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Computer Aided Strategic Planning for the United Nations Sustainable Development Goals (SDGs)

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Abstract— **The role of digital innovations to support the United Nations Sustainable Development Goals (SDGs) has been widely recognized in major recent publications such as the Cisco-ITU report on IoTs and the Ericsson-Columbia study of ICT4SDGs. These and other studies have identified short range and long range challenges that must be addressed. This paper introduces a computer aided planning, engineering and management environment that has been developed to address these challenges for rapid progress in health, education, public safety, public welfare, and other vital areas. This environment, currently operational for a UN Partnership, consists of a set of intelligent advisors that collaborate with each other in a fashion similar to a team of consultants who guide the user through an extensive array of choices throughout the learn-plan-do-check cycle. The intelligent advisors quickly produce highly customized plans for SDG services for different countries by integrating diverse techniques such as semantic web, Big Data, deep learning, enterprise ontologies, business patterns, and gamification. This paper emphasizes the practical and innovative applications of computer aided strategic planning for SDGs and other global efforts in smart cities and next generation enterprises. Experiences and insights gained in development, deployment, maintenance and methodologies for actual use of computer aided planning systems are highlighted.**

Index Terms—**SDG, ITU, ICT4SDG, Computer, SIDS.**

I. INTRODUCTION

The United Nations Sustainable Development Goals (SDGs) establish a 2030 Agenda based on 17 goals [1]. This major agenda, supported by all 193 countries, is a road map that builds on the success of the Millennium Development Goals [2] that was signed by 173 countries in 2000. SDGs focus on economic, social and environmental issues facing the 5 billion population of "have-nots" with the objective of "No One Left Behind". United Nations is strongly supporting SDGs through a large number of global initiatives and partnerships. Digital services, also known as ICT (Information and Communication Technologies) services, have been specifically identified for progress towards SDGs. For example, major reports, conferences, and websites sponsored by Cisco, Ericsson, the International Telecommunications Union (ITU), the United Nations, Columbia University, the World Bank and others have highlighted the role of ICT for SDGs [3, 4, 5, 9, 10, 11]. Our work strongly supports the SDGs and is driven by the following questions:

- What role can ICT play in accelerating the adoption of SDGs and other related initiatives
- What type of implementation vision is needed to actually achieve these goals
- What are the challenges in realizing the vision and what is the methodology needed to overcome the challenges
- What role can a computer aided planning environment play in this methodology to operate at a massive scale
- What is the technical architecture of such a computer aided planning environment
- What are the most significant results so far
- What are the specific examples of this approach
- What are the lessons learned and what are the next steps

We will attempt to answer these questions based on first hand experience gained in leading a UN Partnership that is focusing on ICT services for Small Islands and Developing States (SIDS). The ICT4SIDs Partnership [8] consists of 12 partners from academia, private industries, NGOs (Non-Government Organizations), and SIDS. The Partnership is heavily relying on an innovative computer aided planning, engineering and management methodology and a toolset to rapidly deploy ICT services to support the SDGs in health, education, public safety, public welfare and other sectors.

II. ICT INNOVATIONS TO SUPPORT SDGs

Table1 lists the 17 SDGs and also identifies a few ICT services that could significantly advance the core SDG priority areas. In addition to SDGs, we want to support additional goals specified by SIDS. For example, the Samoa Pathway document, signed by all SIDS, highlights the role of ICT: " (We need to) *establish national and regional information and communications technology (ICT) platforms and information dissemination hubs in small island developing States to facilitate information exchange and cooperation, building on existing information and communication platforms, as appropriate;*" (Source: Samoa Pathway Document, Para h, Section 109 [11].

Table1: Role of ICT Innovation to Support the 17 SDGs

Goal1.*End poverty in all its forms everywhere*. ***ICTRole:*** eCommerce hubs to support cottage industries and microfinancing support and entrepreneurship hubs for economic development [5, 11]
Goal2. *End hunger, achieve food security and improved nutrition and promote sustainable agriculture*. ***ICTRole:*** Agriculture hubs in rural areas with precision agriculture and food safety capabilities. Also use of IoT technologies to increase, protect, and optimize crop production, as well as improve the storage and distribution of food [3, 4, 5]
Goal3. *Ensure healthy lives and promote well-being for all at all ages.* ***ICTRole:*** Healthcare Advisory Hubs for aging and disabled populations in remote areas and hypertension telemedicine hubs in rural areas. Healthcare services that integrate e-learning, e-health and e-administration to offer inexpensive healthcare to remote populations; gamification for

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training of nurses and healthcare officials on needed areas [3, 4, 5, 11, 16]
Goal4*.Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*. ***ICTRole:***Education Hubs for adult education provided through community centers and colleges and use gamification for capacity building [3, 5, 11]
Goal5*. Achieve gender equality and empower all women and girls.* ***ICTRole:***Through Digital Hubs located in different locations that are equally available to all genders [3, 4]
Goal6*. Ensure availability and sustainable management of water and sanitation for all.* ***ICTRole:***Promotion of digital water initiatives [10] and extensive use of IoTs, Big Data and sensor enabled smart water pumps and sanitation outlets [3, 4]
Goal7*. Ensure access to affordable, reliable, sustainable and modern energy for all.* ***ICTRole:***Extensive use of IoTs, Big Data and wireless sensor networks to manage and control energy consumption [3, 4]
Goal8*. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.* ***ICTRole:*** Extensive use of ICT to support tourism, fisheries, entrepreneurship and cottage industries in different geographical areas [4, 5]
Goal9*. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.* ***ICTRole:***Aggressively exploit innovative applications of artificial intelligence and other ICTs to support entrepreneurship and cottage industries [4, 5].
Goal10*. Reduce inequality within and among countries.* ***ICTRole:*** Digital hubs, interconnected to other hubs, available to all countries and to all populations [4]
Goal11*. Make cities and human settlements inclusive, safe, resilient and sustainable*. ***ICTRole:*** Smart cities, Iot4D, Big Data and IBM Smarter Planet Initiatives [9, 16, 18, 4, 5]
Goal12*. Ensure sustainable consumption and production patterns.* Explore new enterprise systems for production, inventory management and for supply chain improvements [4, 5]
Goal13*. Take urgent action to combat climate change and its impacts.* ***ICTRole:*** Use sensors to detect and measure changes in ocean waves and weather conditions, and detect earthquakes by using BI and Big Data [3, 4]
Goal14*. Conserve and sustainably use the oceans, seas and marine resources for sustainable development*. ***ICTRole:*** Use interconnected sensors in various scenarios that upload the information to authorities via satellite for using Big Data analytics [3, 4]
Goal15*.Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt & reverse land degradation and halt biodiversity loss* ***ICTRole:*** Use connected alarm systems across high density urban areas to quickly notify residents of fast-moving fires [3, 4]
Goal16*.Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels*. ***ICTRole:*** Use the IBM Smarter Planet model in which several agencies interact with each other and support proper monitoring and controls for improved governance [9, 3, 4]
Goal17*.Strengthen the means of implementation and revitalize the global partnership for sustainable development.* ***ICTRole:*** Establish communications between hubs by using latest developments in B2B and G2G services [3, 4. 5].

III. IMPLEMENTATION VISION FOR SDGS

Figure1 shows the ICT4SIDS Partnership vision that is designed to implement the rapid adoption of the SDGs, Samoa Pathway and other initiatives such as the Jamaica Vision 2030. This vision shows several rural and regional hubs that are interconnected to larger national hubs that consolidate and disseminates vital information to other users, as specified in the Samoa Pathway document. These hubs also directly support the SDGs as specified in Table1. For example, an ecommerce hub supports economic development in Samoa for Goal1, an e-agriculture hub in a rural area in Solomon Island supports Goal2, and a hypertension hub in Haiti supports Goal3, etc. A Global ICT4SIDS Center provides central administration, analytics, and subject matter training and consultation services to all the hubs in the ICT4SIDS network. The individual hubs may be combined into highly effective community centers for remote villages and may be physical (e.g., rented rooms in a school) or completely virtual (e.g., portals located somewhere in the "Cloud"). Examples of ICT hubs are eSeva Centers in India that allow rural populations to pay bills and buy bus tickets, Telemedicine centers in Africa, and Community Centers for adult education by Faith-based organizations. This implementation vision directly supports the SDG goal17 as stated in Table1. We have estimated that more than 1000 hubs are needed in small islands alone. The objective of this paper is to show how this vision is being materialized by using a computer aided planning, engineering, and management methodology and a toolset.

IV. CHALLENGES AND THE METHODOLOGY ADOPTED

Given the massive scale and the ambitious vision presented in Figure 1, our major challenge is how to materialize this vision quickly, economically, and globally so that no one is literally left behind. Specifically, a large number of collaborating ICT hubs and a Global Center is needed for rapid adoption of Samoa Pathway and UN SDGs. However, implementation of this vision is a non-trivial task due to the following main reasons:

- Where exactly should a hub be located
- What type of service(s) should be provided for the area
- What type of energy and communications will be needed
- What type of ICT infrastructure will be needed
- What are the security, privacy and policy issues
- How can the funding and capacity building issues be handled
- How can the skill shortages in remote areas be addressed
- What are the project management and governance issues

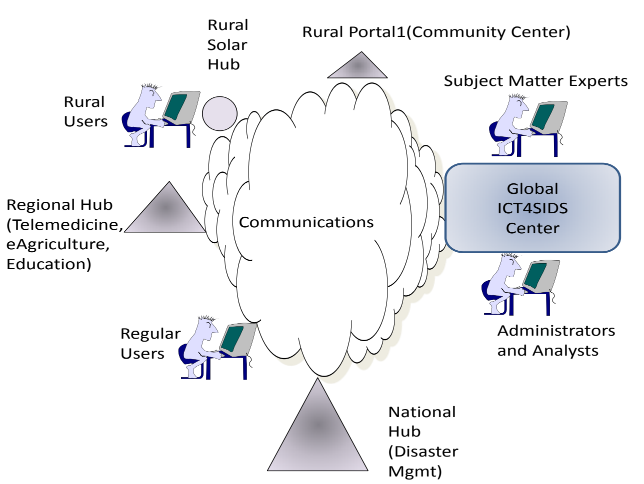


Figure1: Our Implementation Vision to Support SDGs

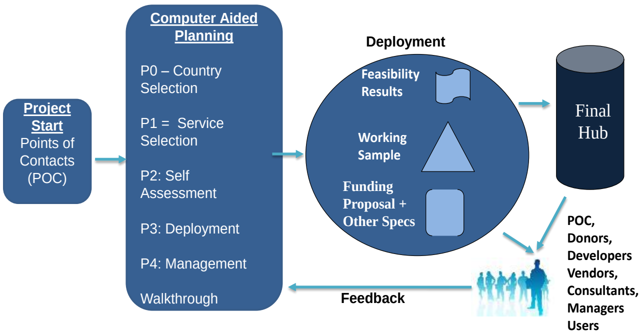


Figure2: Computer Aided Planning Methodology (Simplified)

Due to these and other complex issues, repeatedly mentioned in extensive studies [3, 4], the failure rates of ICT projects of this nature are very high – up to 80% in developing countries [24, 25, 26]. To address these challenges, we used the following three stage methodology displayed in Figure2.

- *Startup:* A Hub vision is proposed jointly by a SIDS and the ICT4SIDS team. A Pilot Project is initiated by a SIDS and a Point of Contact (POC) is appointed.
- *Computer Aided Planning:* A computer aided planning environment is used to conduct an extensive feasibility study within two hours and produce a funding proposal, an RFP and a working prototype of the selected Hub(s). The user is guided through several phases (P0 to P4) shown in Figure2 and explained later.
- *Deployment*: Results of the feasibility study are published in a Hub Portal and a Final Hub is created in collaboration with POC and local experts. Lessons learned are fed back into the computer aided planner for future improvements.

The objective of this computer aided methodology is to address the aforementioned challenges and to do more (provide more services to more customers) with less (less failures in less time and money with less trained staff). Specifically, this methodology can save $50K to $70K per hub, plus time (almost 6 months) and significantly reduce retries, errors and failures. We have learned several practical lessons, to be discussed later, by using this methodology that have improved our ability to select and train the POCs and also resulted in significantly improving the capabilities of the computer aided planning environment, discussed next.

V. ROLE OF COMPUTER AIDED PLANNING

A computer aided environment, called SPACE (Strategic Planning, Architectures, Controls and Education), is at the heart of the methodology discussed previously. SPACE is a powerful computer aided strategic planning environment that has been used extensively in the public as well as private sectors [12, 13, 14, 15]. Figure 3 shows a conceptual model of SPACE as it exists at the time of this writing. As shown, SPACE covers the entire Learn-Plan-Do-Check cycle to address the aforementioned challenges. SPACE uses an extensive array of capabilities that include patterns, games, decision support and planning tools, and specialized tools that invoke different capabilities for different types of situations. Specifically, SPACE consists of the following capabilities [9]:

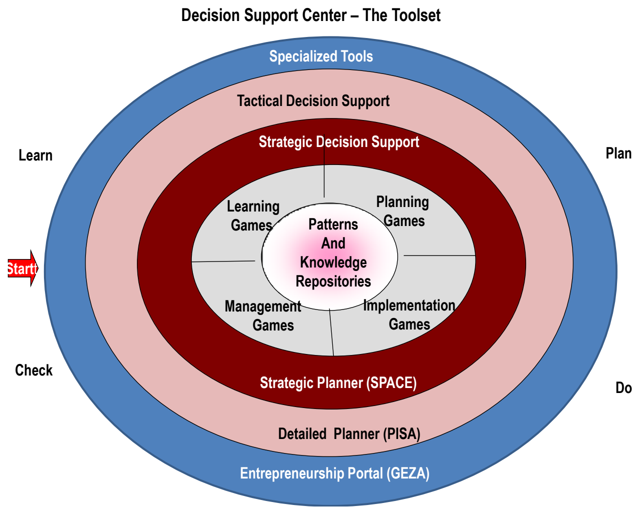


Figure 3: Conceptual Model of SPACE

- *The Knowledge Repositories* (the innermost circle) contain an extensive library of business and technology patterns and expose the users to educational materials, case studies, and examples needed throughout the cycle.
- *Games and Simulations* (the next circle) that support decisions in strategic analysis, mobile services planning, interagency integrations and health exchanges, application migration versus integration tradeoffs, risks and failure management, and quality assurance.
- *The Decision Support Tools* (the outer circles) contain strategic and detailed planning tools that systematically guide the users through various decisions in strategic planning, architectures, integration, acquisition, security, controls and project management activities.
- *The Specialized Tools* (the outermost circle) that present and customize special views of the inner capabilities for specific large scale projects. An example is a global entrepreneurship portal for economic development.

These capabilities are integrated with each other and collectively support a very large number of practical planning scenarios. These scenarios, discussed later, exemplify the novel applications of the SPACE environment. The scenarios start with utilizing the patterns (the innermost circle) and then move to higher level capabilities (the outer circles) that leverage the lower level capabilities and also exploit big data, deep learning, and ontologies.

Let us take a quick look at the SPACE Planner, shown in Figure 4, that covers five phases (P0 to P4). Each phase is supported by an advisor that provides phase specific guidance. The first two phases (P0 and P1) capture country and service specific information. P2 generates a customized plan based on P0 and P1. P3 supports execution of the plan and P4 supports monitoring and control with heavy emphasis on project management and quality controls. 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. The Planner integrates and aggregates the external information already available in knowledge portals and Open Big Data Sources. 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. As shown, the Planner produces a working portal plus extensive information.

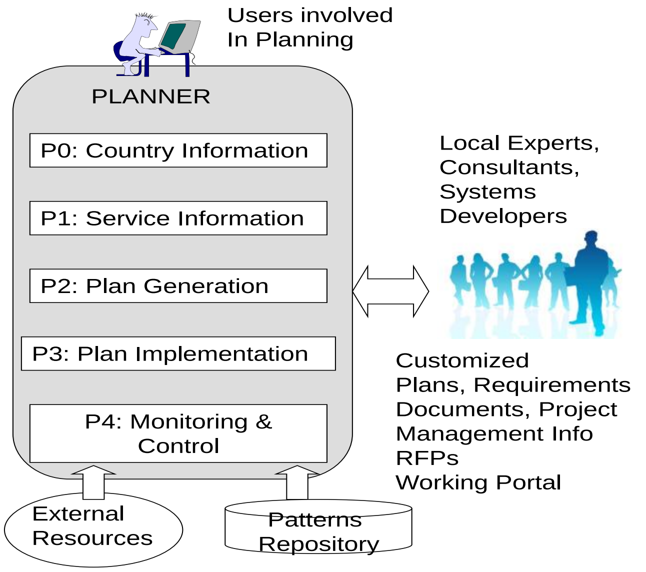


Figure 4: Planner Methodology – High Level View

VI. TECHNICAL ARCHITECTURE OF SPACE

Figure 5 shows the technical architecture of the SPACE environment. SPACE is not an expert system, but is a set of expert systems ("advisors") that collaborate with each other through an extensive knowledgebase and a powerful control engine with capabilities for scheduling, collaboration, inferences and learning. Basically, the SPACE users conduct simple interviews with the SPACE advisors that locate the most appropriate patterns and then these patterns are modified, extended and combined with other patterns to produce country and problem specific solutions. The outputs produced by SPACE contain a mixture of generic and customized information. The generic information captures common best practices (e.g., security). Country/ region specific information is customized by using the Open Big Data published by international agencies such as the World Economic Forum (www.weforum.org), the World Bank Institute Open Data (http://data.worldbank.org/) and the UN Department of Statistics (http://unstats.un.org).

The SPACE system is available on a web server as a SAAS (Software as a Service). The *User Interface Manager* controls authentications and directs the users to the needed advisors based on user background and problem type. For example, the users with minimal ICT background are only shown the Information Explorer and Gamification sections of the website.

The following *Advisors* guide the users through tasks that range from simple knowledge discovery (e.g., government patterns for a country) to development of complex ICT plans for digital cities to interagency communications:

- An Information Explorer that provides a quick reference (directory), and an overview of SPACE capabilities for the beginners. In particular, the Explorer provides browsel and search capabilities for the Patterns Repository for Industry Sectors (PARIS) that houses patterns for different business and government sectors.
- Gamification Advisors that support the eBusiness and eGovernment games being developed for SPACE. These games heavily rely on the patterns in PARIS to provide a context and knowledge. For example, integration game asks the user about industry sector (e.g., government) and thus brings in the industry specific knowledge (e.g., NIEM – National Interagency Exchange Model).
- Strategic Planning (STRAP) Advisors that guide the ICT officials in governments and the private sectors who need to actually plan, architect, integrate, and manage the needed ICT initiatives quickly and effectively by using the best practices. These Advisors collaborate with each other to develop strategic plans for more than 100 services in health, education, public safety, public welfare and other sectors. Details are given elsewhere[13].
- Detailed Planning, Integration, Security and Administration (PISA) Advisors: These detailed advisors collaborate with each other to quickly build real life business scenarios and then guide the user through detailed ICT planning, integration, security and administration tasks by using best practices. Details about PISA can be found in [12].
- Global Entrepreneurship Zone for All (GEZA): A knowledge portal that heavily relies on all other advisors to provide a set of knowledge services ranging from starting a business to international partnership and outsourcing opportunities. An extensive entrepreneurship game is currently being developed that heavily relies on GEZA.

These advisors and associated tools can be invoked independently but are also well integrated with each other (PISA knows about PARIS, SPACE knows about PISA, all games heavily leverage the business patterns in PARIS, and GEZA practically uses almost all SPACE capabilities to support entrepreneurship for developing countries. The core of SPACE is a *Knowledgebase (KB)* that contains best practices, patterns, and rules needed to address various domains in eBuisness and eGovernment.

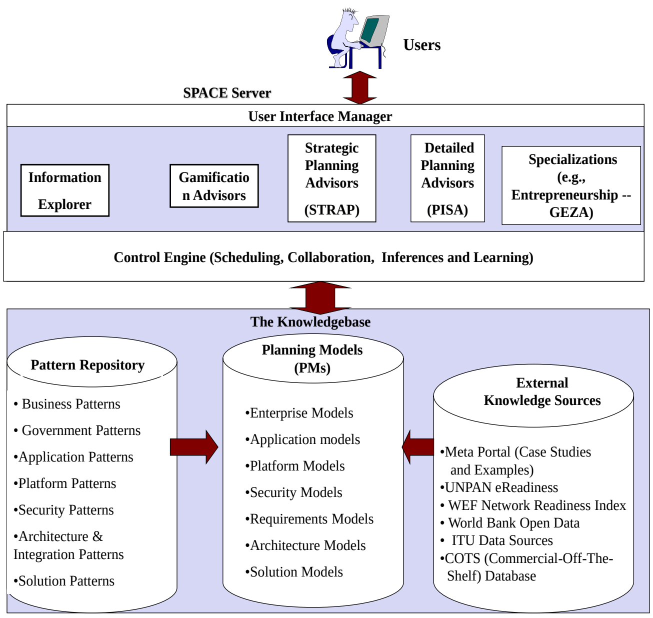


Figure 5: SPACE Technical Architecture

The SPACE advisors rely heavily on a *pattern repository* that houses government patterns for different government sectors and business patterns for more than 20 industry segments including education, healthcare, transportation, public safety, telecom, and manufacturing. The pattern repository also contains application patterns, platform patterns, network patterns, security patterns and integration patterns. Patterns play a central role in SPACE and are explained briefly in Exhibit 1. As stated previously, the users conduct simple interviews with the Advisors that locate the most appropriate patterns and then modify, extend and combine these patterns with other patterns. In addition to patterns, external sources from the World Bank and UN, along with commercial products are stored in a separate repository in the KB. The generated planning models are stored in yet another repository as shown in Figure 5. The knowledge in KB is stored as semantic web by using RDF (Resource Description Facility) and OWL (Web Ontology Language). The knowledgebase and its underlying ontology is explained in detail in [12].

The *Controller* is the control engine of SPACE and is responsible for scheduling, synchronization, collaboration, inferences and learning. Specifically, it coordinates the access to the KB and is responsible for collaboration between the advisors to support various user scenarios. It heavily utilizes case based reasoning (e.g., can a case study from Netherland be applicable to Nepal), fuzzy logic (when are two case studies and patterns similar), and neural networks for learning). All advisors collaborate with each other through the controller to support end user scenarios. For example, a game may be invoked during a planning process and vice versa. The controller uses the following common knowledge processing algorithm:

- Fetch the most appropriate pattern Tj from the Pattern Repository
- Based on Tj and user inputs Uj, develop an initial planning model PMj, and the knowledge accumulated so far (PMj-1)
- Read the external knowledge sources, and customize and enrich the planning model PMj.
- Capture the main changes made in the process to learn what is changed frequently in the patterns and what is not
- Update the pattern repository based on the changes made to the pattern (e.g., create subpatterns)

This common algorithm is based on the following relationship:

$$PM_j = f\,(E, U_j\,, T_j\,, PM_{j-1}, C_j\,) \text{ for j = 0 to 4}$$

This relationship shows that the planning model produced in phase j (PM_j) is constructed by using enterprise parameters such as country information (*E*), patterns T_j for phase j, accumulated knowledge PM_{j-1} in the planning repository, phase specific inputs U_j and COTS (Commercial Off-The-Shelf) database entries C_j for phase j. The advisors specialize this algorithm for their tasks as needed. The main output produced by this process is the planning model *PM*, a set which consists of several subsets where each subset represents results of a planning stage. The initial planning model (*PM*) created is a simple sketch that is successively enriched as more advisors are invoked. Basically, *PM* is a set which consists of several subsets and each subset is created by and maintained by an advisor. At the conclusion of an interview, a complete plan is represented in the *PM*, i.e., *PM* = {*M, A, I*} where *M, A,* and *I* represent the enterprise model, the application plan, and the integrated architecture plan, respectively.

All SPACE advisors are currently using AI at several levels. First, the advisors learn about changes made in the patterns by the user interviews and adjust the patterns accordingly. They also use supervised machine learning and Open Big Data from diverse sources to discover new patterns and detect new situations, We are also investigating natural language processing to generate UML diagrams based on feasibility reports generated. We are currently investigating Deep Learning by using the World Bank Open Big Data.

Exhibit 1: Quick Overview of Patterns

Patterns are a well-known format for capturing engineering knowledge. The idea was introduced by Christopher Alexander, a civil engineer, who wrote a series of books [20, 21] observing that well accepted buildings have common structures. Based on this, he devised a set of rules for architects to construct such buildings. According to Alexander, "Each pattern describes a problem that occurs over and over again in our environment and then describes the core of the solution to that problem in such a way that you can use this solution a million times over without ever doing it the same way twice"[21]. The "Gang of Four" extended the pattern format to software design [23]. Since then, patterns have been used extensively in software design and have been extended to e-business patterns [19] with good results. In addition, requirements patterns, architecture patterns, integration patterns, security patterns, and others have been developed [22, 27, 28]. See the website (www.hillside.net/patterns) for extensive discussion, tutorials, and articles on patterns.

At a very basic level, a pattern *T* is a tuple *T(p, c, s)* where *p* is the problem to be solved, *c* is the context (under what conditions the pattern holds, i.e., why the problem needs to be solved), and *s* is the solution (what works in practice). Additional information such as examples and limitations can also be added to a pattern to help the designer. In addition, each pattern is assigned a name. Some patterns can be quite detailed and complex.

VII. EXAMPLES OF REAL LIFE APPLICATIONS

It should be noted that possible real life application scenarios for a computer aided planning, engineering and management environment such as SPACE are potentially very large. At the time of this writing, SPACE Pattern Repository has more than 150 services that span 10 sectors such as health, education, public safety, public welfare, agriculture, utilities, transportation, and ecommerce. In fact, these patterns can enable many SDG goals listed in Table1. We are in the process of adding more patterns to the repository in the next few months. As noted in the technical architecture, the Pattern Repository (PARIS) supports the SPACE advisors that collaborate with each other and collectively offer a very large number of practical planning scenarios for the end users.

Let us consider the following example. Suppose we add a new service (e.g., telemedicine for blindness) to the pattern repository. This service appears in the Information Explorer and training materials to support educators. The same service also supports games in telemedicine and healthcare. In addition, the strategic planning and detailed planning advisors can now generate ICT plans for telemedicine for more than 100 countries by combining other patterns and data sources available in the knowledgebase.

To illustrate the diversity and range of possible application scenarios, Figure 6 shows four possible categories of simple to large and complex application 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 150 services from health, education, public safety, public welfare and other vital sectors. For example, a user can select 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 health clinics, digital community centers, smart towns, and small to medium enterprises.
- S3: This category represents a service shared by multiple providers. This scenario category can be used to model a large number of B2B scenarios such as Health Information Exchanges (HIEs) between different healthcare providers, supply chains 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 interagency projects and large health exchanges within a state or country. The ICT4SIDS vision presented in Figure 1 falls into this category because it interconnects and coordinates different hubs from different countries on different topics.

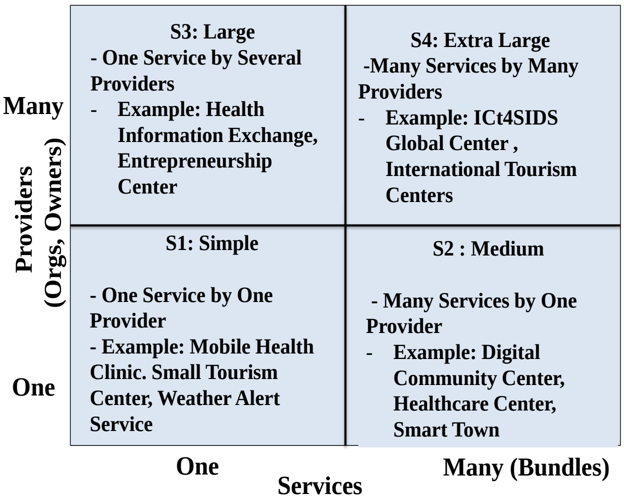


Figure 6: Application Categories from Simple to Extra Large

The following discussion presents four real life application examples from very simple to large and complex scenarios to support SDGs, based on the categories shown in Figure 6. The discussions are brief due to space limitations. Interested readers may use Exhibit2 to visit the major websites and engage in hands-on experiments.

Exibit2: Information for Hands on Experiments

- The ICT4SIDS Partnership site (www.ict4sids.com) provides a great deal of information about most of the SDG related work that has been reported in this paper. Especially the section on "Global Center" provides access to a demo site and all hubs and pilot projects that we are supporting at present.
- The SPACE site (www.space4ict.com) provides complete information about the computer aided platform that is supporting ICT4SIDs. Please visit the SPACE Learning Corner to see how SPACE is being used for education and training. For hands-on experiments on how SPACE actually works, please login as a guest and conduct different experiments.

Note: These sites are always work in progress and evolving.

*Scenario1: Mobile Health Clinics***.** It is well known in the UN circles that Mobile Health Clinics, combined with the mobile computing technologies, have been highly effective in combating HIV and malaria, improving maternal health, and reducing infant mortality in Peru, 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 (MCSS) is needed to address the people, process and technology issues and thus assure repeatable success of these clinics. A support system is needed that leverages the latest ICT developments to serve the physicians, the patients, the healthcare facilities, the suppliers of materials and the regulating authorities. Such a support system profoundly impacts the delivery of healthcare to different parts of the World and is of value to central governments, municipalities, cities, or NGOs (non-governmental agencies) with interest in operating MHCs around the globe. In addition, it can be offered with minimal technologies or sophisticated web and wireless support.

We are using SPACE to help plan mobile health support systems for remotely located populations that need urgent help. These systems are the *primary* healthcare method for countries like Southern Sudan where no established hospitals exist. Special considerations are also needed for mobile clinics in the Far East where remote populations can be reached only by boats. The SPACE patterns and advisors have been used extensively to generate plans for MHCs and MCSS.

Scenario 2: Digital Community Centers for Developing Countries. A Digital Community Center (DCC), also known as a Community Computer Center, is a place in a village, school, or city where the users can get access to needed services through ICT. In poor countries and areas where most people do not own computers, a DCC can become a hub of economic activity where people can access a variety of needed services by using digital devices and networks. The basic DCC service provides computer and communication infrastructure in a public place. Additional services may include government services, healthcare access information, basic computer education, vocational skills, information on government systems, bus tickets, market information, banking services, weather forecasts, legal advice, agriculture-related information, means of grievance redress, etc.

DCCs can also evolve into "Smart Communities" with capabilities to learn and adapt based on user populations. In Small islands, DCCs typically provide area specific capabilities such as fisheries and disaster recovery support. In most rural areas, a typical DCC looks like the following:

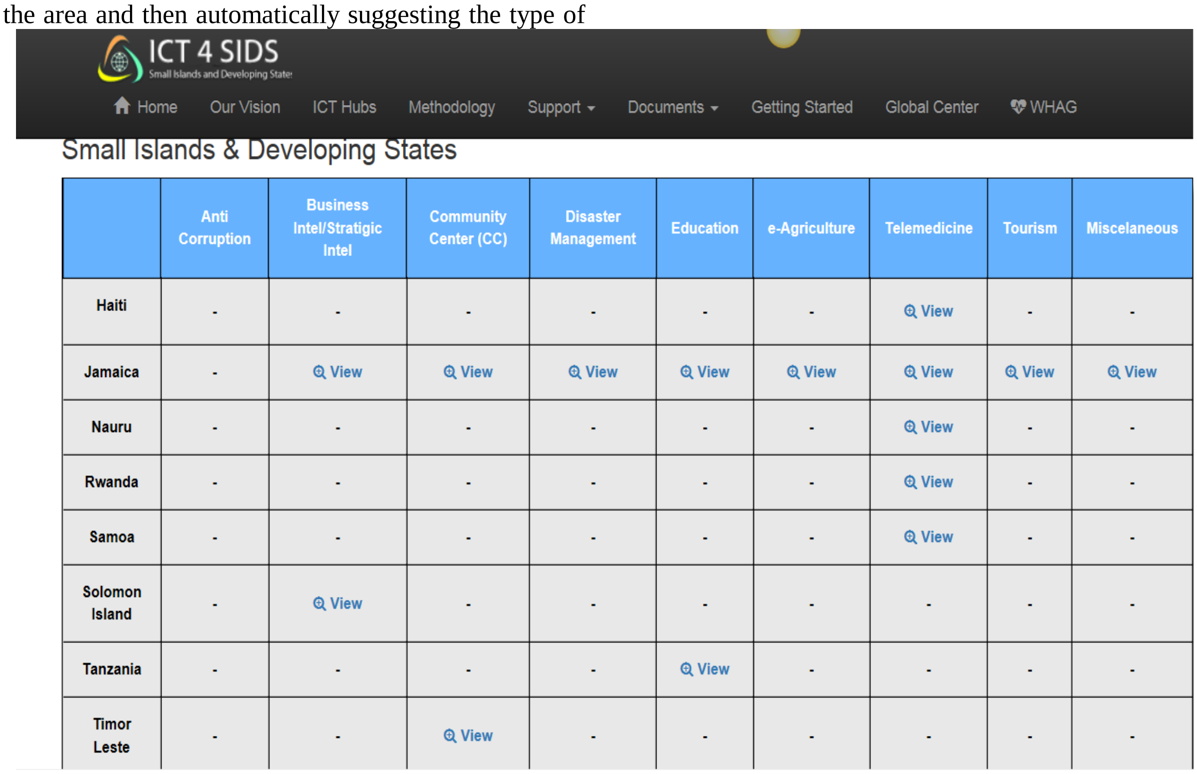
- A physical site (a small building around a bus stop, gas station or rented rooms in a school) that are close to the Internet Backbone.
- A solar powered micro grid for supplying power and communication capabilities through a satellite link
- Basic capabilities to support Skype and Microsoft Office
- A "Computer Room" with a small LAN of 10-12 Laptops/Desktops for access to health, education, agriculture and other vital information systems
- Rental of smart phones (Android, Microsoft, iPhones) for Mobile Apps
- A manager of the Hub, usually a high school teacher who works on a part-time basis

SPACE provides extensive capabilities for DCCs in different parts of the world by extensively using the big data available about the area and then automatically suggesting the type of services needed in the area of interest. The POC further customizes the DCC based on local knowledge.

Scenario 3: World Hypertension Center. Hypertension is the most impactful Non Communicable Disease (NCD) and is of vital importance to SDG Goal3. Specifically, about one third of adults in most communities in the developed and developing world have hypertension and Hypertension is the most common chronic condition dealt with by primary care physicians and other health practitioners. ICT4SIDS Partnership is working with the World Hypertension League (WHL) to form a World Hypertension Action Group (WHAG) Center that will support a large number of Hypertension Clinics (hubs) by using a Telemedicine model. The World Hypertension Headquarter, located at www.whag3all,org, provides the following capabilities that have been developed by using SPACE:

- *A Global Hypertension Database* that will focus on the developing countries and underserved populations (our goal is to capture 10 million blood pressure entries)
- *Advising services* by hypertension specialists, doctors, nurses and other medical professionals who diagnose the hypertension illness and advise the patients.
- *Reporting and Business Intelligence services* by analysts who will use decision support and business intelligence tools for visualization of the patient data stored on the Global Hypertension Database.
- *Education and Training Services* for educating nurses, patients and other healthcare students.
- *Research Investigations* on a wide range of topics that span medical and business issues of value to underserved populations.

Collaboration and Partnership Opportunities between different players (POCs, medical professionals, NGOs, educational institutions, data scientists, and medical researchers) involved in the World Hypertension Action Group (Whag).



	Anti Corruption	Business Intel/Stratigic Intel	Community Center (CC)	Disaster Management	Education	e-Agriculture	Telemedicine	Tourism	Miscelaneous
Haiti	-	-	-	-	-	-	View	-	-
Jamaica	-	View	View	View	View	View	View	View	View
Nauru	-	-	-	-	-	-	View	-	-
Rwanda	-	-	-	-	-	-	View	-	-
Samoa	-	-	-	-	-	-	View	-	-
Solomon Island	-	View	-	-	-	-	-	-	-
Tanzania	-	-	-	-	View	-	-	-	-
Timor Leste	-	-	View	-	-	-	-	-	-

Figure 7 Collaboration Matrix Between Different Hubs

Scenario 4: Global ICT4SIDS Center. This Center, shown in Figure1, represents the ICT4SIDS Partnership vision that is designed to implement the rapid adoption of the SDGs, Samoa Pathway and other initiatives such as the Jamaica Vision 2030. This vision shows several rural and regional hubs in different countries that are interconnected to larger national hubs that consolidate and disseminates vital information to other users, as specified in the Samoa Pathway document. These hubs also directly support the SDGs as specified in Table1. The Global ICT4SIDS Center provides central administration, analytics, and subject matter training and consultation services to all the hubs in the ICT4SIDS network.

This vision is being materialized by using SPACE. In particular, the hubs are being supported by portals generated by SPACE and the collaboration between different hubs is being supported by plug-ins that are automatically included in all portals generated by SPACE. Figure 7 shows the Collaboration Matrix between different hubs in the ICT4SIDS network. The rows of this matrix shows the SIDS (e.g., Haiti, Jamaica, Nauru, Rwanda, Samoa, Solomon Island, etc) and the columns show the different hub types (e.g., Business Intelligence Hub, Digital Community Center, Education, e-Agriculture, Telemedicine, etc). This matrix shows how different collaborations can be supported horizontally (i.e., same country but different hubs), vertically (i.e., same hub type in different countries), and diagonally (different hubs of different types across different countries). To actually see this matrix and observe collaborations, please visit http://ict4sids.com/intro.html. To see the Global ICT4SIDS Center, please visit http://ict4sids.com/Gcenter.html.

VIII. SIGNIFICANT RESULTS AND LESSONS

We have found that the proposed computer aided planning methodology based on the SPACE toolset can save \$50K to \$70K per hub, plus time (almost 6 months) and significantly reduce retries, errors and failures (from 80% to about 10%). In addition, we have learned several invaluable lessons in this project such as the following:

- Computer aided Pilot Projects are essential for rapid deployment of large number of collaborating ICT Hubs needed to support SDGs and other major initiatives
- The first two phases of our methodology (Project Startup and computer aided planning) are a complete success with very promising and repeatable results (high value with low cost). The major benefit is that the knowledge gained is fed back into the tool for improved future use
- Deployment phase needs some work. In particular, choice of Point of Contact (POC) and Funding are the key challenges that are being addressed at present. In particular, we have found that young entrepreneurs and school teachers are good POCs and hub masters.
- The SPACE tool is also a very effective capacity building aid for SIDS officials because it allows hands-on planning experiments – a rare opportunity for them.
- Computer aided planning is much more effective than totally computerized planning in real life situations. Specifically, computer aided consulting is a very attractive paradigm for automated planning and scheduling systems for ICT.
- Gamification has a great deal of potential for training and education of end users. Instead of one large system, we have found that most users very quickly start using smaller components of the system when presented as games.
- Although many knowledge sources are available, but there is no assurance that the knowledge is actually being *used* to make decisions, The computer aided planning approach assures that the best practices are automatically included in developing the plans plus the outputs produced.
- In a computer aided planning approach, new knowledge can be replicated to all operational hubs and in all hubs in the future. For example, if a new lesson is learned, it is quickly replicated and used. In addition, the hub portals generated by SPACE have plugged-in analytics and collaboration capabilities that are available to the poorest populations living in the remotest areas in the world.

We have also encountered some new challenges. The major challenge is training of the practitioners in the underserved sectors. To address this challenge, we have been improving the training and educational capabilities of the SPACE environment and have reorganized the SPACE website so that different user types are exposed to different sections of SPACE. A major limitation of the SPACE environment is that it produces a large number of reports that overwhelm some users. We are attempting to reduce the number as well as the size of reports produced and are also developing several games to improve user experience.

IX. EXPECTED CONTRIBUTION AND CONCLUSIONS

This paper has focused on a major problem that needs to be addressed at a global and massive level. Specifically:

- The SDG 2030 Agenda is a significant practical application problem that impacts over 5 billion people.
- The presented computer aided planning approach is of vital importance for SDGs because manual planning approaches are not adequate at this scale.
- Our work is based on a novel computer aided planning, engineering, and management environment that could accelerate the progress towards SDGs for the underserved population.
- The proposed computer aided planning tool (SPACE) is a powerful system that can develop plans for 150 services in 10 sectors, ranging from simple to very large and complex practical applications for 193 countries.

In conclusion, SPACE is currently an operational system that is actually being used to help developing countries and small to medium businesses to plan and engineer their systems. In addition, SPACE is being used extensively to support graduate courses and professional education in strategic planning and enterprise architectures and integration.

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