Towards Development of a National Blueprint for Better and Smarter Healthcare Services in Thailand

Asanee Kawtrakul*, Kunwadee Sripanidkulchai*, Naiyana Sahavechaphan*, Chularat Tanprasert*, Kristsana Nithikethkul*
*National Electronics and Computer Technology Center
Pathumthani, Thailand

^Department of Computer Engineering
Kasetsart University
Bangkok, Thailand

Chokchai Leangsuksun
Louisiana Tech University
Ruston, LA, USA

Khanat Kruthkul, Bordin Sapsomboon
Mahidol University
Bangkok, Thailand

Panjai Tantatsanawong
Silapakorn University
Nakorn Pathom, Thailand

Abstract—In recent years, Thailand and many countries around the world have faced challenges caused by inequity in accessing healthcare services, chronic disease management, demographic structural changes and an increased number of disabled populations. These facts have amplified dire needs for innovative healthcare services not only for treatments but also for prevention and public health promotion. To expedite the development of such innovations in community-based healthcare, ambulatory care and inpatient services, healthcare experts, technologists, and key stakeholders have teamed up at both the national and international level to develop a blueprint for implementing better and smarter healthcare services for both consumers and healthcare providers in Thailand. Three important business processes healthcare services reimbursement, patient referral and consultation and decision support processes linking sickness and population data are discussed to demonstrate the usability of the blueprint. The blueprint is in various stages of deployment in Thailand.

Keywords-enterprise architecture; blueprint; healthcare services; electronic health record (EHR); business processes; technology roadmap, healthcare data standards; healthcare services reimbursement

I. INTRODUCTION

Healthcare services are identified as one of the largest valued service systems with huge potential for improvement in system efficiency [1]. In Thailand, the main problems in this domain are availability of high-quality services and equality in access to services. Improving the healthcare service system is one of the highest national priorities. Recently, the Royal Thai Government implemented Universal Healthcare Coverage enabling Thai citizens to have access to low-cost services at government-owned healthcare providers. Furthermore, in the latest draft of the 11th National Economic and Social Development Plan for 2012-2016 [2], two out of the six development strategies are directly related to healthcare. The first strategy focuses on promoting a just society to ensure there is opportunity for all to gain access to social services such as healthcare. Citizens in rural and urban areas should have equal access. Furthermore, the quality of care should also be equal. The second strategy is to develop the quality of human resources where good health and wellbeing through health prevention and promotion is the basis.

In addition, the government is actively grooming Thailand to be a regional medical hub to attract medical tourists. There have been a myriad of initiatives to promote Thailand to be the best medical hub from both government and private sectors including stimulus packages for medical research and development, improvement of medical devices, improvement of hospital practices, promotion of medical tourism attracting millions of visitors each year by offering high quality medical care with world-class hospitality and reasonable cost. It is anticipated that millions of foreigners come to Thailand each year to seek medical treatment.

Therefore, healthcare providers in Thailand must be ready to serve both local and foreign patients who are seeking the highest quality services in the region if not in the world. To build and maintain Thailand’s reputation as the principal destination for medical care services, a rigorous adherence to international standards of healthcare, clinical excellence, best in class services, continued quality improvement, reduction in wait times and waste, as well as deployment of advanced medical technology are required.

Information technology is a critical supporting tool to enable better healthcare service quality and efficiency. While healthcare information systems are in use in Thailand, there are no defined standards for how they ought to be developed and implemented. In particular, features to enable information exchange and coordination among providers are often lacking but are required to support real business processes such as patient referral, continuity of care, and preventative care. These facts have amplified dire needs for advanced healthcare services not only for treatments but also for prevention and public health promotion.
In this paper, we outline key challenges in using IT to drive better efficiency, higher quality of service, and more innovation in the healthcare service system in Thailand. We provide a holistic view of ongoing efforts in this space to develop a national blueprint for smarter healthcare services in Thailand. Furthermore, we discuss in more details a few point cases to demonstrate how we are realizing and delivering the blueprint in practice.

II. BACKGROUND AND MOTIVATION

In this section, we review the existing work and the challenges facing the adoption of IT to drive better efficiency and quality for the healthcare service system in Thailand.

There is a substantial body of related work in leveraging IT in the Thai healthcare service system, demonstrating the importance of improving the system using innovative technology. For example, a system to manage and exchange patient records among hospitals that use different hospital information system (HIS) platforms was proposed [3]. This system adopted the international healthcare information standard HL7 v3.0 [4] using XML-based Globus Grid services. Radiological records such as X-ray film images are transferred between hospitals using FTPGrid in DICOM [5] format. The system used open standards but can only support HL7.

As another example, Ramathibodi Hospital's medical center initiated a pilot project assisting patient referral and information transfers between the hospital and other healthcare providers. Each provider may have different clinical terminologies, and thus records must be pre-processed and mapped according to an open standard and agreement between partners. They also adopted HL7 v3.0 as their protocol of choice and piloted the project between two different HIS systems, one used by Ramathibodi Hospital and the other used by clinics that are run by Siam Cement Group for their employees.

Lastly, the National Electronics and Computer Technology Center (NECTEC), has been working on applying technology to improve healthcare in three areas denoted by each of the columns in Figure 1: (i) National Health Information System & Knowledge Base to support curative approaches to preventative medicine, (ii) Intelligent Medical Devices to support continuous care and wellness monitoring, and (iii) innovative e-Health Care Services and Tools to support preventive medicine, call centers and emergency management. NECTEC developed a ten-year technology roadmap for “Smarter Health and Smarter Living” starting from 2008. As part of this effort, data standards, tools and processes to help improve the quality of data and reduce the complexity of healthcare reimbursement among three national health insurance providers has been implemented.

All these previous work exemplify the importance of using IT to improve healthcare services. Augmenting these works with more detailed surveys, requirements gathering, and analysis conducted with stakeholders from government-owned and privately-owned healthcare service providers, national health insurance providers, policy-makers in the Ministry of Public Health, and medical and IT professionals, we identify five key challenges facing the Thai healthcare service system as follows:

1. **Fragmented efforts:** Existing work to use IT to innovate and transform healthcare services have been executed as grass-roots efforts from individual providers. Projects are executed often in isolation, leading to challenges in how to entice more providers to adopt innovative solutions at a larger scale. This results in a limited scale of adoption usually only by providers that originally initiated the effort.

2. **Lack of adopted national data standards:** There is a need for stakeholders to agree upon and co-define a national healthcare information data standard for public health information, e-medical records, e-health records, and data exchange protocols. Defining standards is challenging. Any standard would need to support multiple use cases such as policy-making, insurance reimbursement and day-to-day service operations. Furthermore, the nature of healthcare information is dynamic and standards need to accommodate changes such as new diseases and breakthroughs in treatment.

3. **Heterogeneity in deployed HIS’s:** There are about 10,000 government-owned healthcare providers. However, they do not use the same hospital information system (HIS). Cooperation between all HIS vendors is needed to adopt and implement any changes to address emerging data requirements as well as new capabilities such as enabling the exchange of data across systems and providers.

4. **Paper-driven business processes:** Key business processes in the medical domain are still manually executed and paper-driven. For example, the patient referral process between two providers is based on telephone calls and two sheets of paper. As another example, data acquisition processes to support medical records and public health surveys are often first recorded by pen and paper, and then later entered into computerized systems. This is highly inefficient, delaying when data is made available and possibly introducing errors that impact data quality.

5. **Lack of experienced professionals in rural areas:** Thailand has a small number of healthcare professionals and IT professionals, and an even smaller number that know both areas sufficiently well. For example, hospitals often have the budget to purchase healthcare equipment such as MRI

![Figure 1. NECTEC’s Smart Health Ro admak.](image-url)
scanners but there are not enough radiologists in the country to work at all those hospitals. In addition, there is a shortage of skilled IT professionals supporting hospital information systems in primary care units. Accordingly, enabling remote access to specialists through the use of tele-consultation applications, offloading IT infrastructure management tasks from primary care units through the use of cloud computing and centralized deployment models could potentially equalize access to healthcare services.

While we acknowledge that these challenges are not comprehensive, yet overcoming this small set is still a grand undertaking that can only be successful if there is a concerted effort across various stakeholders. In particular, the first challenge is being resolved through organizational means, both bottom-up and top-down. Many grass-root networks between technologists, public health officials and physicians have been formed such as the Thai Healthcare Information Network (THINK). More recently, these efforts led to the creation of a national consortium to develop national healthcare information standard and system. The consortium cuts across multiple national agencies including the Ministry of Public Health as users and policy makers, the Ministry of Science and Technology as providers of innovation in science and technology, the Ministry of Education as providers of human resources and training in medical informatics, the Ministry of Information and Communication Technology as providers of data governance frameworks, and the Ministry of Industry as specialists in standardization and associated processes. We believe this consortium will accelerate adoption at a larger scale discussed in the first challenge.

In the remaining sections in this paper, we outline a blueprint of a health IT architecture that we have developed for Thailand to eventually address these challenges.

III. BLUEPRINT

In this section, we introduce our proposed blueprint for developing a national Healthcare Information System based on enterprise architecture models adapted from [6]. There are four fundamental architectural layers, namely Organizational, Data, Application and Technical (ODAT) architectures. Each layer provides functionalities and responsibilities with targeted deliverables as listed in Table 1. We further scope the blueprint based on healthcare business domains and processes.

There are seven business domains defined as part of this model, such as health services, laboratory, pharmacy, human resources in health, environmental monitoring, decision support, and finance [6]. These domains are applicable to many countries as well as Thailand. However, there are many business processes in each of the domains, most of which are country-specific. In this paper, we will discuss a selected set of three high-priority business processes corresponding to three business domains for the national Healthcare Information System for Thailand listed in Table 2.

Our rationale for selecting these business processes is based on how much they can drive solutions to address the key challenges discussed in Section 2 as well as their potential impact on society. In the health services domain, we discuss the blueprint for the patient referral and consultation process, addressing challenges 2, 3, 4, and 5 (the need for data standards, heterogeneity in deployed hospital information systems, transformation of paper-driven manual processes to data-driven computerized processes, and more effective use of human resources). We discuss the linking of sickness and population data in the decision support domain and how we address challenge 2. Finally in the finance domain, we discuss the healthcare services reimbursement process addressing challenges 2 and 3. The details of each business process will be discussed in Section IV.

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<thead>
<tr>
<th>Architecture Domain</th>
<th>Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Organizational Architecture</td>
<td>• Business domains</td>
</tr>
<tr>
<td></td>
<td>• Business functions</td>
</tr>
<tr>
<td></td>
<td>• Business processes</td>
</tr>
<tr>
<td></td>
<td>• Governance, Policy, Resources</td>
</tr>
<tr>
<td>2. Data Architecture</td>
<td>• Data model</td>
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<tr>
<td></td>
<td>• Metadata dictionary</td>
</tr>
<tr>
<td></td>
<td>• Classification standards and systems</td>
</tr>
<tr>
<td>3. Applications Architecture</td>
<td>• Software applications</td>
</tr>
<tr>
<td></td>
<td>• Interfaces between applications</td>
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<tr>
<td></td>
<td>• User interfaces</td>
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<td>4. Technical Architecture</td>
<td>• Hardware platforms</td>
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<td></td>
<td>• Connectivity, Networks</td>
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<td></td>
<td>• Security</td>
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<td></td>
<td>• Runtime/Operating system</td>
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<td>• Interoperability</td>
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<thead>
<tr>
<th>Business Domain</th>
<th>Business Processes</th>
<th>Archotypical Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Services</td>
<td>• Patient referral and consultation (challenges 2, 3, 4, 5)</td>
<td>• Patient/guardian/parent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Chief health officer</td>
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<td>• Physician</td>
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<td>• Community health worker</td>
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<td>• District health manager</td>
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<td>• Director of primary healthcare unit</td>
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<td>Decision Support</td>
<td>• Linking of sickness and population data (challenge 2, 3)</td>
<td>• Chief health officer</td>
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<td>• District medical officer</td>
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<td>• Provincial medical office</td>
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<td></td>
<td>• Community health worker</td>
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<tr>
<td>Finance</td>
<td>• Healthcare services reimbursement (challenges 2, 3)</td>
<td>• District health manager</td>
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<td>• Provincial health manager</td>
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<td>• National health finance officer</td>
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<td>• National treasury finance officer</td>
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<td>• Health insurance providers</td>
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As future work in later phases, we will extend the blueprint by defining additional business processes in each of
the domains customized to Thailand. We will implement the blueprint and tool set based on the ODAT framework to address the pragmatic challenges discussed in Section 2 in the near-term as well as ensuring enough flexibility to handle longer-term strategic plans. We refer readers to [6] for more examples on the list of business processes for each of the domains.

A. Organizational Architecture

Organizationally, there are several agencies that participate in the healthcare service system in Thailand such as healthcare providers, insurance providers and governance bodies. In terms of healthcare providers, there are both government-owned providers and private providers. For the context of this blueprint, we will scope our discussion to government-owned providers of which there are about 10,000 geographically distributed throughout the country. They can be classified into 3 main categories, primary care units of which the majority are run by registered nurses, secondary care units or which may have general physicians and limited number of specialists, and tertiary care units or healthcare centers that have specialists in many areas.

Health insurance is provided to all citizens as part of various national initiatives and programs. The largest programs are government-owned and operated by the National Health Security Office (NHSO), the Comptroller General’s Department (CGD), and the Social Security Office (SSO). The overall system is complex because each insurance program is independently operated using different business rules and processes, run by different government agencies. For example, NHSO is affiliated with the Ministry of Public Health, SSO is under the Ministry of Labour, and CGD is under the Ministry of Finance. Improving the health insurance system will require sharing healthcare information across these agencies. We will discuss how reimbursement data is exchanged in Section IVA.

Lastly, the governance body directly responsible is the Ministry of Public Health (MOPH) whose role is to oversee operations of most of the 10,000 government-owned healthcare providers, promote the general wellbeing of citizens in the country, and monitor sicknesses. While the MOPH takes a national view, it has branch public health offices in individual provinces and districts throughout the country to carry out its mission.

We also note that there are aspects of healthcare services such as the definition and maintenance of healthcare data standards that have other stakeholders beyond the MOPH. Another governance body that includes cross-agency stakeholders is also crucial to the success of promoting usage and managing the lifecycle of data standards. The governance body needs to define processes to ensure that updates and changes to the standards are made in agreement with all impacted stakeholders. To this end, the Ministry of Information and Communication Technology established the Thailand e-Government Interoperability Framework (TH e-GIF) to drive the national body for data governance and data standardization to support better data interoperability practice across government agencies.

B. Data and Applications Architecture

There are at least 30 different hospital information systems (HIS) developed by independent software vendors deployed at healthcare IT centers throughout the country. The heterogeneity and multitude of HISs imposes challenges in information processing and exchange. For example, SSO and CGD are insurance providers that focus on the reimbursement to healthcare centers that provide services to insurers according to their insurance plans. Therefore, they require healthcare service providers to submit detailed information of services given to individual patients. Enabling such information exchange through defining and developing data standards and architecture is vital for the success of the national healthcare IT blueprint.

C. Technical Architecture

The technical architecture deployed in the existing legacy healthcare service system is heterogeneous and independently managed by each healthcare organization. It is a highly distributed system consisting of more than 10,000 participants. We will consider the use of new technologies such as cloud computing and mobile technologies to ease deployment and management. Also, security and privacy policies will be discussed in the example business processes in the next section.

IV. BUSINESS PROCESSES AND PROOF OF CONCEPT
BLUEPRINT IMPLEMENTATION

In this section, we discuss the three business processes that we are prioritizing in the first phase of the national blueprint listed in Table 2. Recall that we selected these business processes according to the key challenges facing the Thai healthcare service system.

A. Healthcare Services Reimbursement Processes

Healthcare services reimbursement is one of the most important processes in the financial business domain of a healthcare system. As discussed in Section IIIB, there are several national healthcare insurance providers in Thailand. Generally, there are two models for reimbursement in Thailand. The first model is based on pay-per-service. For each service interaction between a patient and a service provider, a transactional record is created and payment is made specifically for that type of service. A second model is based on capitation where a service provider receives an annual budget based on the number of patients in the provider’s coverage area regardless of amount or type of services performed. For example, a hospital may be a primary care unit for 10,000 citizens and receives an annual budget corresponding to services to such 10,000 head-counts. The choice of which model is utilized depends on complex business rules determined by the type of service, illness, or procedure.

In order for healthcare services to be reimbursed, information detailing the treatment of individual patients needs to be submitted by the healthcare service provider to
the insurance agency in the first model. In addition, to support continuous allocation of budget in the second model, information of patient visits to service providers is also needed. Figure 2 depicts the data flow architecture to support this process, starting at the bottom from data providers, to data aggregators, and finally to data consumers in the national health insurance programs. Data providers in this case are the healthcare service providers such as hospitals and community health. District-level or provincial-level branch offices of the Ministry of Public Health collect data from multiple healthcare service providers under their responsibility, then aggregate and send the data to the headquarters of the insurance programs. Some types of data flow directly from the healthcare provider to the insurance programs whereas other types of data flow to the district and provincial offices first.

The reimbursement process is data-intensive. In order for this process to run effectively, we need to address the aforementioned data standard and HIS heterogeneity challenge. Our goal is to leverage the ODAT framework from Section III and systematically define data architectures and develop sustainable technical architectures as part of the National Health Information System (NHIS) blueprint. The four axes in Figure 3 correspond to the different desirable features of the data architecture. Tools and processes to support the data architecture are shown in the outer circle. In particular, data usability corresponds to the business processes defined as part of the organizational architecture and the corresponding applications to support those business processes in the applications architecture. Data quality and interoperability map to the data architecture whereas data cleansing tools and data standard definitions support the data architecture. Lastly, the technical architecture is represented by the security axis that deals with security policies, as well as tools for infrastructure management and monitoring.

NHIS enables data standards and information exchange with an on-demand access to standard health information from various healthcare providers to appropriate health insurance agencies. We are examining the existing data models that are in use by HIS’s and insurance agencies, as well as international standards such as HL7 [4] to define a national standard. In order to provide secure and robust access control to ensure the information with appropriate access rights, we plan to deploy a Public Key Infrastructure (PKI) to support issuance of credentials and to facilitate credential management. PKI provides security mechanisms such as confidentiality, integrity, authentication, and non-repudiation. In addition, we introduce an Authorization System (AS) that employs X.509 Attribute Certificate (AC) to generate policy attributes with respect to the access rights and to support authorization management. Role-Based Access Control (RBAC) and the Privilege Management Infrastructure (PMI) are foundations for the AS. We achieve information privacy and integrity with XML-Encryption and XML-Signature respectively. Single sign on will be supported via Security Assertion Markup Language (SAML). More details on the implementation are available in [7]. The system is being deployed and evaluated in 7 pilot provinces by 2012 with plans to expand to the entire country afterwards.

B. Patient Referral, Consultation and Emergency Management

One of our major goals is to increase equality in access to healthcare, improve the quality and effectiveness of healthcare services, reduce human error, and position Thailand to become a major medical hub. There are dire needs in order to cope with anticipated increasing number of referral patients both Thai and foreign. Referrals and consultations are part of standard healthcare practice, for example, referrals to specialists at hospitals that may be better equipped to handle the particular type of illness. One of the key performance indicators (KPIs) used in day-to-day operations by healthcare providers is the number of cases that are suitably referred by or received by the provider. The objective of this KPI is for each provider to correctly assess its own capabilities. A provider should only accept cases that it can handle. Any other cases, either above or below its capabilities should be referred to other providers.
Figure 4. Data flow architecture to support patient referral and consultation.

In order to support this process, we need to solve multiple challenges. First the process itself is manual and paper-driven (challenge 4). The source service provider makes a telephone call to the potential receiving provider to determine if the receiving provider is available and capable of taking the referral request. Once a patient transfer is agreed upon, the source provider completes a 1-page paper document that provides limited patient information. Detailed patient records, lab results, symptoms and treatment are not as part of the document. Some of that information may be communicated over the phone or by the patient if he/she is conscious. In the same manner, when transferring a patient back to the source healthcare service provider, a 1-page paper document is provided.

Today's consultation practice requires the patient to travel from one provider usually in a remote area lacking specialists to another provider usually in an urban area with specialists (challenge 5). Furthermore, in the rural southern border of Thailand there are a number of injured citizens from national security incidents but a shortage of physicians and emergency medicine specialists in those areas. Traveling can be prohibitively expensive and perhaps not physically comfortable for patients with certain conditions.

The ability for providers to exchange patient health records and continuity of care documents would transform existing processes resulting in a more innovative remote consultation and referral processes. The data flow architecture to support this process is depicted in Figure 4 where the data providers and data consumers are the healthcare service providers in the system. In order to enable such exchange, we need to define a data standard (challenge 2) that can be easily adopted by the multiplicity of HISs deployed today (challenge 3).

To address this issue, we develop a service-oriented system and toolkit that allows electronic patient data exchange among various healthcare service providers. It needs to support open standards and ease of data conversion and transfer from any HIS. The system has two primary components, namely a service brokering system and healthcare standard data conversion. The exchange server is a service-oriented brokering system that maintains a referral service registry and automates patient record transfer in a proposal-agnostic manner. It will be implemented using cloud-computing platforms to ensure system robustness and scalability. Remote sites will be linked using high-speed government networks such as Government Information Network (GIN) and UNINET [8].

Figure 5 illustrates our EHR exchange server architecture. It serves many healthcare organizations as an EHR exchange registry and brokers patient record transfer services. On the other hand, a standard medical data conversion tool provides software modules to assist data conversion from the health-care provider HIS system's proprietary format to an open standard HL7 V3.0 protocol, clinical name mapping and vice versa. In addition, the exchange server also provides an SDK to support a set of web service operations for referral service registry, authentication & authorization and data exchange. The success of this project will be an anchor of the national healthcare IT blueprint that will improve the Thai healthcare service ecosystem and enable Thailand towards becoming a global medical hub. Details of the exchange server open source project can be found at [9]. We anticipate that the exchange server will enable innovative healthcare services such as automatic referral system and tele-consultation for remote diagnostics in the near future.

C. Decision Support Process Linking Sickness and Population Data

Linking of sickness and population data is a common business process to establish public health priorities, monitor the effectiveness of public health services and decision support for policy makers at the national level and sub-national level. For example, Bangkok Metropolitan Administration (BMA) would like to track the outbreak of emerging diseases and correlate that with other sources of
information in the BMA registry of street food vendors. Figure 6 depicts the data flow architecture to support this process. Healthcare service providers in the Bangkok area contribute illness data to the BMA through district and provincial data aggregators. The BMA can take that data and perform correlation with other sources of data available from other registries.

As another example, at the national level, the Ministry of Public Health would like to know if certain diseases are prevalent in specific regions in order to allocate their efforts and resources to address the promotion of good health and prevention of diseases accordingly. Rayong province is a target community where there is concern about pollution-related sickness. The population in Rayong has a mix of various occupations in manufacturing, tourism and agriculture. There are 14 hospitals in the area of which 7 are public and the rest are privately owned. These hospitals deploy various HIS’s (challenge 3). Data transformation to a common standard (challenge 2) and integration are main challenges. Again Figure 6 depicts the required data flow between various entities to support the process. In this case, cooperation across ministries is required in order to correlate public health data with environmental data usually collected in much more detail by the Ministry of Natural Resources and Environment. We expect that such cross-ministry collaborations will be formed in order to implement a successful NHIS that looks at all facets of public health information to support decision making by the government as well as by the private sector.

V. SUMMARY AND FUTURE WORK

Information Technology is transforming the services industry and will no doubt enable innovative services to revolutionize the healthcare industry in Thailand. We identified many challenges in today’s healthcare service system such as the lack of coordination amongst transformative efforts, the lack of universal data standards, the heterogeneity of hospital information systems, the use of paper-based manual business processes, and the lack of human resources. We argue that a national blueprint is an important first step towards solving these challenges to deliver a more efficient healthcare service system with higher service quality. Adopting a layered enterprise architecture approach, we demonstrated the applicability of the framework with important pilot business processes, healthcare services reimbursement, patient referral and consultation, and decision support for improving quality of service. We discussed the challenges facing each of these business processes, the data flow architecture, and the proposed solutions involving the development of standard data models, tools, and infrastructure to support the improved processes. We have begun to deploy proof-of-concept systems in a subset of provinces throughout the country. Our blueprint is by no means complete, but it will be a foundation for better healthcare services for all citizens in Thailand. Its ultimate success will be measured by patient satisfaction, improved quality of life, and improved access to services. We will continue to refine our blueprint, collect more data, and measure the outcomes. We also will extend the scope of the architecture and implementation to encompass additional business processes, application scenarios, and innovative services.

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