Our Partners

Computer Aided Planning, Engineering and Management for Smart Services and Enterprises

Amjad Umar, Ph.D.
Director and Professor of ICT Programs, Harrisburg University of Science and Technology
Adjunct Professor of Systems and Telecommunications, University of Pennsylvania
Chief Architect, United Nations-ICT4SIDS Partnership and Fulbright Senior Specialist in ICT
Email: umar@amjadumar.com

Abstract: Smart services and enterprises exploit a mixture of agility, detection, and learning capabilities to satisfy the end user needs. However, planning, engineering and management of these systems involve many decisions that require people, processes and technologies tradeoffs. This paper describes a decision support environment, called SPACE (Strategic Planning, Architecture, Controls, and Education), that systematically guides the users through the maze of strategic decisions needed to plan, architect, deploy and manage agile and smart services in the public and private sectors in global settings. We are currently focusing on smart hubs and smart towns for the United Nations ICT4SIDS (ICT for Small Island & Developing States) Partnership. The paper highlights the lessons learned based on our work through the United Nations with more than 30 countries and outlines research plans to support a very smart environment that detects problems early, adjusts accordingly and learns quickly by using extensive descriptive, predictive and prescriptive analytics.

Introduction

Smart services and enterprises exploit a mixture of agility, detection, and learning capabilities to satisfy the end user needs. For the purpose of this paper, we have adopted the following definition suggested by IBM: A smart system has three basic features, displayed as three axis in Figure 1:

- Detect (D) a problem/opportunity
- Adjust (A**)** quickly as needed
- Learn (L) to improve the future operations

In addition, we propose that a smart service must also satisfy the functional and non functional requirements imposed by the users – a system that does not provide the basic features needed by the users cannot be considered smart. Specifically, we contend that a smart system must provide the DAL (Detect, Adjust, Learn) features and also must satisfy the following:

- Functional requirements (e.g., the features provided by the service must be actually needed by the users and supported completely by the service.
- Non-functional requirements that include security and privacy considerations, usability of the service, interoperability and integration guidelines with other needed services, regulatory and standards compliance, and service continuity in case of disasters and outages.

For example, a smart environmental protection service must be a feature rich service that satisfies the performance and regulatory/security requirements of EPA (environment protection agency) and should *also* be able to:

- Detect pollution concentration in city streets (automatic alarms when the radiation level rises to a certain level)
- Adjust the system to shut down some sources if needed
- Learn what caused the pollution to prevent in the future and predict future pollutions instead of just detecting (predictive versus reactive mode)

The smartness cube shown in Figure1 illustrates how a "dumb" system with almost no capabilities for detection, adjustment or learning (point A) can gradually reach the smartest stage with 100% DAL capabilities (point H). An assessment of existing systems can be represented as different points on the cube and strategies to move towards smarter systems can be represented as different paths on the cube. Thus smartness can be introduced gradually. A wide range of technologies such as sensors, speech recognition, computer vision, pattern recognition, self-healing networks, mobile apps, data analytics, and intelligent workflow systems can be used to move existing systems to smarter points in the cube. However, technologies alone cannot make a system smart. In fact, smartness can be achieved through a combination of people, processes and technologies.

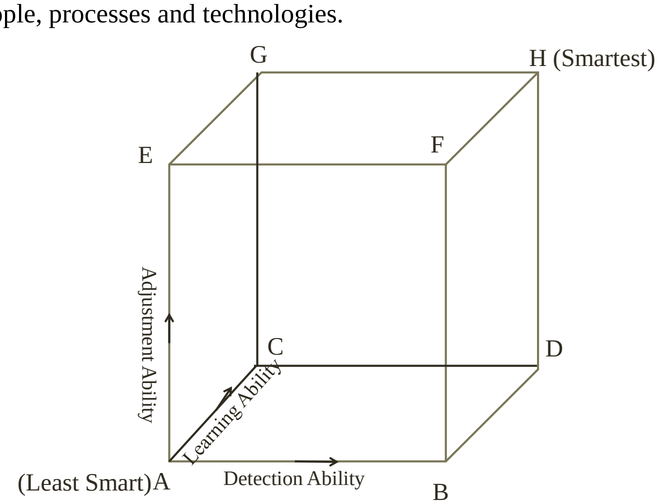

Figure1: The Smartness Cube

The Main Challenges

Many ICT projects are duplicating and re-inventing the wheel leading to a failure rate of 60-85% due to expensive retries [4, 7, 12]. "Smart" projects are no exception. Consequently, many smart projects will fail. Smart projects face additional challenges due to numerous technical as well as business/management decisions that involve

- People, processes and technology tradeoffs (e.g., can well trained people and efficient processes/policies compensate for the lack of technologies especially in developing countries).
- Small versus large projects considerations (e.g., should all components of a large system such as a city be smart and can a smart "bus" between dumb components make it smart).
- Regional factors that differentiate smart systems in the developed versus developing countries (e.g., will a smart city in Nepal be the same as a smart city in Belgium).

Consider, for example, a small city that wants to provide "smart" health and human services. What does that mean? A city supports several sectors that span health, education, public safety and public welfare and each sector provides several services (see Figure 2). All the sectors are interconnected through an ICT infrastructure and each sector also has its own internal ICT infrastructure to support its services, shown in Figure 2. Specifically:

- Which services in which sectors should be made smart? Large and complex systems (e.g., enterprises) consist of individual components and communication mechanisms between components.
- Small systems have few components, e.g., a small health clinic but large systems consist of many systems (systems of systems), e.g., corporations, cities, healthcare networks
- The components may be technology or human components.
- To build a smart system, individual components are smart (through DAL) or interactions *between* components are smart (e.g., healing networks)
- People, processes, and technology tradeoffs must be evaluated carefully instead of piling up technology bags. In particular, DAL features can be supported by people, processes, or technologies making tradeoff analysis necessary. Low technologies may be compensate through smart people and processes, However, if smart technologies are available, then less smarts are needed in people and processes.
- In developing countries, smart technologies may be available but not be suitable. For example, is it smart to build an automated smart system in Nepal that lays off 200 people (is it better to build smarts in people and processes?).

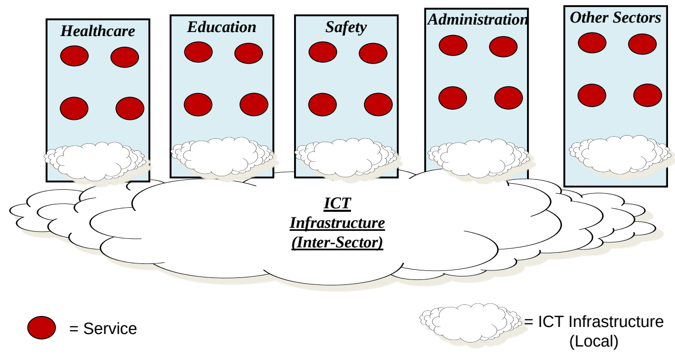

Figure 2: Conceptual View of a Smart City

A powerful decision support environment is needed to address these non-trivial challenges. Such an environment, presented in the next section, should suggest a set of criteria, toolkits, frameworks and advise users about how to build a roadmap and self-assess the "smartness" objectives.

Computer Aided Planning, Engineering and Management

We have developed SPACE (Strategic Planning, Architectures, Controls and Education) – a comprehensive planning, engineering and management environment -- for smart services and enterprises in developing countries. SPACE, spinoff of the United Nations eNabler Project, satisfies all these requirements. Specifically, it is based on best practices, considers local factors through early warnings, can be generated within an hour at a very low cost and also suggests solutions that support DAL. In addition, SPACE:

- Avoids failures due to reinvention of the wheel
- Generates detailed plans and solutions within an hour for cost that is suitable for the underserved sectors
- Supports a computer aided consulting model that can help launch a consultants without borders practice [8]
- Utilizes best practices and local factors through patterns
- Produces smart solutions based on people, processes and technologies tradeoffs

Most importantly, SPACE supports individual services that can be combined into complex "*service bundles*" to represent offices, community centers, corporations and cities. This allows us to plan and architect very simple to very large and complex situations as discussed below.

Figure 3 presents a conceptual view of the SPACE environment. SPACE primarily consists of a set of intelligent advisors and games integrated around a common knowledgebase. These components are described below.

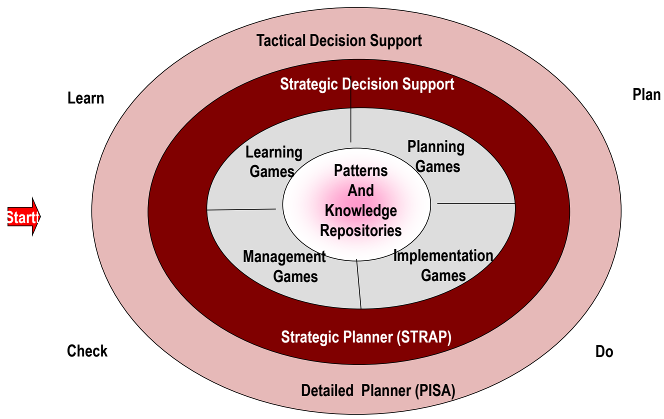

Figure 3:Conceptual View of SPACE

- **<u>Patterns and Knowledge Repository</u>** that captures the core knowledge needed by all SPACE tools. The pattern repository consists of industry patterns (e.g., health, education, public safety, public welfare, transportation), technology patterns (e.g., computing platforms, wired and wireless networks), operational patterns (e.g., security and integration patterns), and even country patterns (e.g., government patterns in different countries). [1, 2, 4].
- **<u>Games and Simulations</u>** that support decisions in strategic analysis, mobile services planning, security planning, interagency integrations and health exchanges, application migration versus integration tradeoffs, risks and failure management, and quality assurance.
- **<u>Strategic Planner:</u>** A strategic decision support tool for the IT officials in governments and the private sectors who need to strategically plan, architect, integrate, and manage the needed IT initiatives quickly and effectively by using the best practices.
- **<u>Planning, Integration, Security and Administration (PISA):</u>** A detailed decision support tool that can be used to quickly build real life business scenarios and then guide the user through IT planning, integration, security and administration tasks by using best practices and patterns.

Figure 4 shows an architectural view of the SPACE Environment that highlights the role of the Planner in producing the outputs. The Planner is a family of intelligent "advisors" (expert systems) that collaborate with each other to cover four phases (P0 to P4), shown in Figure 4. These advisors invoke the games, patterns, and other resources to generate the outputs shown in Figure 4. SPACE Advisors also use "Big Data" from the UN, the World Bank and other sources to trigger rules and make strategic decisions. These outputs can be further customized by local experts and/or end users. Additional information about SPACE can be found at the website www.space4ictd.com.

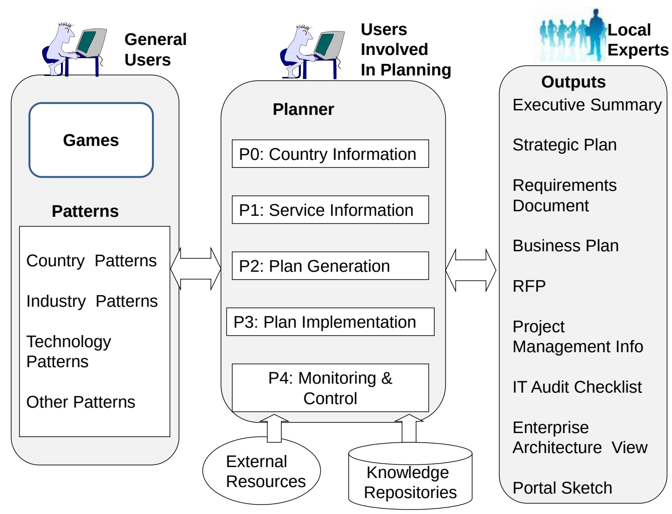

Figure 4: SPACE Architectural View

Examples of Using SPACE: Simple to Large & Complex

SPACE advisors in phases P0-P4 shown in Figure 4 are used to plan and architect very simple to very large and complex situations. Our initial experiments with SPACE have given us valuable insights from simple scenarios but have indicated much better cost-benefit ratios from larger scenarios. Thus we are especially interested in examining the benefits as well as the costs of large smart enterprise initiatives with many integrated smart services. The short examples in this section provide some technical insights about SPACE. It should be noted that possible real life application scenarios for a computer aided planning, engineering and management platform such as SPACE are potentially very large.

Figure 5 shows four possible categories of simple to large and complex scenarios in terms of services and service providers. Examples of scenario categories are:

- S1: This category represents single service for a single provider. The users of SPACE can select more than 100 smart services from health, education, public safety, public welfare and other vital sectors. For example, a user can select a Mobile Health Clinic as a simple scenarios.
- S2: This category represents a service bundle by a single provider. SPACE users can combine many individual services to form service bundles that represent smart hubs for health, education, public safety, public welfare or other vital sectors.
- S3: 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: This category represents service bundles between multiple providers. This scenario can be used to model large and complex projects such as smart cities and interagency projects and large health exchanges within a state or country.

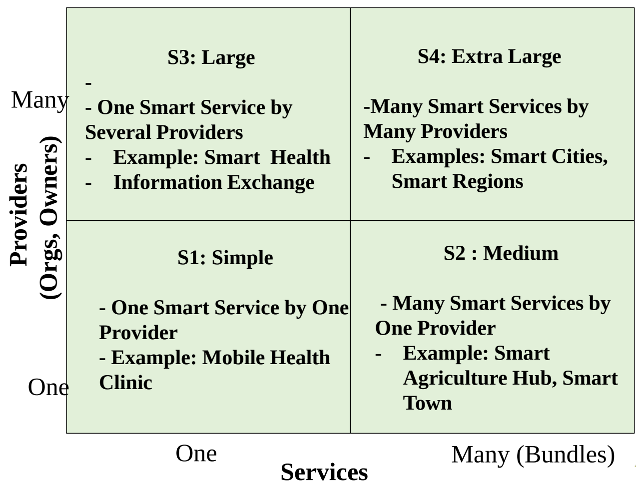

Figure5: Small to Large Scale Smart Systems

Figure 6 shows a conceptual view of a smart city pattern based on SOA (service oriented architecture). This pattern shows several agencies with their own private ICT infrastructures -- known as ESBs (enterprise service busses) – represented as big arrows. A B2B ESB serves as a smart broker between the agencies of the smart city. This architecture is quite flexible and can be scaled from small villages to very large cities. Let us assume that the individual service providers (agencies) are not smart but the Regional Broker that provides the interactions and collaboration mechanisms between the providers is smart: For example, in case of an emergency, this Broker:

- Detects a problem (large number of injuries)
- Adjusts and finds the most suitable provider (e.g., the closest hospital with capabilities for head injuries and facilities needed based on the patient EHR)
- Learns how to respond better the next time

Thus a smart ESB compensates for the lack of DAL capabilities in the providers. If one provider develops its own internal smarts (e.g., detects, adjusts and learns in emergency situations), then it augments the smart capabilities of the overall city. In developing countries, the needed smarts may be implemented through smart people and/or processes

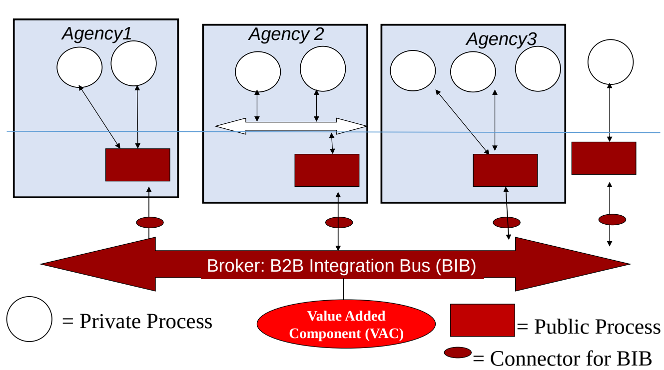

Figure 6: Technical View of a Smart City

The SPACE advisors shown in Figure 4 systematically guide the users through the phases (P0 to P4) to generate variations of the smart villages, towns and cities shown in Figure 6. We are constantly improving the SPACE capabilities to produce smarter services.

Concluding Remarks and Future Directions

Planning, engineering and management of smart services and enterprises involves many decisions that require people, processes and technologies tradeoffs. We are developing a decision support environment, called SPACE, that systematically guides the users through the maze of strategic decisions needed to plan, architect, deploy and manage agile and smart services in the public and private sectors in global settings. Our future work will focus on enriching SPACE into a smart decision support environment that detects problems early, adjusts accordingly and learns quickly by using extensive descriptive, predictive and prescriptive analytics.

References

[1] Adams, J., et al, *Patterns for e-Business: A Strategy for Reuse*, IBM Press, October 2001.

[2] Alexander, C., *The Timeless Way of Building*, Oxford University Press, 1979

[3] Bode, S., & Riebisch, M. *Tracing the Implementation of Non-Functional Requirements.* Retrieved Feb 2, 2014, from igi-global.com: http://www.igi-global.com/viewtitle.aspx?titleid=52227&sender=aa801e50-1c1f-45d0-96e9-348334b0606f, 2011

[4] Dada, D., *The Failure of e-Government in Developing Countries*, EJIDSC, Vol 26, no. 7, 2006,: http://www.ejisdc.org/ojs2/index.php/ejisdc/article/viewFile/277/176.

[5] Gamma, E., et al, *Design Patterns*, Addison Wesley, 1994.

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

[7] Rosenfeld, E., *After all this…. Why Do Projects Fail?*, http://www.adaptivepartners.com/projfailb.htm.

[8] Umar, A., *Computer Aided Consulting for Developing Countries*, *IEEE International Technology Management Conference*, Hague, June 2013.

[9] Umar, A., "Computer Aided Planning, Engineering and Management of IT Services", *IEEE International Technology Management Conference*, Dallas, June 2012.

[10] Umar, A., and Zordan, A., "Enterprise Ontologies for Planning and Integration of eBusiness*", IEEE Transactions on Engineering Management*, May 2009, Vol. 56, No. 2, pp. 352-371.

[11] Umar, A., Intelligent "Decision Support for Architectures and Integration of Next Generation Enterprises ", *Informatica*, V. 31, No. 14, pp. 141-150, 2007

[12] Weblink1: Standish Group Chaos Report, published annually by the Standish Group (www.standishgroup.com), last accessed: April 22, 2014

Biography of Dr. Amjad Umar

Dr. Amjad Umar is the Director and Professor of ISEM (Information Systems Engineering and Management) program at Harrisburg University of Science and Technology, and an Adjunct Professor of Systems & Telecommunications at the University of Pennsylvania. He is also Chief Architect of the United Nations ICT4SIDS Partnership and a Fulbright Senior Specialist on ICT. In his current position, he teaches graduate level courses in strategic planning of digital and smart enterprises, enterprise architecture and integration of digital and smart enterprises, information security, and strategic intelligence. He also supervises graduate research and practical projects in ICT4D – his main area of interest. As Chief Architect of the United Nations ICT4SIDS (ICT for Small Island & Developing States) Partnership, he currently is focusing on smart hubs and smart towns for the Small Island & Developing States.

His 20+ years of experience includes senior management and consulting/advisory positions with governments and industries around the globe. As a Director of Research at Bellcore (part of the Bell Labs system) for 10 years, he supervised large scale projects in IT planning, enterprise architectures and integration, mobile computing, information security, and collaborative systems. He is Founder/CEO of a startup that specializes in Computer Aided Planning of ICT-based Systems for the underserved populations. He has consulted with global telecom organizations, US Department of Navy, US Army Research Labs, Frost and Sullivan (England), Toyota Corp., Society of Manufacturing Engineers, manufacturing organizations, professional services organizations, and academic institutions in England, Singapore, China, Italy, New Zealand, South Africa, Argentina, Canada and more than 20 developing countries. He has written eight books and more than 50 research papers in his areas of specialization. He holds an M.S. in Computer and Communication Engineering and a Ph,D. in Information Systems Engineering, both from the University of Michigan.