Computer Aided Planning, Engineering and Management for Health and Human Services

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1. Overview

We propose a computer aided planning, engineering and management platform that can be used to rapidly deploy high quality healthIT services for diverse scenarios. This platform, called SPACE (Strategic Planning, Architecture, Acquisition, Controls & Education), is a spinoff of the United Nations eNabler Project that has been developed for rapid deployment of health, education, public safety and public welfare services for the underserved segments of our society. Our goal is to significantly expand and enrich the healthIT (HIT) aspects of the SPACE platform to produce the following results: ©

- Quickly (within an hour) produce detailed designs and sample prototypes for ambulatory health clinics that satisfy the needs of minority populations and other underserved segments.
- Significantly reduce the cost and time needed to deploy a new service and reduce chances of failures.
- Produce extensive documentation (integration requirements, detailed design specifications, and project management guidelines). These documents can be used as a powerful checklist that can be used to minimize failures [5] and for management and controls.

The most significant aspect of our approach is that we also produce a working solution as a vendor neutral portal that can be deployed quickly by different vendors. The portal produced will include:

- The most appropriate tools and standards needed for the specific user population. This customization is done by SPACE by using patterns in healthIT and regional considerations plus a user interview.
- Collaboration capabilities with other services through service oriented architecture (SOA) patterns.
- A health analytics component that will provide descriptive analytics, predictive analytics, and prescriptive analytics features by using the Excel plug-ins for Analytics.
- A workflow system so that different workflow scenarios can be modeled instead one fixed workflow.
- Capabilities to make it smart through detection of problems quickly, adjustment to rapidly handle the problems and learning, based on big data module, to do a better job in the future.
- Gamification to educate the patients and the staff on different capabilities provided by the HIT service.

2. Our Approach

SPACE (Strategic Planning, Architecture, Acquisition, Controls & Education), the foundation of this proposal, is a computer aided planning, engineering and management environment that addresses the supports the entire Learn-

Plan-Do-Check cycle and quickly produces highly detailed plans plus working solutions based on best practices for a wide range of ICT services that are customized for the chosen country/region. SPACE is based on the latest thinking in enterprise ontologies, business patterns, gamification, semantic web and machine learning. Specifically, we heavily use patterns to produce customized solutions for different situations. This knowledge will be directly applicable to HealthIT (HIT) deployments. Our focus is on SPACE4Health, a customization of SPACE that concentrates on applications of SPACE in HealthIT. We have completed some preliminary work on SPACE4Health and are hoping that this funding opportunity will deepen our understanding of computer aided planning, engineering and management in HealthIT, with special attention to design.

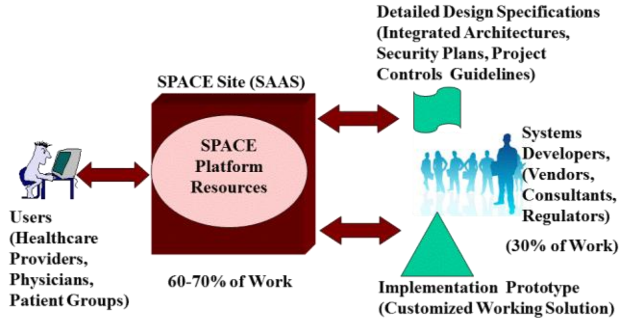


Figure 1: High Level External View of SPACE4Health

Figure 1 shows a very high level view of SPACE4Health. The user develops the strategic plans, design specifications and HIT prototypes in less than an hour. SPACE does 60-70% of the work, the remaining 30-40% is done by local experts and/or the users themselves.

Figure 2 shows the conceptual framework of SPACE that is at the core of this proposal. As shown, SPACE covers the entire Learn-Plan-Do-Check cycle through an extensive array of capabilities that include patterns, games, strategic decision support and planning tools, and detailed decision support and planning tools. As mentioned previously, SPACE currently supports more than 100 services in 10 sectors that include health, education, public safety, public welfare, economic development, transportation and other vital sectors. The architecture of SPACE is very flexible so that new services and sectors can be easily added and enriched.

This proposal concentrates on SPACE4Health, a specialization/extension of the current SPACE environment, that will be used to rapidly deploy high quality HIT services for the underserved populations. SPACE4Health will extend the following capabilities of SPACE:

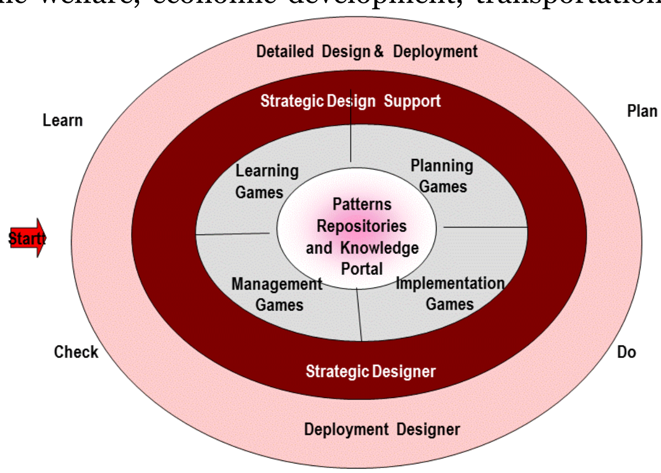


Figure 2: SPACE Conceptual View

- *The Pattern Repositories* (the innermost circle) will contain an extensive library of service patterns, business patterns, technology patterns, security patterns, and integration patterns specifically needed to support HIT.
- *Games and Simulations* (the next circle) that can be used to educate the patients and the HIT service staff in their daily tasks.
- *The Design Support Tools* (the outer circles) contain strategic and detailed planning tools that systematically guide the users through various decisions in strategic planning,

architectures, integration, deployment, security, controls and project management activities needed in an HIT.

The patterns, knowledge portal, games, and decision support and design advisors are currently integrated with each other and will collectively support a very large number of practical design scenarios for HIT.

3. SPACE Methodology

SPACE covers six phases (P0 to P5), shown in Figure 3 that span the design, implementation, use and measurement activities described in the PA-14-001 FOA. Each phase is supported by an advisor that provides phase specific guidance. At the end of each phase, extensive documentation is provided to support the next phase. For example, at the end of P3, complete documentation is made available to the users to support the later phases of implementation and monitoring/control. SPACE integrates and aggregates the Big Data about 193 countries available on sites such as the United Nations Public Administration Network (www.unpan.org), World Economic Forum (www.wef.org) and the World Bank Open Data website (www.worldbank.org). In addition, it provides access to useful educational and training materials in different steps of P0, P1, P2, P3 and P4 to educate the users as they develop the plans. A technical architecture of SPACE that supports this methodology is presented in Appendix B. In this section we will illustrate this methodology used for design of HIT services. The following example illustrates the overall flow of SPACE to design and implement a HIT service in an underserved sector. The following description shows the flow, as displayed in Figure 3:

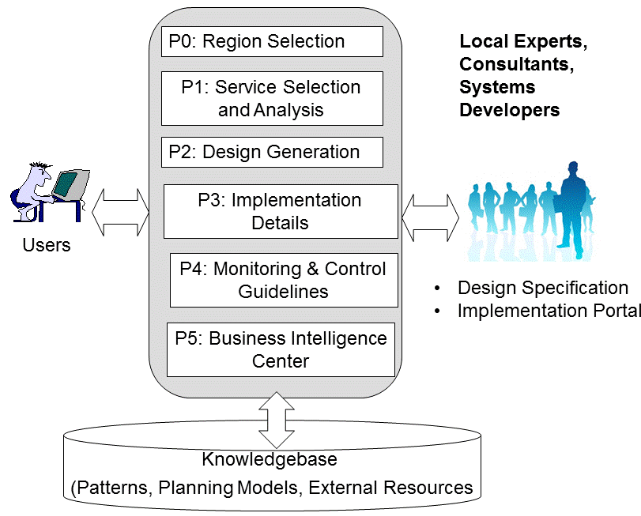


Figure 3: High Level Methodology

P0 Phase (Region/Country Information): The user (healthcare provider) chooses a country/region (e.g., Nigeria). This automatically fetches the Big Data information already available about Nigeria on the sites such as (www.unpan.org, www.wef.org, and www.worldbank.org).

P1 Phase (Service Selection and Design): The user selects a service or a "service bundle", in our case a HIT service. The selected service definition is fetched from the business pattern repository. In our case, the pattern fetched is a *Business Process Pattern (BPP),* shown in Figure 4, that captures an overall view of a healthcare service provider. This diagram shows the enterprise functional areas based on HL7 domains (e.g., sales, marketing, corporate management, healthcare clinical services, healthcare administrative services, back-office operations), the major business processes in each functional area (e.g., purchasing and payment within procurement) and the key interactions between these processes as arrows that could be cast into HL7 messages. This BPP, represented internally in XML, can be customized to represent healthcare providers from a simple doctor's office to a large hospital and can be modified for different regions and populations. We will primarily focus on the following service functional areas:

- Healthcare Clinical Services that have been subdivided into patient care (e.g., nursing, emergency services, cardiology, etc), EHRs, physician systems and healthcare management (e.g., health information exchanges, master provider index, master patient index,) and clinical services management (e.g., compliance, patient education, service evaluation and refinement, clinical decision support). Mention services such as telemedicine,)
- Healthcare Administrative Service that have been subdivided into patient administration (e.g., admissions, discharges, payment, health insurance, etc) and facilities management (e.g., cleaning, equipment management, record keeping, staff supervision, etc)

In SPACE, a BPP plays a central role in making several decisions during the planning, engineering, deployment and management of healthcare and other services. A BPP, and additional information, is stored in the pattern repository in a machine readable format (in XML and OWL) and is modified, and enriched by different advisors during the user interview in later phases of the interview.

P2 Phase (Design Generation): The user is led through strategic analysis (buy, rent, outsource) and cost-benefits tradeoffs associated with the HIT service. During this phase, the BPP pattern is modified, extended, and enriched by the different advisors and is used to populate the strategic plans, design specification and resulting portal of the HIT service. Specifically, SPACE uses and modifies a BPP to:

- Represent an enterprise business architecture (EBA) because it can be used to represent various business processes and their interrelationships and interactions. Also critical business processes are identified to represent a business strategy.
- Identify what BPs are automated, how and which ones are not. This gives a very good management model to determine which services have not been automated in a clinic and conduct impact analysis for automation.
- Conduct quick sensitivity analysis such as the following: a) if one BP is eliminated, then what other BPs will be impacted, b) if an application package that supports a BP is replaced with another application, what other applications/BPs will be impacted, c) which application, if replaced, will have the most impact in terms of integration, d) which application, if replaced, will have the least impact in terms of integration.
- Develop workflow models and integration scenarios based on the sensitivity analysis.
- Guide the users to simulations, games and decision support tools for detailed design analysis.
- Translate a BPP to a detailed technical architecture by allocating different services to different sites and suggesting a network configuration based on these allocations.
- Suggest security and integration patterns based on the technical architecture
- Develop sketch of an HL7 Clinical Data Architecture (CDA) document

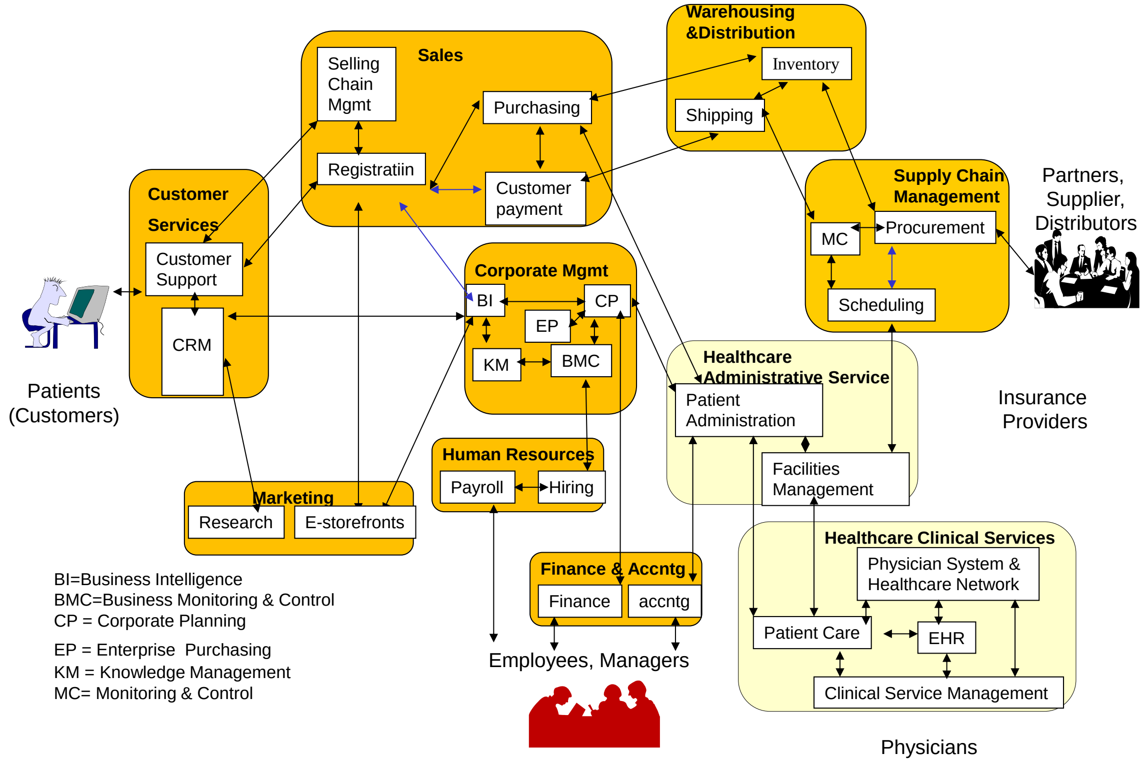


Figure 4: Business Process Pattern for a Healthcare Provider

P3 Phase (Implementation Considerations): The main output of this phase is a sample portal that can be installed, configured and extended easily by the users based on their location specific considerations. We will extensively modify this portal to satisfy the requirements of HIT.

P4 Phase (Monitoring and Controls): The progress of the project is monitored and controlled through project management techniques specified in the Project Management Institute Book of Knowledge. The quality of the results produced is evaluated by using the best practices in quality control based on ITIL.

P5 Phase (Business Intelligence Center): At the end of this phase, extensive documentation is provided to support the day-to-day running of the HIT service with basic support for Health Analytics.

4 Examples of Using SPACE4Health – Small, Medium, Large and Extra Large

4.1 Overview of Examples

The examples in this section hopefully provide further technical insights about SPACE4Health. It should be noted that possible real life application scenarios for a computer aided planning, engineering and management environment such as SPACE4Health are potentially very large. As noted in the technical architecture, the SPACE4Health advisors collaborate with each other and collectively support a very large number of practical planning scenarios. To illustrate, let us consider the following example. Suppose we add a new service (e.g., telemedicine) to the pattern repository. This service appears in the training materials to support staff education. The same service also supports games in telemedicine and healthcare. In addition, the strategic and detailed design advisors can now generate ICT plans for telemedicine for more than 100 countries by combining other patterns and data sources available in the knowledgebase.

SPACE4Health can be used to plan and architect very simple to very large and complex situations. Figure 5 shows four possible categories of scenarios (S1, S2, S3, S4) in terms of services and service providers. Examples of scenario categories are:

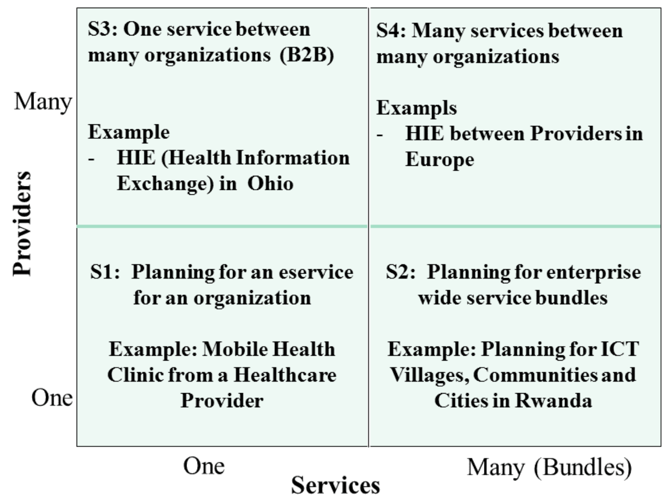


Figure 5: Service Scenarios in SPACE4Health

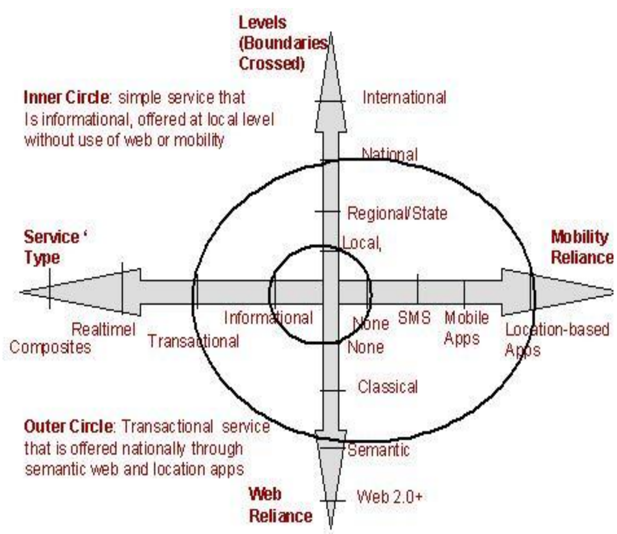
- S1 (small): This category represents single service for a single provider. The users of SPACE4Health at present can select more than 20 services from the healthcare sector. We plan to add 50 more healthcare services in the next two years. We will discuss deployment of mobile healthcare clinic as an example in section 2.4.2.
- S2 (medium): This category represents a service bundle by a single provider. As stated previous, many individual services can be combined to form service bundles that represent doctor's offices, health clinics, telemedicine centers, integrated practice units (IPUs), assisted living centers, health community centers, and healthcare agencies. We will discuss a Telemedicine IPU in section 2.4.3.
- S3 (large): This category represents a service shared by multiple providers. This scenario category can be used to model a large number of B2B services such as Health Information Exchanges (HIEs) between different healthcare providers and interagency services in governments.
- S4 (extra large): This category represents service bundles between multiple providers. This scenario can be used to model large and complex projects such as large health exchanges within a state or country. Section 2.4.4 describes an HIE between different providers.

At the time of this writing (January 2014), S1 and S2 are fully supported in SPACE4Health. S3 is supported at a very simple level and S4 is an area of future work. In fact, we plan to significantly expand S3 and S4 by using this funding opportunity. The details of what we know at present in these scenario categories are illustrated through examples of mobile health clinics, integrated practice units and health information exchanges. The examples here are brief --very detailed documents, tutorials, video clips and learning games that explain these capabilities are available at the SPACE website []. In addition, SPACE is available as a free SAAS, so an interested user can test the available capabilities.

4.2: S1 Example (Small) – Computer Aided Design of a Mobile Health Clinic Service

Mobile Health Clinics (MHCs), combined with the mobile computing technologies, have been highly effective in combating HIV and malaria, improving maternal health, and reducing infant mortality in --eru, South Africa, Uganda, and the Philippines. In particular, location-based text messaging applications have been highly effective to attract young people to mobile clinics that provide informational, testing, and/or clinical services. While there are many success stories about mobile clinics, numerous failures have occurred due to logistical issues (e.g., running out of supplies in the middle of nowhere), technology issues (no wireless signal in the area), procedural problems (healthcare professionals could not get visas on time), and social issues (some parents did not like their children to be invited to a clinic without parental consent). A *Mobile Clinic Support System* is needed to address the people, process and technology issues and thus assure repeatable success of these clinics. Figure 6a shows a conceptual view of a support system that leverages the latest ICT developments to serve the physicians, the patients, the healthcare facilities, the suppliers of materials and the regulating authorities. An MHC service, and all other healthIT services, can be offered at different levels and through different delivery mechanisms. The view presented in Figure 6b illustrates the main idea in terms of four dimensions:

a) Mobile Clinic Support System



b) Four Dimensional View of a Service

Figure 6: Mobile Health Clinic Design

- Service Type: a healthIT service can be informational only (e.g., provide information about different diseases), transactional (e.g., provide vaccinations), real-time (e.g., online telemedicine advice and consultation), and comprehensive (combination of informational, transactional and realtime). Each service type introduces unique planning, engineering and management (PEM) considerations.
- Levels (Boundaries Crossed): a health service, as an example, can be offered locally within a city, in a region/province, in a country, or internationally (across countries). Each boundary level also has its own unique PEM challenges.
- Web Reliance: The health service may just rely on pamphlets, may use simple informational websites based on static content, or may use dynamic sites with Web

2.0+ features. Higher Web reliance supports more sophisticated services to wider populations but also introduces more PEM challenges.

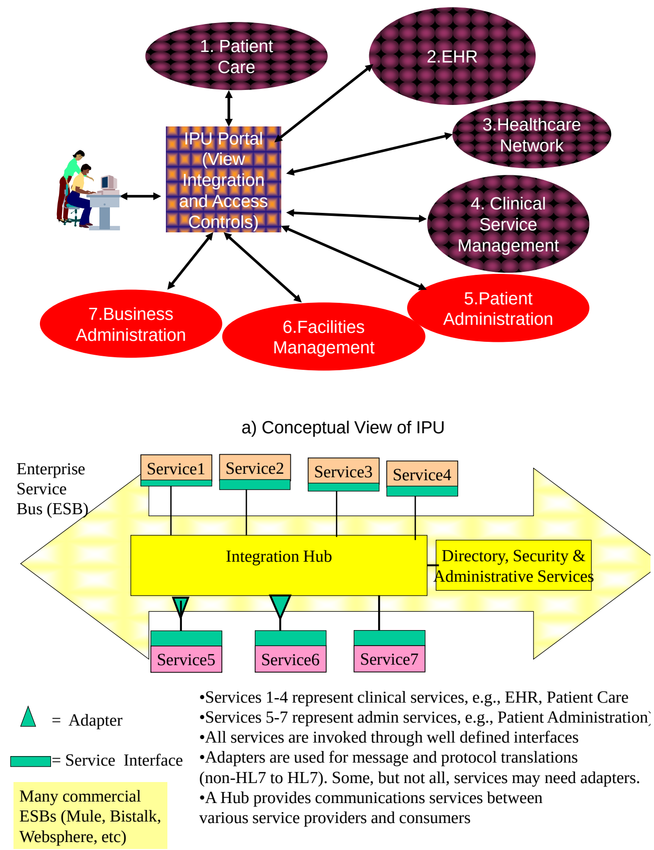
- Mobility Reliance: The services may rely on simple handsets for text messages to sophisticated location-based devices with sensor networks. Increased mobility reliance also enables more powerful services to wider populations but requires more complex infrastructure.

SPACE4Health advisors systematically guide the users through the phases (P0 to P5) of the Methodology introduced in Section 2.3 for an MHC service. In phase P0, the user selects the region/country where the MHC will be deployed and in phase P1 the user selects the four dimensions of the MHC service shown in Fig7b. Based on this information, P2 fetches the MHC business pattern and creates a high level design of the mobile clinic support system. P3 converts this high level design into a detailed technical design by using the appropriate technology and security patterns. P4 produces monitoring and control guidelines with heavy emphasis on project management and quality controls. P5 produces extensive documentation (requirements document, detailed design, and project management guidelines). P5 also produces a sample portal of the mobile clinic support system that can be used to quickly develop a production level mobile clinic support system. As mentioned previously, our goal is to produce 70% of the work needed to deploy this service. The rest 30% is done by the local experts.

2.4.3 S2 Example (Medium): Computer Aided Design for a Telemedicine IPU (Integrated Practice Unit)

S2 capabilities of SPACE4Health allow users to combine different individual services into enterprise-wide service "bundles" that are managed by one organization. This powerful feature, as stated previously, can be used to model doctor's offices, health clinics, telemedicine centers, integrated practice units, assisted living centers, health community centers, healthcare agencies and hospitals. We explain the basic capabilities by using the Integrated Practice Units (IPUs) as an example. As stated previously, IPUs are at the core of the value-based healthcare services that concentrate on the patient instead of the provider [24, 25]. But IPUs are not easy to plan, design and implement because the IT platform for IPUs is centered on patients and not providers, uses common data definitions, encompasses all types of patient data (e.g., physician notes, images, chemotherapy orders, lab tests, and other data), the medical record is accessible to all parties involved in care, it includes templates and expert systems for each medical condition, and is architected to make it easy to extract information [24]. Although IPUs can be established by large providers, they present major challenges for ambulatory services for the priority populations and underserved segments of our society.

A starting point of designing IPUs is the Healthcare Pattern shown in Figure 4. We propose an *IPU Support System* to address the people, process and technology issues related to IPUs for repeatable success. Figure 7a shows a conceptual view of an IPU support system that leverages the latest ICT developments to serve the physicians, the patients, the healthcare facilities, the suppliers of materials and the regulating authorities through 7 services. Services 1 through 4 concentrate on clinical aspects and services 5, 6 and 7 concentrate on administrative aspects of an IPU. Figure 7b translates this conceptual design to an SOA based architecture based on an enterprise service bus (ESB) that can offer a complete clinic based on the IPU model. Simply stated, an ESB provides Routing, Directory, Security & Administrative Services and may consist of one or more hubs for small or large organizations. In this architecture, HL7 is used as an exchange protocol on the ESB and the adapters convert the non-HL7 protocols to HL7. The IPU services may be remote telemedicine services such as tele-nursing and tele-pharmacy.



b): SOA View of IPU

Figure 7: Integrated Practice Unit Design Considerations

The SPACE4Health advisors systematically guide the users through the phases (P0 to P5) of the Methodology introduced in Section 2.3 for an IPU. In phase P0, the user selects the region/country where the IPU will be deployed and in phase P1 the user selects the four dimensional view of the IPU service. Based on this information, P2 fetches the IPU business pattern and creates a high level design of the IPU support system shown in Figure 8a. P3 converts this high level design into a detailed technical SOA-based design shown in Figure 8b by using the appropriate technology and security patterns []. P4 produces monitoring and control guidelines with heavy emphasis on project management and quality controls. P5 produces extensive documentation (requirements document, detailed design, and project management guidelines). P5 also produces a sample portal of the IPU that can be used to quickly develop a production level IPU system.

2.4.4 S3 and S4 (Large and Extra Large): Inter-Enterprise and Inter-Agency (B2B, G2G) Service Bundles: HIEs

To model large and more complex service bundles that include multiple independent agencies and organizations of categories S3 and S4, we have developed a "B2B Composer" that takes different services and composes them into larger and more complex service bundles that may represent health information exchanges of different size and shape. The B2B Composer is specifically designed to handle the interagency problems that require collaboration and coordination between multiple independent agencies. HIEs are not easy to plan, design and implement because they introduce serious interagency concerns. Figure 9 shows a conceptual view of an HIE pattern based on SOA with several local providers with their own private ESBs, and a regional ESB that interconnects the local EHRs to a regional EHR through HL7 exchange messages. This architecture is quite flexible and can be scaled to very large scale HIEs.

The SPACE4Health advisors systematically guide the users through the phases (P0 to P5) of the Methodology introduced in Section 2.3.3 for an HIE. In phase P0, the user selects the region/country where the EHC will be deployed and in phase P1 the user selects the four dimensions view of the HIE. Based on this information, P2 fetches the HIE business pattern and creates a high level design of the HIE. P3 converts this high level design into a detailed technical HIE design shown in Figure 9 by using the appropriate technology and security patterns []. P4 produces monitoring and control guidelines with heavy emphasis on project management and quality controls. P5 produces extensive documentation (requirements document, detailed design, and project management guidelines). P5 also produces a sample portal for the HIE shown in Figure 9. As mentioned previously, our goal is to produce 70% of the work needed to deploy an HIE. The rest 30% is done by the local experts.

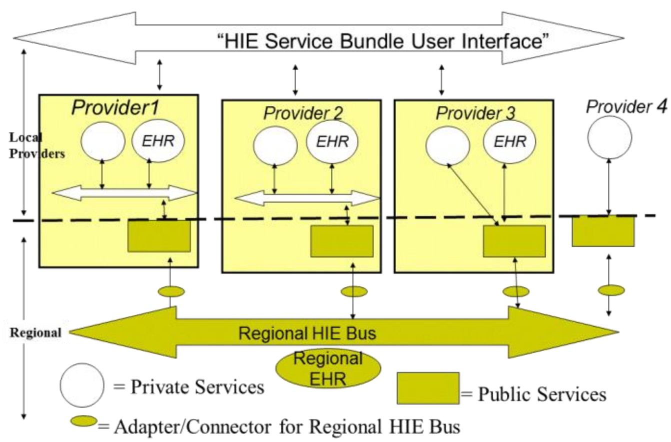


Figure 8: Health Information Exchange Technical Architecture Vision

Major References

[1] Porter, M. E., and Lee, T., "The Strategy That Will Fix Health Care", Harvard Business Review, October, 2013.

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