for a fee.

Public Health Priorities and Types of Information

While the basic architectural framework should not depend on a particular public health priority, for the purpose of illustration, we must prioritize public health information in terms of dissemination of information in two directions. One would be for routinely known needs such as AIDS, malaria, and so on, and the other for newly emerging issues on a short or near term basis; for example, the impact of Avian Flu, Swine Flu, Severe Acute Respiratory Syndrome (SARS), Chikungunya, Dengue, Coronary Heart Disease, and Diabetes.

Content Type

Any information about a particular public health issue may be available in four basic modes for on-line availability: text, picture, audio, and video. 'Text' means a web page that may include some

graphics as necessary. 'Picture' means depicting a particular piece of information pictorially for ease of understanding; this type is meant to serve the need of non-literate or low-literate people who would benefit from having this feature. 'Audio' refers to the ability to listen to public health information, be it via the Internet or a mobile phone. 'Video' refers to a video clip to explain a particular public health issue. In general, 'audio' and 'video' are important for non- and low-literate users as they can listen or watch to understand a phenomenon.

The above four dimensions are inter-related for the ePH consideration. For instance, a particular public health priority may be available primarily in one of the content types, but not all. That is, from an architectural point of view, we do not want to imply that it is necessary to have all information contents available in all modes. Development of these will depend on cost as well as needs. Secondly, when we consider the population factor and the mode of access, we can see that it is necessary to cater to different needs. For example, for a non-literate user, the assumption that the information that is available through a classical text-based User Interface (UI) on a computer is viable is neither practical nor sufficient. Rather, for a non-literate user, there is a strong need for a *text-free* UI. Such text-free UIs can be pictorial in nature so that the user can click on a button to understand what type of information it refers to; not only that, the button, when the mouse is moved over, plays a small audio to explain what the button is about. In the case of a mobile phone, an audio service may be provided so that the user can directly talk to, which in turn, the service understands and interprets the information. Note that unknown to the user, the feature may generate a call to an automated system or an actual person, who can then offer feedback to the user on the required information either as an audio or a video clip or a text message.

We next focus on the users themselves. In India, there are many different languages and demographic groups, further stratified by economic factors. For instance, users in a particular language may be more non-literate than users in another language. Secondly, even among literate users, a significant portion of the population does not know or understand English. Currently, India has deployed computers in many village areas – with its English-based interface, but only a small fraction of the literate population can take advantage of simple features such as web-browsing and searching; thus, such computers are rarely used. While Hindi is a national language, only small fractions of literate users understand Hindi to the fullest; i.e., the problem is not simplified if the user-interface is in Hindi. What this means is that providing a text-based UI in just a single language does not satisfy the need of the overall population. In fact, it is critical to develop text-based UIs in different languages. With the advent of Unicode (Unicode), characters in fifteen Indian scripts are already available. In fact, this set encompasses many Indian languages. For example, the Devnagari script is used in many Indic languages in the northern part of India; Bengali script in Unicode can be used in Bishnupriya Manipuri and Meitei languages since the script is the same; furthermore, Bengali script, as defined in Unicode, includes a few extra characters, that are needed for the Assamese language—this means the Assamese language is also covered by Unicode. Thus, it is now a matter of developing language-based text-based UIs. Our architectural framework recognizes the need for text-based UIs in different languages in order to reach a larger population group.

In summary, by considering different dimensions, we envision the following broad categories from a systems approach perspective that must be considered in the architectural framework:

- **ePH content:** Either routine contents such as AIDS or Malaria, or non-routine contents such as when needed in the case of an epidemic (e.g. avian flu, swine flu)

- **Information type:** Text, picture, audio, video
- **Language factor:** A variety of languages
- **Literacy factor:** Non-literate, low-literate users
- **User's access mode:** Text-based or text-free UI, or mobile phone

The next question is how to consider these categories in the architectural framework of the ePH system. Although the information availability mode is via both the Internet and Mobile phones, we must address the literacy factor to recognize that the user's access mode must cater to three different modes: text-based UIs, text-free UIs, and mobile phones. Text-based UIs and text-free UIs are both required for Internet-based access to cater to literate, low literate, and non-literate users who need access to the ePH system. Moreover, the text-based UI must be available in different languages. Regarding mobile phones, we consider it as a single mode or simply, as a third User Interface. This is because traditionally, a telephone service does not require a user to be literate (because language or written texts are non-issues). However, at a much deeper implementation level, it would need to have different features for interactive sessions for the users of different literacy groups. Consider when a mobile phone is turned off; it is not uncommon for the caller in India to hear a message in three languages about the mobile phone being turned off: English, Hindi, and the local language. Finally, we believe that the demographic factor does not need to be highlighted separately; this can be addressed through a combination of the language and the literacy factors.

ARCHITECTURAL FRAMEWORK

Taking a holistic systems approach, along with the critical dimensions for India outlined above, we now propose a conceptual architectural framework for the ePH system. Our architectural framework for the ePH system has four primary functional components:

- User-Interface
- Information base
- Request Interpreter
- Content translator/broker

A pictorial view of their functional relationship for the proposed architectural framework is shown in Figure 2.

We now elaborate on each of these components.

User Interface

The *User-Interface* is the entry point for a user to the ePH system. From an actual physical device point of view, this breaks r down further to a computer for Internet access or a mobile phone. In the case of a computer, we may have both text-based UIs (albeit for multiple languages) and text-free UIs as discussed earlier.

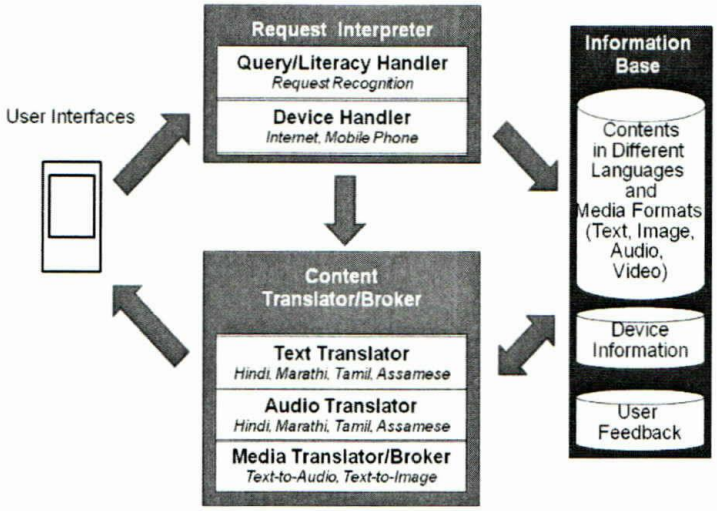
Information Base

The *Information Base* is the storage of public health information that would be of interest to users. They would be available in a variety of media: text, pictures, audio, and video. Furthermore, information may be contained at different levels of content depth, and in different languages. It should be noted, that the Information Base is not meant to be a single entity. While from a functional point of view, we refer to the Information Base as one, it can be broken down into multiple different entities based on media types such as text, picture, audio, and video, and/or based on languages.

Request Interpreter

The *Request Interpreter* can serve a number of different roles. For instance, a user may request information about AIDS to be provided in her

Figure 2. ePH architectural framework



native language. In this case, the Request Interpreter contacts the Information Base for a copy to be provided in that language. Another type of request may be that a user indicates (through the User Interface) being non-literate but provides his preference of native language. The Request Interpreter then contacts the Information Base to provide the information to the user either in a pictorial form, or an audio, or a video clip in the user's native language.

Content Translator/Broker

The *Content Translator/Broker*, in its simplest form, works as a simple forwarding function when the Information Base already has the content that the user requested in the desired mode. Its role, in the more complex form, is multi-faceted. For example, if the request of a user cannot be served by the Information Base in the preferred type requested by the user, an alternate form may be presented. Consider a user requesting information about malaria in the Bishnupriya-Manipuri language in audio form. Suppose that the Information Base currently does not have any information about it in this format, but has a description about malaria in textual format in the Bishnupriya-Manipuri language. In this case, the Information base sends the response first to the Content Translator/Broker, that in turn does a text-to-audio translation in real-time and plays it out to the user. For another request, the Content Translator might serve the role of providing the response in an alternate format. For example, the user requests a video format; however, there is no content available in a video format, but it has it available in an audio format. In this case, the Content Translator/Broker plays the role of a broker to provide the content in a different format. Over time, with the advent in technology, a Content Translator/Broker would be able to translate from one language to another language in real-time, both for textual contents and also for audio clips.

The most important aspect of the proposed architectural framework is that it presents a futuristic vision that takes into consideration the requirement of an ideal ePH system for a country

of the size of India with its diversity from many different directions. On the one hand, it is important to consider all the various factors, while on the other hand, the simplicity of our architectural framework is that it focuses on the important goal of serving the diverse end users without unduly complicating the framework. We believe that from a functional point of view these four major components would satisfy the need.

IMPLEMENTATION CHALLENGES

Having discussed the ePH architectural framework, we now discuss certain implementation challenges that can arise.

Consider first the Request Interpreter. This is not to be misconstrued as a basic web-server or a web-client. In fact, as of now, there is no known Request Interpreter that can satisfy the need of this architecture. The current search engines such as Google or Yahoo are text-based search engines; secondly, they cannot meet the user preference coming from heterogeneous devices; thirdly, they cannot serve as a resolver. For instance, a Request Interpreter must also serve the role of a resolver to different forms and/or locations of information in the Information Base. The concept of a resolver has been around on the Internet since its nascent days. An example of a resolver is when a user requests to go to a web site (such as http://www.google.com) that first identifies its domain (www.google.com); the domain is first resolved to a valid IP address to which the request is routed. A more sophisticated resolver is the Handle system (Handle). In our case, we envision the proposed resolver to work at an application level with a much broader scope as its role is to resolve requests based on multi-lingual texts as well as audio requests with multiple modes of operations. Consider a voice-command based search request through the phone system that is used in many parts of the world. For example, in such a system, if a user calls a phone number for flight information, a voice-prompt based interactive system identifies what the user is interested in knowing (the specific flight number, arrival or departure, and so on). We believe this mode of operation is extremely important to provide with the text-free User Interface for non-literate users so that they can use the microphone on a computer or a mobile phone to speak and request any particular information. Thus, such requests will be directed to the Request Interpreter that may involve a resolver to identify where to direct the request. Note that audio over the Internet is now possible since voice over Internet (VoIP) technology is now a standardized mechanism allowing users to make voice communications over the Internet.

In essence, the Request Interpreter is an abstraction for certain types of actions. For a specific medium, different search mechanisms or a request resolver may be developed or customized for different types of users. Rather than being a complex monolithic system, the Request Interpreter function may be implemented using multiple different units for different purposes by providing functions for different types of searches and capabilities for the resolver function through different computing units. It is important to recognize that unlike a web-browser, the Request Interpreter does not reside at the user's end. Rather, the user's end starts with the User Interface (UI). The UI is provided with certain intelligence that is more than a web browser, with the capability to direct the request to the right Request Interpreter.

Consider next the Content Translator/Broker. This is another function that is not currently available as we are envisioning it and it also does not need to be served through a monolithic system. Instead, different requests can be routed through a different Translator/Broker in order to meet the needs of the ePH system in terms of translation from one medium to another or being able to offer alternate solutions. In fact, going from the architectural view to an actual computing system design would lead to this function

splitting into multiple sub-functions to minimize software system implementation and computing system management complexity. For instance, a particular computing system may handle all the requests related to the text-to-audio translator. Thus, when the brokering function determines that this translation needs to be invoked, then the request is forwarded to the appropriate translator. Not only that, such translator systems may be organized separately for different languages. It must be noted, that we are not advocating that every such translator be developed from scratch; rather, there are existing off-the-shelf text-to-audio translators for some of the languages that can be used in this translation function. Another translation function is when a specific text needs to be translated from one language to another. Such translations may potentially change the semantic meaning. Since we are dealing with Public Health, it is important to ensure that such translations do not give information that can lead to misunderstandings. Therefore, consistency in vocabulary that is aligned with the unified medical language systems (UMLS) is important since UMLS provides facilities for natural language processing. Along with this, a domain model that captures key concepts would be important to consider (Oldfield 2002). Recently, there has been some work on controlled vocabulary in Public Health (Niedźwiedzka et.al., 2008).

The Information Base is another function that serves as the abstraction for different content bases. In practical implementations, this function may be divided based on languages and different media types. It is, however, worthwhile to develop a good naming scheme for different content identifiers, along with associated attributes so that it is helpful both for the Request Interpreter in identifying correct documents (be it text, audio, or video) and for the Translator/Broker to further resolve it. The document object identifier (DOI) is a well-developed concept that has already been used in practice (DOI). The DOI system is currently used for identifying documents, including persistent identification. Either the DOI may be extended for the purpose of the ePH system or a similar identifier system would need to be developed.

Consider next the User Interface; in particular, consider text-free User Interface for low-literate and non-literate users. There has recently been some development in this regard (Medhi, Pitti & Toyama, 2005; Medhi, Sagar, & Toyama, 2006; Medhi & Kuriyan 2007; Sherwani et. al. 2007, Medhi & Toyama 2007a; Medhi & Toyama 2007b). We believe that such text-free UI plays a very critical role in the ePH system, especially since a sizeable audience requiring Public Health in India is from this demographic group. In general, most non-literate users, given that they are from the lowest income group, would not be able to afford a computer. On the other hand, due to efforts by governmental organizations such as the National Information Centres (NICs) and non-governmental organizations (NGOs), the non-literate user group is expected to have access to computers at certain locations ("community centers"), where the users can go to use the facility. It is important that such computers be customized to cater to the language (sometimes multi-lingual) needs of the local community as well as with the capability for text-free UIs with audio capabilities. In some instances, such devices may be customized so that some user preference/settings may be set up beforehand; in this regard, some functional components from the Request Interpreter may be off-loaded to the user end.

It is crucial to note at this point that the system is proposed with security robustness and foolproof access to ensure authenticity of information. This factor is important not only to enable high quality reliable information, but also to ensure that the system does not fall into the hands of miscreant elements of the society promoting their own agenda. This thought is important given the fact that our approach is influenced by postmodernism that propagates the existence of multiple interpretations; it should not pave a way for multiple interpretations of health related and medical

facts. Postmodernism influences the approach and model, not the content. For this to happen, a multi-level governance mechanism needs to be introduced into the system so that information goes through several levels of rigorous reviews before it is deemed publishable.

We can see from the above discussion that there are many components that would need to be built to fit into our proposed architectural framework. Certainly, not all can be accomplished in a short period of time. A systemic approach is needed to reach the end goal. Earlier in this chapter, we discussed that our approach to the ePH system with critical systems thinking (CST) put our framework under the postmodern systems thinking within the scope of the System Of Systems Methodologies (SOSM). In addition, the proposed architectural framework is also partly influenced by the network-based distributed computing[4] paradigm. Rather than taking a software process approach to distributed computing, we take a systems approach to identify different functional components in a distributed fashion. It can be said that our approach then is a hybrid of an N-tier architecture (Manuel and AlGhamdhi 2003) and a peer-to-peer architecture[5] (Oram 2001) when we consider both the functional and sub-functional components of our proposed framework.

It is important to point out that neither the SOSM nor the distributed computing addresses the actual development of the overall computing system to reach the end goal. Given that many components are not going to be ready in short time intervals (both from a logistics and cost point of view), we propose that the actual system development should be a spiral-like approach. The spiral model is a well-known model for software development and enhancement (Boehm 1988). In our case, the spiral model also encompasses design decisions and enhancement. Rather, we argue that the end goal is not fixed; it will evolve with time as new issues in Public Health need to be addressed. Thus, the design phase from the architectural framework must be extensible with a spiral-like fashion, as opposed to a design for a purely closed loop system.

We end this section by commenting on the actual communication technology for Internet connectivity. Depending on different parts of the country, the network connectivity may not be the same; in fact, certain areas may have very low bandwidth network connectivity. Thus, in such cases, both the User Interface end as well as the Request Interpreter would need to have bandwidth-aware intelligence so that the response provided is not bandwidth consuming. This would require customization functions as appropriate.

USER-FEEDBACK

We presented our architectural framework with a goal to communicate a vision. This framework also incorporates user-feedback that is collected as needed for further processing (shown within the Information Base in Figure-2). We also discuss how we envision e-governance in a collaborative setting.

A system development of the scale of ePH in India must have a feature built in for user-feedback for its different interest groups. On one end, is the end user who either may not get the information she wants or the content is not of an adequate nature. Therefore, the end user UI must also have the ability to provide user feedback. For example, for non-literate users, this can be done by asking them to reply to a series of questions after certain information is provided to the user. Their responses to the questions, although to the user they appear to be going to the same system, would in fact go to a functional component that handles user feedback. So that a user is not "penalized" for not giving a high approval rating, this phase must have the ability to randomize the request where the responses are stored in a secure way so that the feedback evaluator does not know the actual user who provided the feedback and the information the user provided is available only through the

user's anonymity. Such feedback should then go back to the system designer (another reason for our proposal to consider a spiral model) so that enhancements to the ePH can be done. Since the specifics of the user-feedback handling is more of a software system implementation level issue, this is only shown as a component within the Information Base in the architectural framework as the collection point of the feedback information. Certainly, additional interfacing by external entities to this component is needed for further processing

Besides the end user who provides feedback, the overall system must also allow other constituents to provide feedback on a variety of things. For example, non-government organizations (NGOs) are going to be an important user group of the ePH system and their needs and requirements may be quite different from that of an average end user. In other words, people's participation through user-feedback is an important component in e-governance.

Such user-feedback capabilities go to the heart of e-governance. For example, electronic feedback can be processed and summarized to understand new needs or changes to the currently developed system. These can then be taken into account quickly to make enhancements.

Unlike traditional governance, contents for the information base can also be contributed by the citizens of the country through another User Interface. This will help speed up information availability to the citizens, especially when it may be extremely time consuming to provide every piece of information in every language and media type. In addition, it is certainly possible that such contents are not reliable information. On the other hand, however, what we have seen with services such as Wikipedia on the Internet is that such contents often converge to highly reliable information. Such a system may be supplemented with a scoring system, where knowledgeable citizens can also give scores on the validity of the content. Thus, user-provided information may be classified as "not approved" to a point in time, when through the scoring system, it becomes recognized that this information has validity. Thus, in the e-governance context, we see contents can be broadly separated into three groups: user-provided but lacking an adequate score, user-provided that has an acceptable score, and approved information (either generated by public health officials or moved into this group through the scoring system).

The application of the ePH we have modeled in this chapter may offer the public authorities a framework for effective integration of ICT enablement in Public Health. This may in-turn facilitate the access of its services for the diverse population of the country. The ePH architectural framework we have evolved can be used as an integral part of the overall e-governance agenda of the Government of India. Integration of this kind of a framework would enable efficiency, effectiveness, clarity, transparency, and accountability of Public Health services within the e-governance framework.

REFLECTING ON THE EPH

The ePH that we have proposed in this chapter is an attempt to address the Public Health information requirements for the diverse population of India. We realized at the outset that given the uniqueness of the Indian context and the challenges that we have discussed associated with this context, the ePH will have to be designed in such a way that it is able to accommodate the contextual variety and complexity, rather than underplaying and simplifying the same. Taking a critical systems approach, we have chosen to adopt the postmodernist style that led us to consider a range of design variables and see how these can be coherently understood within a conceptual framework. We also considered a range of challenges that can emerge for the framework – a style that again emerges from postmodernism and critical thinking that

encourages self-critique and paves the way for challenging the basis of one's own thinking. This lends the idea that there is no absolute truth, but truth is what we create as humans out of our own impressions of the situations around us. We have considered our own ePH framework as an impression, open to debate and questioning. Our attempt has been to propose a framework that is likely to be able to accommodate changing demands and situations as they emerge in the model of a complex adaptive system, taking cues from a critical systems approach. This has been considered with the proposed integration of feedback loops, spiral design, and a distributed computing paradigm. In so doing, we have also made an attempt to bring together various design parameters, including involvement of diverse stakeholders both in the planning and implementation stages. A critical systems perspective has enabled us to approach the ePH architectural framework in the light of the above considerations.

CONCLUSION

In this chapter, we have attempted to evolve an architectural framework for the ePH, relevant to the Indian context, with a postmodern systems thinking perspective. We first elaborated on what we understand Public Health to be and then discussed the challenges in terms of diversities that are posed by India as a country. We then elaborated, why as a result of this, systems thinking and approaches can lend a perspective to work towards an architectural framework for the ePH in India and considered how this can be woven into the e-governance framework of the country. Finally, we touched upon some of the challenges of the ePH that need to be considered during the implementation of the ePH.

Although we have taken India as the case-in-focus, we believe that this framework can be replicated and adapted to other countries with similar situations or with a similar stage of economic development, where challenges posed by illiteracy, ignorance, and lack of access may be of a similar nature.

It needs to be considered that given the fact that this framework has been evolved in a context where there is considerable complexity in the absence of any such prior framework at the national level, it is likely to face certain challenges in its implementation (some of which we have already tried to articulate in this chapter). Along with this, it is probable that there will be certain critiques of this framework itself. Our approach does have an affiliation with the postmodernist point of view, but at the same time, we have taken just two variables in the systems design – language and literacy. This approach needs to be widened with the inclusion of further variables in the systems design. Language and illiteracy were the two major variables we identified for this stage of a zero-based design for the ePH. We therefore propose this framework to our informed readers as a work-in-progress, open to new ideas and further deliberation on new variables and newer paradigms of developments. Our interest is to further explore how we can evolve a methodology for implementation of this framework. We equally invite deliberation from our audience for ideas on how we can best leverage our understanding of Critical Systems Thinking, in general, and the use of postmodern systems thinking, in particular, in this exercise, along with its integration with the distributed computing paradigm.

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ENDNOTES

1 Positivism is a school of thought according to which, knowledge can only be derived from sense experiences, and the methods to be followed for the same are to be rational, formulae driven, and relate to what is inferable. The methodologies inspired by positivism include hard systems thinking, system dynamics and organizational cybernetics, which are driven by obvious objectivity and observatory knowledge.
Interpretivism is a school of thought according to which, knowledge can be derived only by delving into the thoughts and feelings of the observed, and identifying the unobvious and what is beyond the surface level. Systems methodologies inspired by interpretivism are soft systems approaches that make provisions of taking different human perspectives into consideration in the intervention process.
Postmodernism is a school of thought according to which, there can be numerous interpretations of knowledge, which can be arrived at with various approaches and perspectives; no form of knowledge can be considered as more valid than a different form of knowledge.

2 Emancipatory approaches are those that make human emancipation as the basis of the intervention process with the belief that the end result of any systems exercise should be the betterment of human beings.

3 For a detailed narration of these methodologies and approaches, refer to Jackson (2003).

4 Distributed computing refers to a system with more than one processor and/or storage that is distributed over multiple computers for a certain task (Attiya & Welch 2004).

5 An N-tier (typically, a three-tier) architecture in a distributed software system is a client-server architecture that includes a

middle-tier that processes a client's request to forward to the appropriate server (for example, a database server). In a peer-to-peer architecture, an entity can serve both as a client and a server at the same time, i.e., it is a server to others while it can take turns to be a client to request from others.