Computer Aided Strategic Planning for Rapid Deployment of Blue Economies

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Abstract: Blue Economies are supported by a wide range of cyber-physical solutions such as web portals, mobile apps, IoTs, robots and drones. These solutions need to be customized for different geographical locations with different capabilities and should be produced quickly and at massive scales to meet the specific demands of the SIDS and other countries. To complicate matters further, several government policies and industry guidelines regulate the deployment and use of many solutions. It is virtually impossible to handcraft the needed solutions individually and manually. This paper presents a computer aided strategic planning toolkit for rapid deployment of blue economies. This toolkit, called SPACE, operates as a factory that can rapidly build highly customized solutions very much like the auto factories that build millions of highly customized cars to satisfy needed safety and ergonomic requirements.

1. Overview of Blue Economies and The Role of Digital Technologies

According to the World Bank, Blue Economy is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem". Simply stated, Blue Economies are the economies based on the ocean that cover the entire life cycle of fisheries and the environment in which they survive. The common activities used in blue economy are marine aquaculture, fish processing, sea ports, coastal tourism, and shipbuilding and repair. New areas include desalination, marine biotechnologies, ocean energy and seabed mining. Figure1 shows a business-oriented view of blue economies. Most of the services, shown as light grey, are part of the core business services but two blue boxes show the blue economy services. Note that some of these are *Traditional Blue Economy* services (e.g., marine aquaculture, sea ports, coastal tourism, and shipbuilding and repair) that have been with us for centuries. However, others are *Newer Blue Economy* services such as desalination, marine biotechnologies, ocean energy and seabed mining.

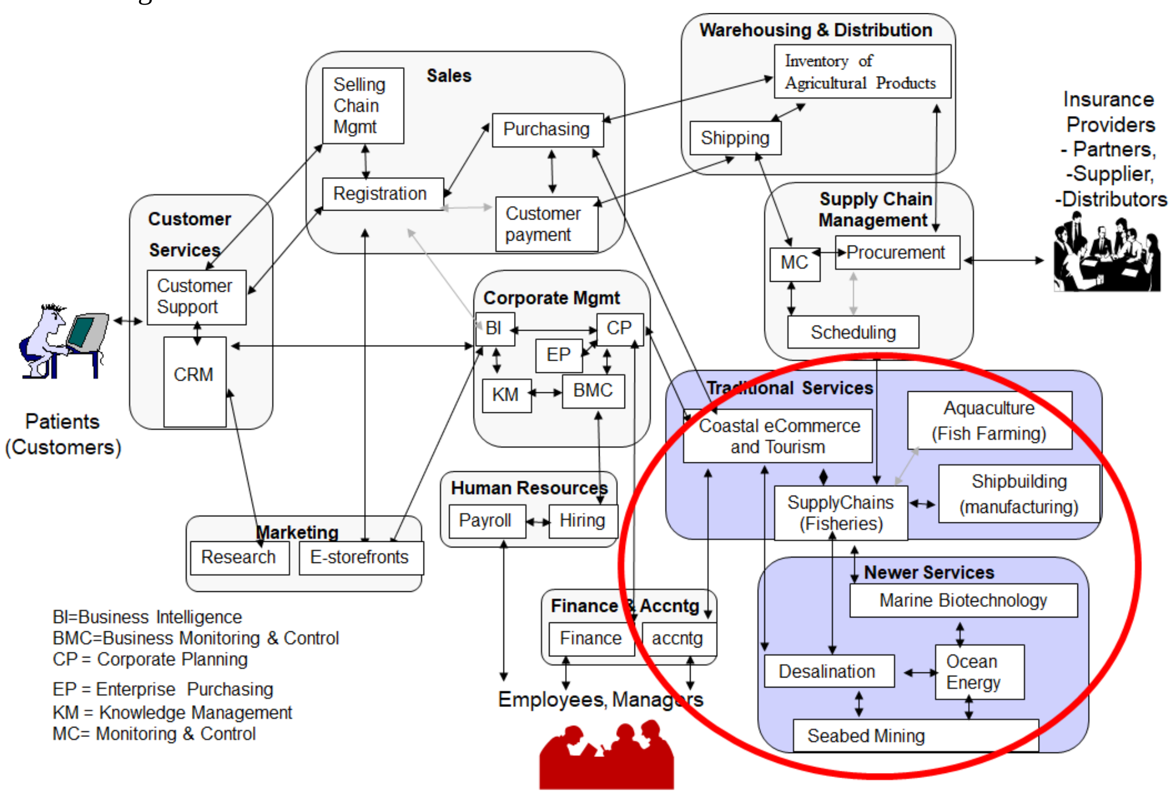

Fig 1: Blue Economies Business Pattern

The view presented in Figure1 is a "business pattern" that can be specialized and simplified for smaller businesses and islands. This business pattern captures the Blue Economy specific processes/services such as aquaculture, fish supply chains, seabed mining and others in the red circle. Although the main focus of Blue Economies is on ocean related services, displayed in the red circle, Figure1 also captures the general administrative processes such as customer services, sales, marketing, finance and accounting, and corporate management. In addition, the business processes (BPs) of warehousing and supply chains for the fisheries products and food distribution are shown. The common BPs (grey) are typically the same in any industry. However, some common services such as inventory management is now concerned with the fisheries or other ocean related products. This business pattern presents a big picture but ur main focus is on blue economy specific (blue) boxes that consist of:

- *Traditional* services that have been around for centuries (e.g., marine aquaculture & fish processing, sea ports, coastal tourism, and shipbuilding and repair)
- *New Blue Economy services* that have been introduced in the last few years (e.g., desalination, marine biotechnologies, ocean energy and seabed mining).

Use of Digital Technologies (ICTs) to accelerate blue economies offers an opportunity for SIDS (Small Islands and Developing States) and other countries to create new income streams and to diversify their economies. In particular, SIDS are endowed with vast ocean territories and exclusive economic ocean zones that they can exploit for economic growth. Strong growth is expected in almost all areas of blue economies. Figure2 shows a high level view of a Blue Economy Portal that supports the business pattern shown in Figure 1. Specifically, this portal provides the following ICT-enabled services:

- General Internet access, search and email services
- Core services such as general administration, marketing and customer support
- Warehousing and supply chain management services

The two blue boxes represent the blue economy specific services. Examples of the Traditional Blue Economy services are:

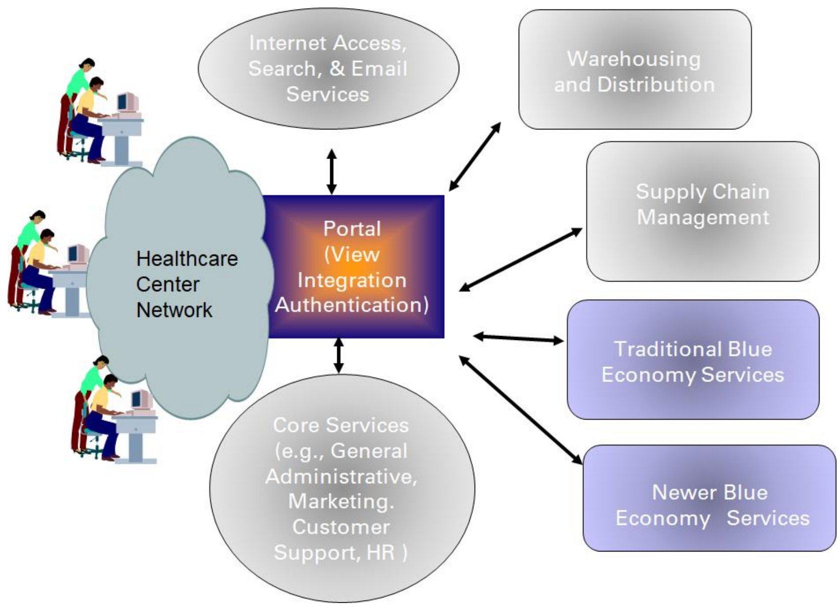

Figure 2: Portal View of a Basic Blue Economy Service Center

- Marine Aquaculture: growing fish and shrimp instead of chickens, cows and other livestock in agriculture.
- Fish Processing: processes associated with fish and fish products between the time fish are caught or harvested, and the time the final product is delivered to the market. This includes fisheries supply chains.
- Sea Ports: where ships may dock to load and discharge passengers and cargo. The sea ports also become hubs of fishery-based ecommerce and emarkets.
- Coastal Tourism**:** recreation oriented activities that take place in the coastal zones that attract tourists.
- Shipbuilding and Repair: part of manufacturing industry. Thus Industry4.0 (4th industrial revolution) and smart manufacturing are active areas of growth for shipbuilding.

Examples of the Newer Blue Economy services are:

- Desalination: taking away salt and minerals from the sea water to make it suitable for drinking and other common domestic and industrial needs.
- Marine Biotechnologies. combination of marine sciences and biotechnologies that uses robots and other AI capabilities (see for example, the MIT CSAIL Lab).
- Ocean Energy: movement of the **ocean's** waves, tides, and currents carries **energy** that can be harnessed and converted into electric power. This is the ocean version of hydraulic power.
- Seabed Mining: involves extracting submerged minerals and deposits from the sea floor. There are several interesting applications of computer vision in seabed mining.

2. How Can Digital Technologies Help to Accelerate Blue Economies

Many cutting edge technologies (e.g., 3D Printing, AI, Big Data with Satellite Images, Blockchains, Data Analytics, IoTs and Cyber Physical Systems, and Smart Mobile Apps) can be used to accelerate the adoption of Blue Economies in SIDS. Table1 shows a high level view of possible impacts of these technologies (represented as rows) and the main Blue Economy processes as columns. As displayed in Table1:

- **3D Printing:** 3D printers can produce robot fish that can be studied for better understanding of fish growth. 3D printers are also used for "printing" artifacts (e.g., jewellery and toys) for tourism and for recycling plastic waste to produce sunglasses, handbags, sandals, etc.
- **Artificial Intelligence (AI):** AI, especially when combined with Big Data, has many applications in almost all Blue Economy services as displayed in Table1. AI has applications in early disease detection of fisheries, in precision fisheries, in tourism, in robotics and Industry 4.0 for ships, robots for marine biotechnology, and seabed mining by using computer vision. Some AI apps use sensors to detect when fish are hungry and then feed them at that time only, thus saving food costs. AI algorithms have been also applied in desalination and water treatment and some robotic fish use AI to detect pollution underwater. Some of the tasks are complex -- the robots are sent out as a group and must be able to navigate their environment, avoid obstacles, including those of other robotic fish, recharge themselves at charging stations and generally make decisions autonomously of humans.
- **Blockchains:** Simply stated, blockchain is a Digital Ledger (i.e., a record of transactions) that is accessible publicly and is incorruptible by any one person. This means that transactions between suppliers and purchasers can occur immediately and safely. This makes blockchain a popular technology for trade at seaports and also for monitoring the safe transportation of fish in supply chains (i.e., assuring that the temperatures were kept at desired levels during the transportation).
- **Data Analytics:** These models can be used in Smart Fishery supply chains, predictive (regression) and prescriptive (optimization) models can be used for optimal resource allocations in many blue economy services such as salination and ocean energy. Satellite image processing through machine learning algorithms that recognize objects has many applications in Blue Economies. Examples span comparative studies of aquafarms and detecting the presence of fish in the sea to inform the fishers where and what type of fish are located where – this is of direct economic value to the fishers.
- **IoTs and Cyber Physical systems (e.g., Robots and Drones): These technologies are being used from** ship building to marine biotechnologies. Sensors are used in many of the drones and robots to navigate underwater and collect needed data. Some sensors offer real-time monitoring of fish activities and connection to cloud-based analytics. Robots actively sort sick or harmed fish as well as those that are ready for processing. Other robotic opportunities in our oceans include large-scale, solar-powered robotic vacuum cleaners that could pick up around 150 tons of plastic from the ocean. Drones can be utilized for monitoring offshore fish farms and survey the ocean and provide analysis through the use of sensor technology. Some drones even include a virtual reality headset that allows users to explore open water while staying dry. Drones can also collect information that can be used to create predictive models.
- **Smart Mobile Apps**. These apps integrate many of the aforementioned technologies, and invoke others remotely, for almost all of the Blue Economies. There appears to be a mobile app for almost everything we do.

Table1: Digital Technologies for Blue Economies – A Quick Overview

Technologies	Aquaculture	Sea Ports & Tourism	Shipbuilding & Repair	Desalination	Ocean Energy	Seabed Mining	Marine Biotech
3D Printing & Other Core technologies such as Web & Databases	Produce robot fish for studies in fisheries	Jewelry and toys for tourism, recycle , plastic waste	Models of ships, basically Industry4.0 for ships				
AI & Big Data with - Satellite Images	Early disease and appetite detection in fisheries	AI for Tourism (e.g., for marketing & sales)	Robotics & Industry 4.0 for building &repairing ships	ANNs in desalinate-ion and water treatment	**AI** to accelerate **tidal power**.	Seabed Mining by Computer Vision	Robots for Marine Biotech, (MIT CLab)
Blockchains	Fishery supply chains	Secure transaction ecommerce					
Data Analytics	Smart	Descript. & Predictive	Prescripti	Predictive & prescriptive	Cognitive Analytics for	Cognitive Analytics for	

(including Cognitive Anaytics)	Fishery SCM	models for tourism	ve Models for Materials	models for clean water	Energy	Mining	
IoTs & Cyber Physical Systems	Robotics foe Aquaculture		Industrial IOTs for shipbuilding	Industrial IOTs for Desalination Plants	Sensors for Energy **Conservation**	Robotics for Seabed Scans	IoT & M. Biotech
Smart Mobile Apps	Apps for Fish Processing)	Apps for Sea Ports markets & Tourism	Apps for Shipbuilding & Repair	Apps for Desalination	Apps for Energy Mgmt	Apps to support Seabed Mining	Apps for Marine Biotech

3. Computer Aided Strategic Planning for Blue Economies

Rapid deployment of blue economies around the globe require a wide range of digital solutions that need to be customized for different geographical locations with different capabilities and need be produced quickly and at massive scales under different government policies and industry guidelines. It is virtually impossible to handcraft the needed solutions individually and manually for every location and user needs. We have developed a factory model that builds highly customized solutions rapidly very much like the auto factories that have built millions of highly customized cars that integrate multiple technologies to satisfy needed safety requirements. Specifically, we are using a computer aided planning, engineering and management approach that is based on a "factory" model and is especially useful for Small to Medium Businesses and Towns (SMBTs). Our *software factory is* illustrated in Exhibit1.

Our vision is to use the SPACE (Strategic Planning, Architecture, Controls & Education) toolset, introduced in Exhibit1, as a "Factory" to rapidly generate needed artifacts blue and other economies. Specifically, we are requiring that the solution services *must* be: a) low cost (i.e., affordable by SMBTs) but high impact, b) location and topic specific, c) integrated with each other, and d) smart so that they can acquire new knowledge automatically for better performance in the future. As a test-case, we have used the SPACE factory to populate portions of a Smart Global Village (SGV) – a *sandbox* with more than 800 "smart hubs" for 135 countries and spanning 12 sectors including disaster resilience and management. *As discussed below, we are now including blue economies as a new sector, especially for SIDS.*

Exhibit1: Example of a Software Factory

The SPACE (Strategic Planning, Architecture, Controls and Education) environment behaves as a software factory that quickly produces *Smart Collaborating Hubs (SCHs)* as shown in Figure3. An SCH is a center of activity that contains highly specialized and smart artifacts such as an Administrative Portal, a Citizen App, Training Materials and relevant Policies on a particular topic. Most importantly, all SCHs have pre-fabricated capabilities for collaboration with each other. The main input of SPACE is a Patterns Repository that contains an extensive library of business and technology patterns that can be combined into complex "bundles" to represent smart community centers, towns, cities and commercial enterprises spanning multiple sectors.

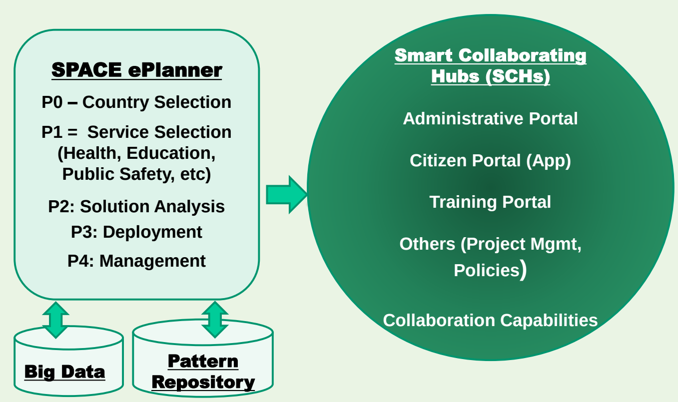

Figure 3: SPACE Factory that Generates Smart Hubs

Figure 7 shows our methodology that rapidly produces smart collaborating hubs by using the SPACE (Strategic Planning, Architecture, Controls and Education) environment. The integrated tools of the SPACE environment support the following phases of the Methodology:

- PHASE1: User decides what needs to be implemented where (e.g., an emarket in Jamaica) and invokes an appropriate advisor (e.g., an SDG Advisor to strengthen SDGs in an area) from our growing library of advisors. We are currently developing a Blue Economy Advisor, briefly described in Exhibit2, that will suggest the strategies to launch the most appropriate blue economy services in a particular location. This phase is essentially a "pre-processor" to PHASE2.
- PHASE2: The user invokes the SPACE ePlanner (the "factory") to generate a smart collaborating hub plus a strategic plan, feasibility study, funding proposal, an RFP, project management guideline and other artifacts needed to support the hub. For example, the ePlanner generates most of the artifacts needed to support a telemedicine or tourism hub.

- PHASE3: The artifacts generated by the ePlanner are analyzed/revised and a final smart hub is created. The final hub is "registered" in the Collaboration Network that interconnects all smart hubs (e.g., a community center in Solomons is registered for collaborations with any smart city, town or community on our network). Any "post-processing" (e.g., feeding the ePlanner artifact to a 3D printer) are also conducted in this phase.
- PHASE4: The results are finalized and hub administrators go through training for smooth operations.

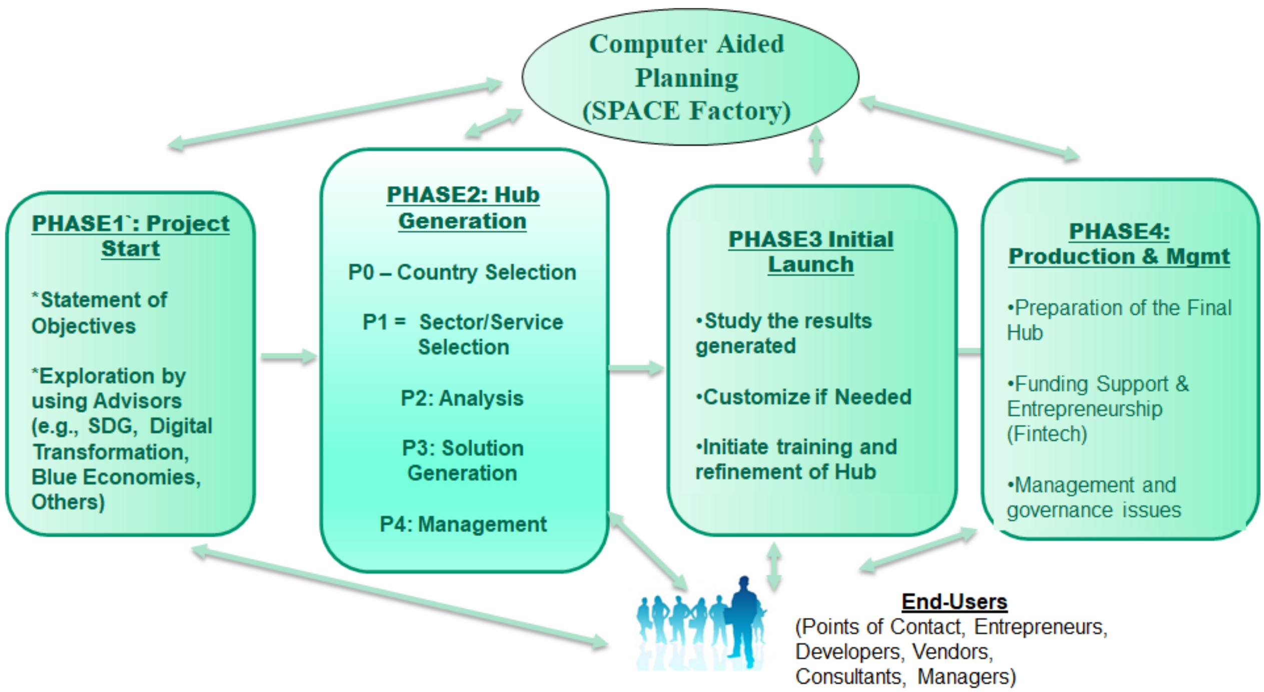

Figure 4: Computer Aided Planning, Engineering and Management Methodology based on SPACE Factory

Exhibit2: Overview of the Blue Economy (BE) Advisor

The main objective of this Advisor is to help the SIDS decide which one of the 9-10 BE services should be launched first and which ones later or not at all (i.e., develop a BE Strategic Plan). For example, given Samoa and the following BE services (marine aquaculture, fish processing, sea ports, coastal tourism, shipbuilding and repair, desalination, marine biotechnologies, ocean energy and seabed mining) should be launched first. The Advisor first chooses a country (e.g., Samoa), and then selecta a service the Business Pattern in Fig . The Advisor eliminates some services in each step due to some considerations (e.g., cost, SWOT). It then does Technology Analysis roughly based on Table1 to determine which technologies available in Samoa could reduce the costs and increase the benefits, etc. Once done, the Advisor could invoke the SPACE, or another Tool, for detailed planning and implementation of the chosen services. More information about this Advisor will be provided later.

4. Sample Results – A Smart Global Village and a Smart City & Communities (SCC) Lab

Since 2015, we have been using the SPACE Environment to support our work with the UN ICT4SIDS Partnership, NSF work on Smart and Connected Communities (SCCs), local and regional initiatives such as Digital Pakistan that is now evolving into Digital Asia, urbanization initiatives such as the Consortium for Urbanization, Digital Transformation initiatives spurred by COVID19, and now the Blue Economies issues. In parallel, the SPACE Environment has been used to teach graduate level courses in Strategic Planning, Enterprise Architectures and Integration, and Smart Cities and Communities. As a result, large number of NGOs, government officials, industry personnel and graduate students have used SPACE. Instead of different toolsets for different audiences and problem domains, we have used SPACE as a single factory with different preprocessors and post processors for different audiences. This thinking is reflected in the Methodology presented in Figure4.

As a consequence of large number of experiments around the globe, SPACE has generated a Smart Global Village (SGV) -- a large sandbox (more than 800 hubs spanning more than 130 countries) for all SPACE users. Figure 5 shows the overall SGV. We have also used SPACE as a factory to generate the Smart City & Community (SCC) Lab that consists of a set of *Smart Collaborating Hubs (SCHs) for SCC communities.* Figure 5 shows the SCC Lab also. These hubs offer topic and location specific services and are also interconnected through a smart collaboration network with *some* Knowledge, Detection, Adjustment and Learning (KDAL) capabilities. The SGV and SCC Lab are being used extensively to develop very interesting and innovative collaboration scenarios for healthcare exchanges, entrepreneurship networks, emarkets and global supply chains. We are using a system of systems approach to gradually make the SGV and SCC Lab smarter: a) gradually make the individual portals in each hub smarter, b) make each hub smarter by improving the collaboration between portals in each hub, and c) make the overall SCC Lab smarter by making the collaboration *between the* hubs smarter through better user community involvement. Basically, smart cars gradually become more effective as better digitized road maps become available and smart cars and smart roads, with sensors, learn from each other and become much smarter over time.

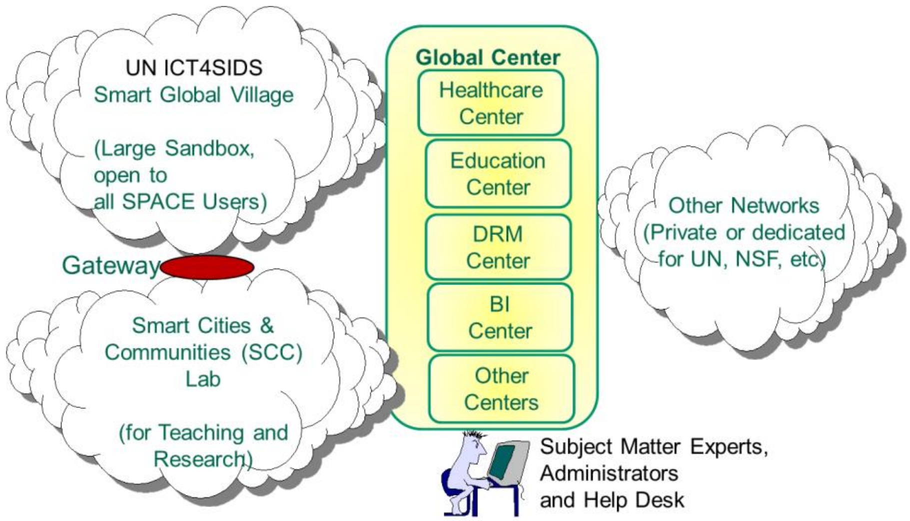

Figure 5: The Smart Global Village

5. Concluding Remarks

Large initiatives such as blue economies require a wide range of digital solutions that need to be customized for different geographical locations with different capabilities. These solutions need to be produced quickly and at massive scales to meet the specific demands of various populations and under different government policies. It is virtually impossible to handcraft the needed solutions individually and manually for every location and user needs. We have developed a factory model to rapidly build highly customized solutions very much like the auto factories that build millions of highly customized cars to satisfy needed safety requirements for different user populations. Our factory-based methodology has produced a Smart Global Village (SGV) that is growing rapidly.

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