SmartMesh®   MeshBox®

SGIN

Space Ground Integration Network
for

SUNSHINE

SGIN UNiversal Sustainable HyperMesh
INfrastructure Ecosystem

2020.02.19

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1. Introduction and Motivation

If you want peace, work for justice.

- Pope Paul VI

*Si vis pacem, para bellum (*If you want peace, prepare for war [latin])

- Parabellum – John Wick Chapter 3 movie

This call for action brings together Ecosystem partners, led by SmartMesh and MeshBox to effectively address the 17 UN Sustainable Develop Goals (UN SDG). Using advanced, next-generation technology, we aim to equip the underserved with tools to educate and make a living for themselves, with dignity and the freedom to choose their own path out of the clutches of poverty.

Together, we choose peace, by working for justice.

Project SUNSHINE has the goal of helping to address the SDGs.   To be effective, SUNSHINE must be sustainable itself, which is achieved due to the following technology and business models:

- Space-Ground Integration Network
- HyperMesh Infrastructure for the Underserved
- Working for the UN SDGs Generates Wealth in the Community
- Keeping the Wealth in the Community
- Incentivizing Operations through Shared-ROI

2. Space-Ground Integration Network (SGIN)

Our current Cyber-Physical Infrastructure is a technological marvel, gifting mankind with tools to innovate at an ever increasing exponential rate. We depend on such innovation if we are to survive and thrive as a species.

However, the need for faster, higher-bandwidth, exchange of information and monetary transactions continues to expand exponentially in scope, even bringing in everyday objects and machines. The current infrastructure is inefficient and suboptimal, due to the centralized nature of the business model, and by the resulting centralized networks which have been created.

The next generation infrastructure, for both developed and developing countries, will not be just another iteration on the previous architectures.   Rather, it will be a *HyperMesh*™ architecture, a *distributed*, synergized blend of networking, computing, content distribution, financial technology, and cyber-physical infrastructures.

A vital component of the HyperMesh, for inclusive proliferation of internet access is the Space-Ground Integration Network.
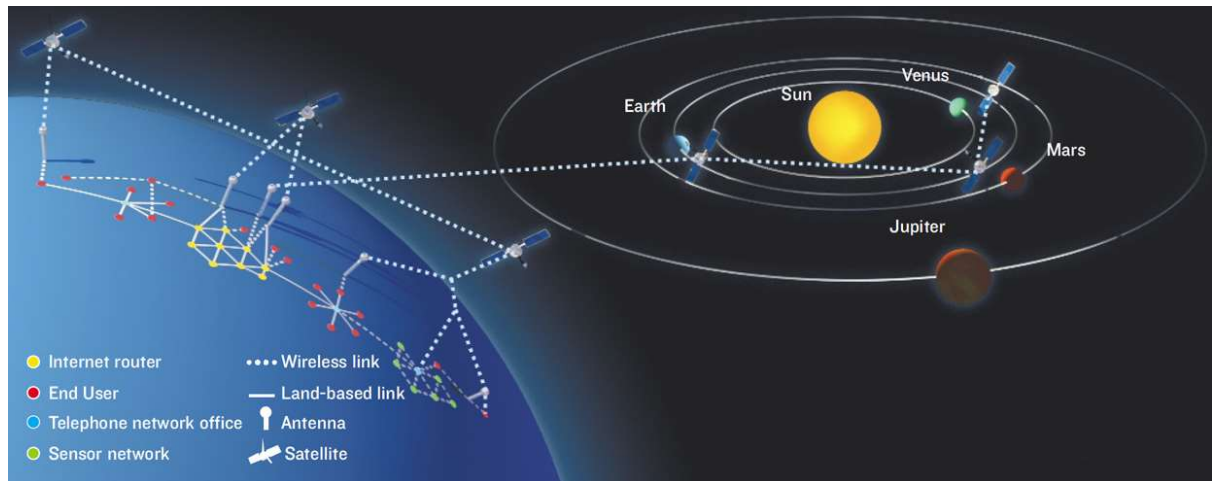
The HyperMesh^{TM} Infrastructure is being built from the ground-up, in a distributed fault-tolerant manner, incentivized by blockchain cryptocurrencies, powered by renewable Transactive Enenrgy, and enabled by a world-wide Satellite Internet with local *peer-to-peer (P2P)* Meshed communication on the ground.

Project SUNSHINE is implementing a future-proof infrastructure for the human race with the following components.

- **S**GIN = Space Ground Integration Network spanning many Fractal levels, from global communications, down to IoT devices.
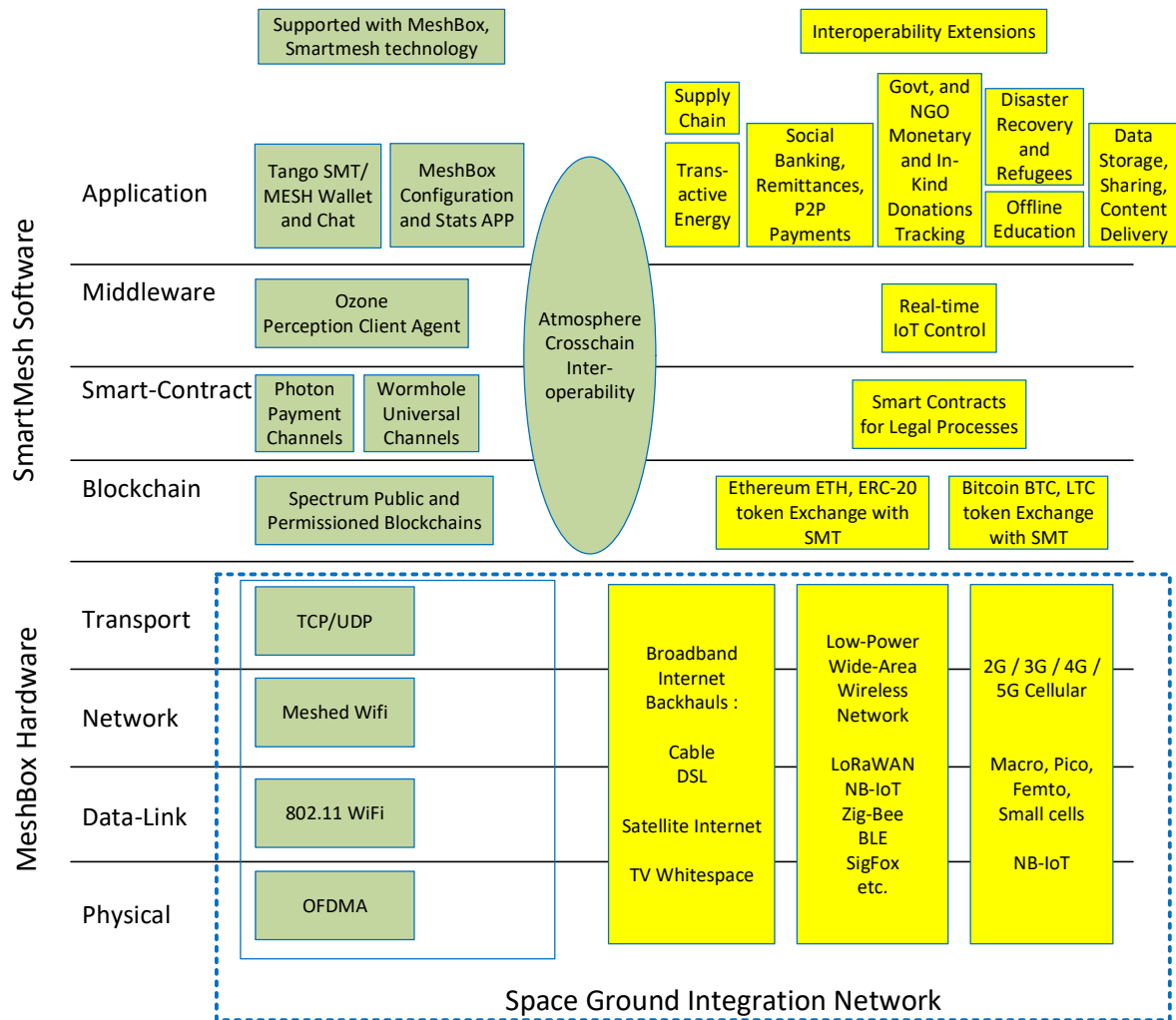- **UN**iversal = Inclusive for all peoples, across diverse business, legal, governance, and technology sectors and processes.
- **S**ustainable = Goal to address the UN Sustainable Development Goals, to bring dignity and a sustainable livelihood for the 3.9 Billion people without internet access, 2 Billion people who are unbanked, and 1.2 Billion without access to electricity [1].
- **H**yperMesh **IN**frastructure = Cyber-physical Infrastructure with Fractal structure on which communications, blockchain payment networks, and transactive energy routing are overlaid.
- **E**cosystem Synergies = The HyperMesh will be better than the sum of its parts. For instance, ant and bee colonies can form a highly effective society even though each individual has limited intelligence. Birds fly without a centralized leader, using Swarm Intelligence techniques. Neurons in the human brain can transcend animal instincts and develop conscious, intelligent thought.   Artificial Intelligence and Machine Learning will make SUNSHINE adaptable and anti-fragile (becoming stronger after surviving each new threat).

SmartMesh Foundation, **MeshBox Foundation**, and ecosystem partners implement the HyperMesh Protocol Stack, as shown in the figure.

SmartMesh Software

Application	Tango SMT/ MESH Wallet and Chat	MeshBox Configuration and Stats APP
Middleware	Ozone Perception Client Agent	
Smart-Contract	Photon Payment Channels / Wormhole Universal Channels	
Blockchain	Spectrum Public and Permissioned Blockchains	

Supported with MeshBox, Smartmesh technology

Interoperability Extensions

Atmosphere Crosschain Inter-operability

Application: Supply Chain; Trans-active Energy; Social Banking, Remittances, P2P Payments; Govt, and NGO Monetary and In-Kind Donations Tracking; Disaster Recovery and Refugees; Offline Education; Data Storage, Sharing, Content Delivery

Middleware: Real-time IoT Control

Smart-Contract: Smart Contracts for Legal Processes

Blockchain: Ethereum ETH, ERC-20 token Exchange with SMT; Bitcoin BTC, LTC token Exchange with SMT

MeshBox Hardware

Transport	TCP/UDP	Broadband Internet Backhauls :	Low-Power Wide-Area Wireless Network	2G / 3G / 4G / 5G Cellular
Network	Meshed Wifi	Cable DSL	LoRaWAN NB-IoT Zig-Bee BLE SigFox etc.	Macro, Pico, Femto, Small cells
Data-Link	802.11 WiFi	Satellite Internet		
Physical	OFDMA	TV Whitespace		NB-IoT

Space Ground Integration Network

Some background and history are helpful at this point.

Networking has progressed from 1st generation Circuit-Switching, to 2nd generation packet-switching.   Now, blockchain is enabling a turning point through 3rd generation **Token-Switching**.   In this new paradigm the scope is greatly expanded from information exchange to token-exchange, using crypto-currency tokens. Tokens can represent not only monetary value (e.g. Bitcoin and Ethers), but also non-monetary entities such as a IoT data, property titles, personal identity, medical records, a vote in an election, and even physical objects in a supply chain.

Blockchain technologies are also progressing from 1st generation Bitcoin, 2nd generation Ethereum with the addition of Smart Contracts, to the 3rd generation of Programmable Societies.   SmartMesh has added a 4th dimension, with the **HyperMesh blockchain**, with layering of Mesh communication, renewable energy infrastructure, blockchain based applications, and the ability to operate with intermittent or non-existent connection the Internet.

SmartMesh Foundation has implemented Token switching with the world's first Green (low-energy) blockchain mining protocol, the **Spectrum public blockchain**.   Spectrum provides a solid Fintech Blockchain foundation on top of which Smart-Contracts, Middleware, and Applications, such as the **Tango** Distributed/Decentralized Application (DApp) are constructed.

SmartMesh has also developed the world's first off-chain capable Payment Network, **Photon** for P2P payments, which offloads most transactions off of Spectrum. Photon is a Smart Contract running on Spectrum and is the first Blockchain TPS scalabiilty architecture to work even when not connected to its blockchain, Spectrum.

MeshBox Foundation has developed indoor and outdoor Mesh appliances, with Wifi Mesh networking, content delivery, data storage, and supports Spectrum and Photon. MeshBoxes interface to wide area broadband networks such as Satellites, and wide area low-power IoT networks such as LoRaWAN.   MeshBoxes integrate Disk drives to store IoT big-data, content, user data, and blockchain data-structures. MeshBox supports IoT through various protocols.   For instance, ecosystem partners are working with MeshBox to bridge the Internet to LoRaWAN Access Points, NBIoT, and many IoT sensors, actuators, cameras, and AI-based biometric devices.

MeshBox, as a building block for SGIN, provides a solid Hardware foundation of communications, computation, and data storage, which is leveraged by upper layers.

The HyperMesh supports Interoperability at all Protocol Layers, including:
- Interoperability between Blockchains solutions through **Atmosphere** via Spectrum.
- Interoperability between token payment networks with and **Wormhole Universal Channels** and Photon
- Communications interoperability through Wifi Mesh network with Satellite, LoRaWAN etc.

This document gives a comprehensive description of the next-generation SUNSHINE infrastructure, which leverages the HyperMesh architecture.
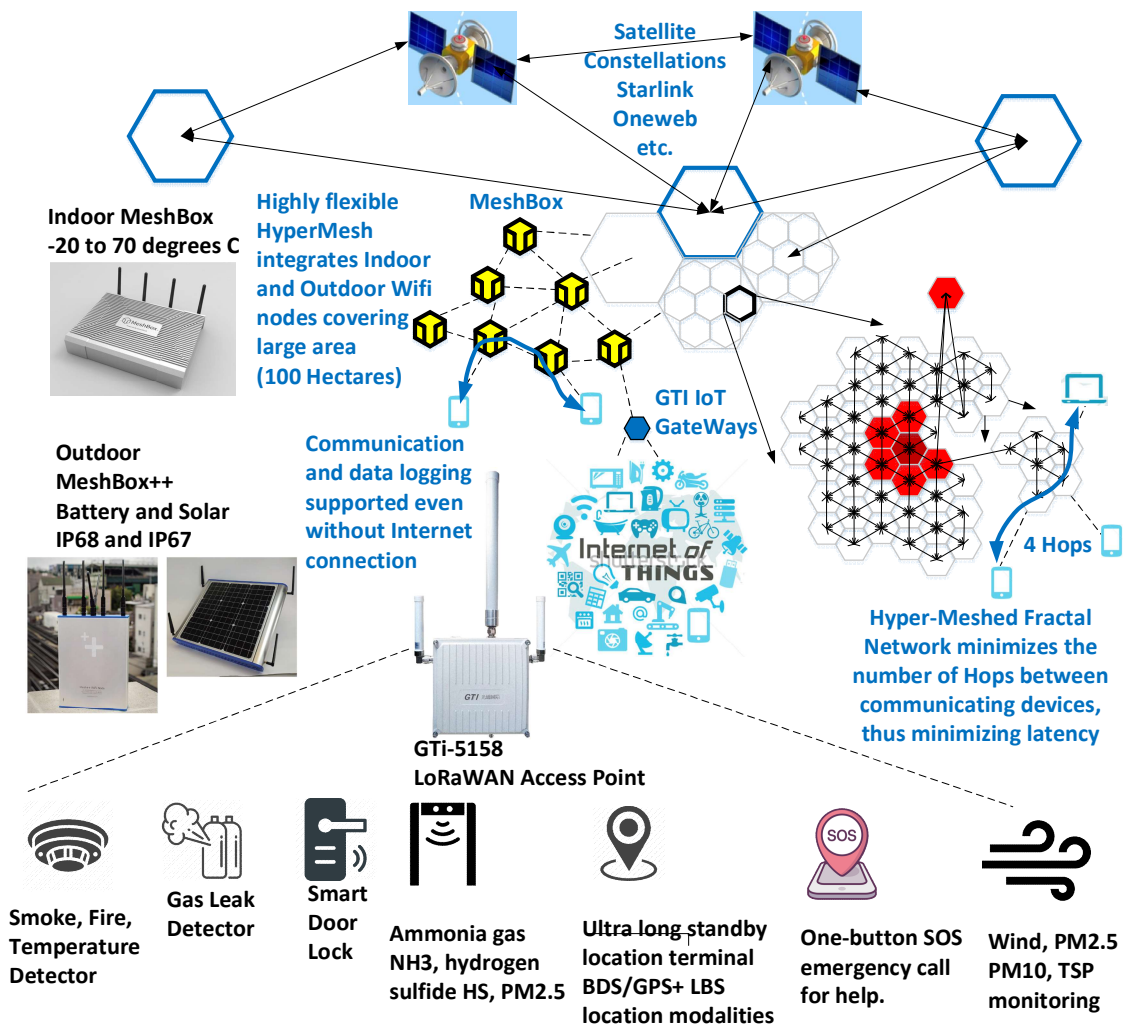
3. HyperMesh Infrastructure for the Underserved

The customer base of SUNSHINE is a large proportion of the global population, including 4 billion people without Internet, 2 billion without identities and banking services, and 1 billion without electricity.   If such issues are addressed and solved, this will help lift many out of the depths of poverty.

A key differentiator of the Meshbox and Smartmesh technologies are proven innovations which allow the HyperMesh system, corresponding blockchain-based payment network, and

Transactive AI agents to work in Off-Grid, and Off-Internet (and thus Off-Blockchain) scenarios, which makes the system highly robust and fault-tolerant.

The following shows the HyperMesh architecture.   At the heart of the hardware aspect of HyperMesh are MeshBoxes, which work with IoT Access Points, and renewable energy generators, enabled by SmartMesh blockchain.   Such an architecture is made possible by the SmartMesh Spectrum blockchain, Photon Payment Network, Tango Distributed App, and various applications for Internet of Food, Transactive Energy, and basic communication and banking.

Satellite Constellations Starlink Oneweb etc.

Indoor MeshBox -20 to 70 degrees C

Highly flexible HyperMesh integrates Indoor and Outdoor Wifi nodes covering large area (100 Hectares)

MeshBox

Outdoor MeshBox++ Battery and Solar IP68 and IP67

Communication and data logging supported even without Internet connection

GTI IoT GateWays

Internet of THINGS

4 Hops

Hyper-Meshed Fractal Network minimizes the number of Hops between communicating devices, thus minimizing latency

GTi-5158 LoRaWAN Access Point

Smoke, Fire, Temperature Detector

Gas Leak Detector

Smart Door Lock

Ammonia gas NH3, hydrogen sulfide HS, PM2.5

Ultra long standby location terminal BDS/GPS+ LBS location modalities

One-button SOS emergency call for help.

Wind, PM2.5 PM10, TSP monitoring

Such technologies can be used as a starting point, and further developed into real-world solutions by SUNSHINE which address the UN SDGs.   HyperMesh Ecosystem partners work together, like never before, in various aspects of this overarching goal to meet the UN SDGs by 2030.

4. Working for the UN SDGs Generates Wealth in the Community

SmartMesh and MeshBox enabled HyperMesh Infrastructure architecture targets to dramatically improve the lives of the underserved by addressing the 17 UN Sustainable Goals.   Through the co-optimization of cost-effective computing and communications hardware, advanced financial technologies based on the blockchain, and Smartphone Applications such as Social Banking, community members are able to generate wealth. This is done by selling goods and services to their community, both locally, and globally, using tools which are designed to help people escape poverty.

The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. The Goals interconnect and in order to leave no one behind, it is important that we achieve each Goal and target by 2030. [UNSDG]

SUNSHINE is composed of individuals and institutions from multiple disciplines who work together to realize a peaceful and prosperous world. A comprehensive UN SDG initiative makes use of diverse disciplines in order to effectively move the state of the human race towards the worthy goals.

- Social science workers for inclusiveness, can research policy, people's living conditions, and other societal issues and develop an overall strategy and tactics based on such social conditions.   Social science workers can collaborate with NGOs to determine the social solution requirements and how promote the HyperMesh to those in developing counties.
- Engineers can design and implement HyperMesh solutions, such as Distributed Applications running on smartphones, MeshBox hardware and SmartMesh blockchain.
- Businesses can gather marketing requirements and work with social science workers to develop an overall strategy and functional requirements of the SUNSHINE solution.

Businesses will eventually market and sell the HyperMesh solution to developing countries.

SUNSHINE partners include SmartMesh and MeshBox, and other ecosystem partners which have advanced technologies to address the following issues:

1. Inclusive Connectivity
2. Inclusive Banking (Finance)
3. Inclusive Energy

The following are the UN SDGs, a brief explanation, and how SUNSHINE, leveraging the HyperMesh architecture can address the issues.

UN Sustainable Development Goals	Issue	SUNSHINE HyperMesh Solution
1. No Poverty	836 million people live in extreme poverty. Economic growth must be inclusive to provide sustainable jobs and promote equality.	MeshBox Internet Communication and Data Storage provide education to break the cycle of poverty starting with children. Education arms people with the tools to make a living for themselves. Cryptocurrency and Spectrum blockchain enable a sharing economy. MeshBox owners earn tokens for offering MeshBox services.
2. Zero Hunger	Over 1/3 of the world's food is wasted. The food and agriculture sector is central for hunger and poverty eradication.	HyperMesh's blockchain-based Internet-of-Food-and-Farm Supply Chain with IoT networks can be used to optimize farming and securely distribute food where needed. Food can be cooked with Renewable Transactive Energy instead of using harmful dried-dung, firewood or kerosene.
3. Good health and well being	Ensuring healthy lives and promoting the well-being for all at all ages is essential to sustainable development	Clean renewable energy, enabled by Micro-Grid-based Transactive Energy systems are used to improve the health and livelihood of the underserved population. Clean, affordable energy can be used to refrigerate and cook food. MeshBox-enabled Internet can provide education so that the underserved can make a living for themselves.
4. Quality education	Educate children in the community to read and learn. Obtaining a quality education is the foundation to improving people's lives and sustainable development.	Meshed Communication with Internet connectivity, and integrated Disk Drives in MeshBox store educational materials which can be used even with intermittent or no Internet connection. Transactive Energy provides Electric lighting which allows children to study after sunset.
5. Gender equality	Gender equality is not only a fundamental human right, but a necessary foundation for a peaceful, prosperous and sustainable world.	Transactive Energy enables electric appliance cooking. Women and girls spend less time gathering firewood and making dung bricks for cooking. Education helps girls to be more independent, able to make a living for themselves and have a better chance to escape the cycle of poverty.

|		
6. Clean water and sanitation	Water scarcity affects more than 40% of the world's population. Clean, accessible water for all is an essential part of the world we want to live in.	Purify/desalinate water with Transactive Renewable Energy. Better education helps the underserved take better care of their health, being will to accept immunization and vaccine shots to prevent contagious disease from spreading.
7. Affordable and clean energy	Energy is central to nearly every major challenge and opportunity.	HyperMesh Transactive Energy System enables the monetization of Solar and other renewable energy sources in Micro-grids which generate cheap, clean electricity locally. Sharing of energy between Prosumers through TRAIN (Transactive Real-time AI Negotiator) mitigates renewable energy intermittency issues.
8. Decent work and economic growth	Sustainable economic growth will require societies to create the conditions that allow people to have quality jobs.	HyperMesh enables communities to leapfrog old technologies and maximize cost-effectiveness. Spectrum Blockchain and MeshBox banks the unbanked, enabling entrepreneurship. MeshBox owners become business owners, earning token revenue from community members by sharing their Internet connection, and data, content, and cached websites with neighbors.
9. Industry innovation and infrastructure	Investments in infrastructure are crucial to achieving sustainable development.	Spectrum blockchain allows for eCommerce, and Mesh networking enables education, which form the basis of innovation. Artificial-Intelligence based Security and Spectrum blockchain safeguards HyperMesh.
10. Reduced Inequalities	To reduce inequalities, policies should be universal in principle, paying attention to the needs of disadvantaged and marginalized populations.	The underserved can become entrepreneurs, changing their lives permanently, using the HyperMesh Infrastructure to generate income by selling/maintaining HyperMesh systems (MeshBox-enabled Internet, Educational materials, Renewable Energy).
11. Sustainable cities and communities	There needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation and more.	HyperMesh is more energy-efficient and cost-effective than conventional infrastructure and fosters Leap-Frogging entire communities towards sustainability.
12. Responsible consumption & production	Sustainable consumption and production is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all.	Peer-to-peer trading and a sharing economy benefits families and groups to live in a self-sustainable manner, which reduces wastage, and can help mitigate climate-change issues.
13. Climate action	Climate change is a ticking time-bomb that will result in billions of people being pulled into the abyss of poverty, death, and destruction, if we do not act quickly to reverse greenhouse gas emissions. Everyone, but especially the poor and	Drawdown techniques to mitigate climate change vary from Renewable Transactive Energy to Internet of Food, better land management, family planning, and educating girls. Highly efficiency e-commerce, energy, and communications reduces energy usage. Affordable, scalable solutions are now available to enable countries to leapfrog to cleaner,

	underserved are at risk for suffering as Climate-Change presents a major Human Rights issue. The wealthy nations generate the most green-house-gases, but will suffer the least from climate-change impacts. The poor countries, who do not have the resources to cope with rising temperatures and sea water levels will suffer the most.	more resilient economies. SmartMesh and MeshBoxes provide a strong incentive through a high-ROI business model which can accelerate the adoption of helpful solutions.
14. Life below Water	There is a continuous deterioration of marine life due to climate change and pollution. Careful management of oceans and seas is a key feature of a sustainable future.	Cleaner renewable energy and recycling/reuse/reduce programs reduce waste dumped into rivers/oceans. Climate-Change draw-down techniques will hopefully keep the ocean temperatures from rising too much in order to reverse the decimation of the marine ecosystem.
15. Life on land	Thirteen million hectares of forests are being lost every year while the persistent degradation of drylands has led to the desertification of 3.6 billion hectares. In addition to providing food security and shelter, forests are key to combating climate change.	Transactive Energy eliminates need to raze forests for cooking fuel. HyperMesh enabled prosperity reduces need to raise animals to sell for income. A plant-rich diet helps to reduce green-house-gases. Climate-Change draw-down techniques will hopefully keep the ocean temperatures from rising too much. Climate-Action is critical to mitigating extreme weather events and reducing the severity of rising sea levels wiping out coastal regions.
16. Peace and Justice, Strong Institutions	Access to justice for all, and building effective, accountable institutions at all levels are important to promote peaceful and inclusive societies for sustainable development.	Access to affordable energy, communication, and offline e-commerce improves quality of life, reduces inequalities, and promotes job creation. Corruption-free supply-chains allow in-kind and monetary aid and donations to reach the underserved, eliminating corrupt middle-men who usually take a cut from the donations.
17. Partnerships for the goals	A successful sustainable development agenda requires partnerships between governments, the private sector and civil society.	SUNSHINE !

5. Keeping the Wealth In the Community

The HyperMesh is a new Infrastructure architecture, which uses a grassroots deployment model. The money which is usually paid to third party corporation services providers, such as Internet Service Providers, Content Delivery Services, and Energy Utilities can be, in large part, earned by the common masses participating in the HyperMesh Infrastructure.
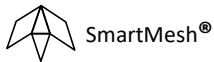
A HyperMesh™ Infrastructure leapfrogs that found in developed countries, through a social-economic paradigm shift.

Project SUNSHINE develops the HyperMesh, the next generation banking, and energy infrastructure which are moving from a centralized, slow, and expensive infrastructure (Left) to the distributed, fast, and cost-effective HyperMesh architecture (Right).
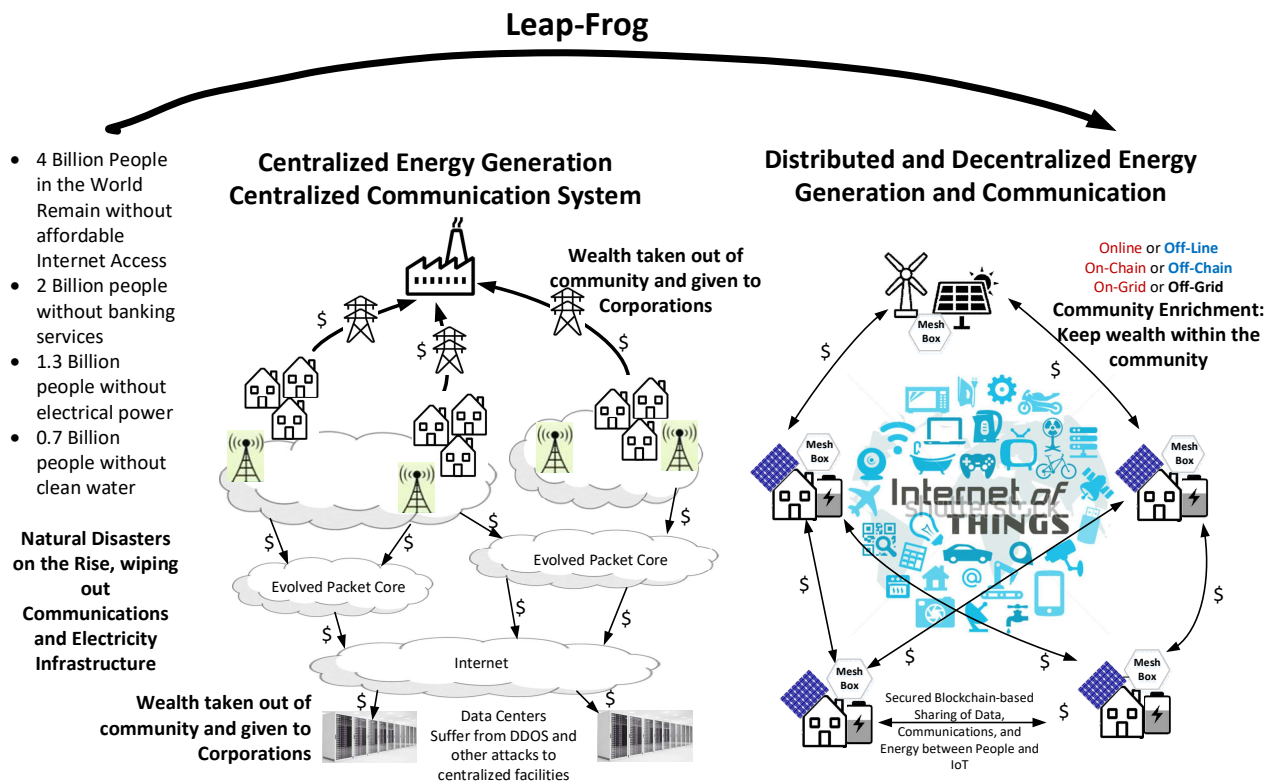
In conventional infrastructure economics, consumers pay the service provider (internet, electricity, etc) for the service. The service provider decides when and where to deploy services (e.g. whether to install new cellular base-stations and where) and how much to charge for such services.

A HyperMeshTM Infrastructure enables a Shared-ROI paradigm shift to enable social well-being with grassroots Infrastructure deployment.

- Instead of the service provider determining when and where to roll out service, the residents of a community decide when and where to deploy infrastructure such as MeshBox® routers.
- Residents earn tokens (money) by providing services (communication, content storage, video streaming, and Transactive Enenrgy) to their community neighbors.
- This keeps the money within the community and keeps all of the autonomy for the infrastructure deployment in the hands of the people who use the services. The community, and residents, and guests help each other in a synergistic relationship in order to bring prosperity to the entire community.

Smartmesh®, Meshbox®, and our ecosystem partners aim to move society in the right direction, by providing a highly advanced Wifi Mesh Network solution with the Spectrum blockchain to enable an Internet of Value. Such a HyperMeshTM infrastructure will soon be extended with Transactive Energy using renewable energy and battery systems to provide highly robust energy sources for remote areas.

The proposed solution enables blockchain based Fin-tech, high-throughput wifi-communications, and a distributed content storage system, while operating
- with or without the Internet
- with or without a blockchain; with Photon state-channel secondary architecture,
- with or without an electrical grid; with renewable battery and solar technology.

Together, with partners such as Satellite operators, LoRa technology providers, and Smartmesh®, Meshbox® brings about a paradigm shift to enable Infrastructure deployment with Shared-ROI. Instead of the service provider determining when and where to roll out service, the residents of a community decide when and where to deploy infrastructure such as MeshBox® routers.

The Infrastructure, enabled with Smartmesh® and Meshbox® technology can speed up the realization of an IoV Infrastructure, to bring dignity and a sustainable livelihood for the 3.9 Billion people without internet access, 2 Billion people who are unbanked, and 1.2 Billion without access to electricity [Paygo].

The proposed SUNSHINE leverages the synergistic combination Ecosystem partners of SmartMesh and MeshBox to effectively address the 17 UN Sustainable Develop Goals.

6. Incentivizing Operations through Shared-ROI

SmartMesh and MeshBox, with ecosystem partners have developed advanced technology tools, specifically targeted to help the underserved by address the UN SDGs. When investors or donors (including the underserved themselves) help a community by investing in the HyperMesh Infrastructure, tokens which are earned for goods and services are distributed to community members (keeping the wealth in the community) and shared by investors and the HyperMesh operators (such as SmartMesh and MeshBox). Thus, the

HyperMesh Infrasturcture technology developers will benefit from revenue sources from the wealth generated from the community.

SmartMesh has incentivized the deployment of the HyperMesh Infrastructure through a Return-on-Investment model.   MeshBox node owners are able to connect to the Internet and receive the following revenue, in the form of SmartMesh Tokens (SMT) or MESH Tokens, for sharing various services to community members.
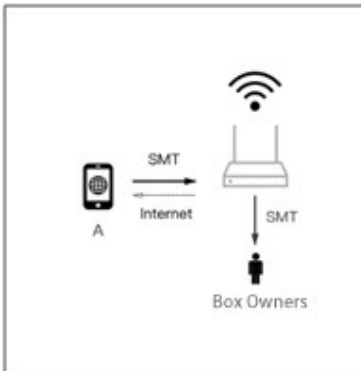
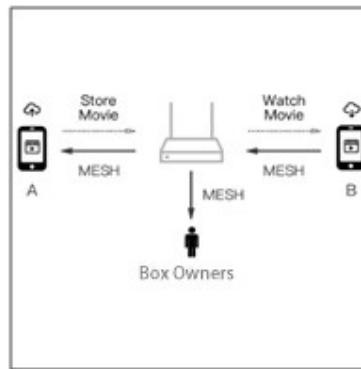- Running a Mining node, to earn Gas fees for signing blocks on the Spectrum blockchain
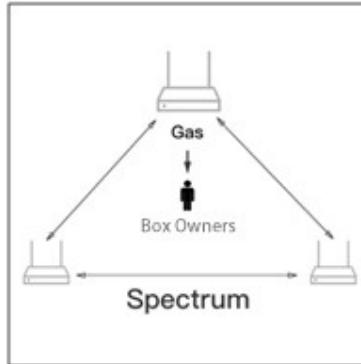
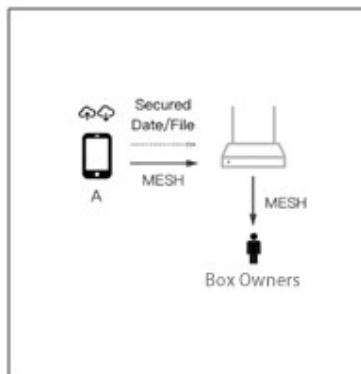- Photon payment network Fees for transfer of tokens for P2Ppayments.
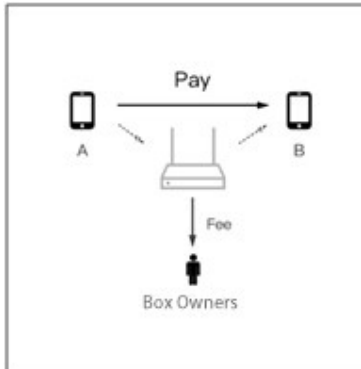
- MeshBox Wifi network and Internet access.

- Storage of audio/video content, websites, and community data, on the MeshBoxes' internal Disk Storage.

- IoT Sensor and Actuator networks using MeshBoxes as a control and data logging node.

- Targeted advertisement and location based services

To provide a user-friendly interface, SmartMesh Distributed Applications provide connectivity, banking, energy, and IoT services to users.

The SmartMesh Tango DApp, incorporates the SmartMesh Wallet and tools to generate Shared-ROI by monetizing Wifi, Internet, data storage, and Photon Payment related services.

- Real-time communication: including private chat, group chat and #Everyone# chat room.
- Near-field social networking: Users with The SmartMesh Tango application can find others for chat in close range without Internet.
- SmartMesh Wallet: on-chain token transfer.
- Photon Network Payment: On and off-chain channel micropayment .
- Mining: Staking a certain amount of SMT tokens allows participation in the mining of the public chain with associated rewards.

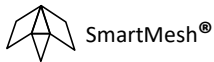# 7. Space Ground Integration Network Architecture

With the addition of Satellites and balloons to the MeshBox network on the ground, SUNSHINE aims to build a highly efficient worldwide Space Ground Integration Network (SGIN), which is composed of:

- **Space-Internet** for world-wide coverage, even in the remotest areas such as mountains, islands, rivers, oceans, and forests.
- **Ground Network**, linked with satellites, and providing edge-computing and edge-storage, to maximize the efficiency of the Satellite link.

Satellite Internet, SmartMesh and MeshBox technologies are synergized through the following:

- Satellites provide world-wide internet coverage, which is especially useful for non-urban, islands, rural, in-accessible, on-sea, and in-air locations.
- Satellites can use fewer, higher-speed Satellite links, connected to fewer MeshBoxes on the ground.
- MeshBox ground-based Mesh-networking to provide high-bandwidth, high-density coverage, for both Indoor and Outdoor coverage.
- MeshBox scales the Satellite data-rate significantly through the use of Edge computing, Edge storage (caching), leveraging time-locality and space-locality of content accesses.
- Mesh network covers Non-Line-of-Sight (NLOS) locations, which Satellite signals do not cover well, due to higher carrier frequencies providing higher data-rates, but more susceptible to attenuation from physical obstacles and weather patterns.

To enable SUNSHINE, SmartMesh , MeshBox, and Satellite partners work together to provide a cost-effective **SGIN implementation**.

- World-wide Internet with Satellite systems, optimized with wide-area WiFi meshed communications spanning both indoors and outdoors.
- Economy of Scale benefits using high-bandwidth satellite links, connected to low-cost ground-based Wifi Mesh networks for localized, last-mile deployment, even to far-flung locations and developing countries.
- Fintech applications for blockchain and payment networks to bank the unbanked, which are layered onto SGIN.
- Transactive Energy and other applications layered onto SGIN.

7.1 SGIN Fractal Network Architecture

The following shows a Fractal architecture which is used to scale SGIN using Satellites and MeshBox networks.   Scalability spans from the lowest-level Domain of IoT devices, all the way to a Universal Domain.

The hierarchical levels are defined as follows:
- H(11) = Universal Domain = Domain which spans to beyond the Earth, including networks to the Moon, Mars, and beyond.
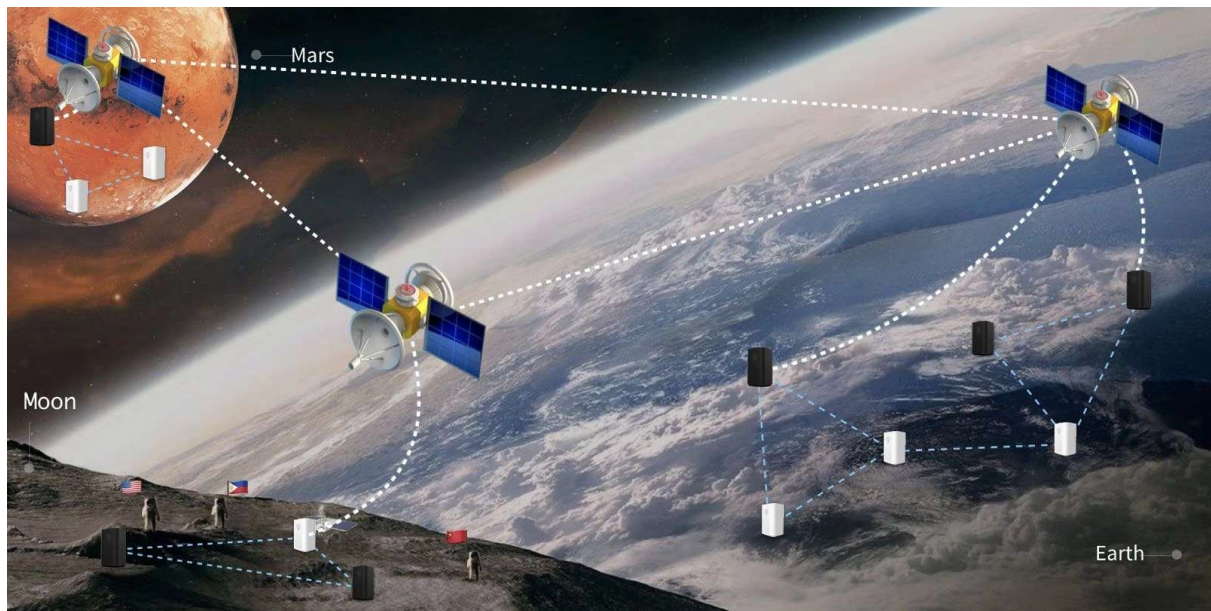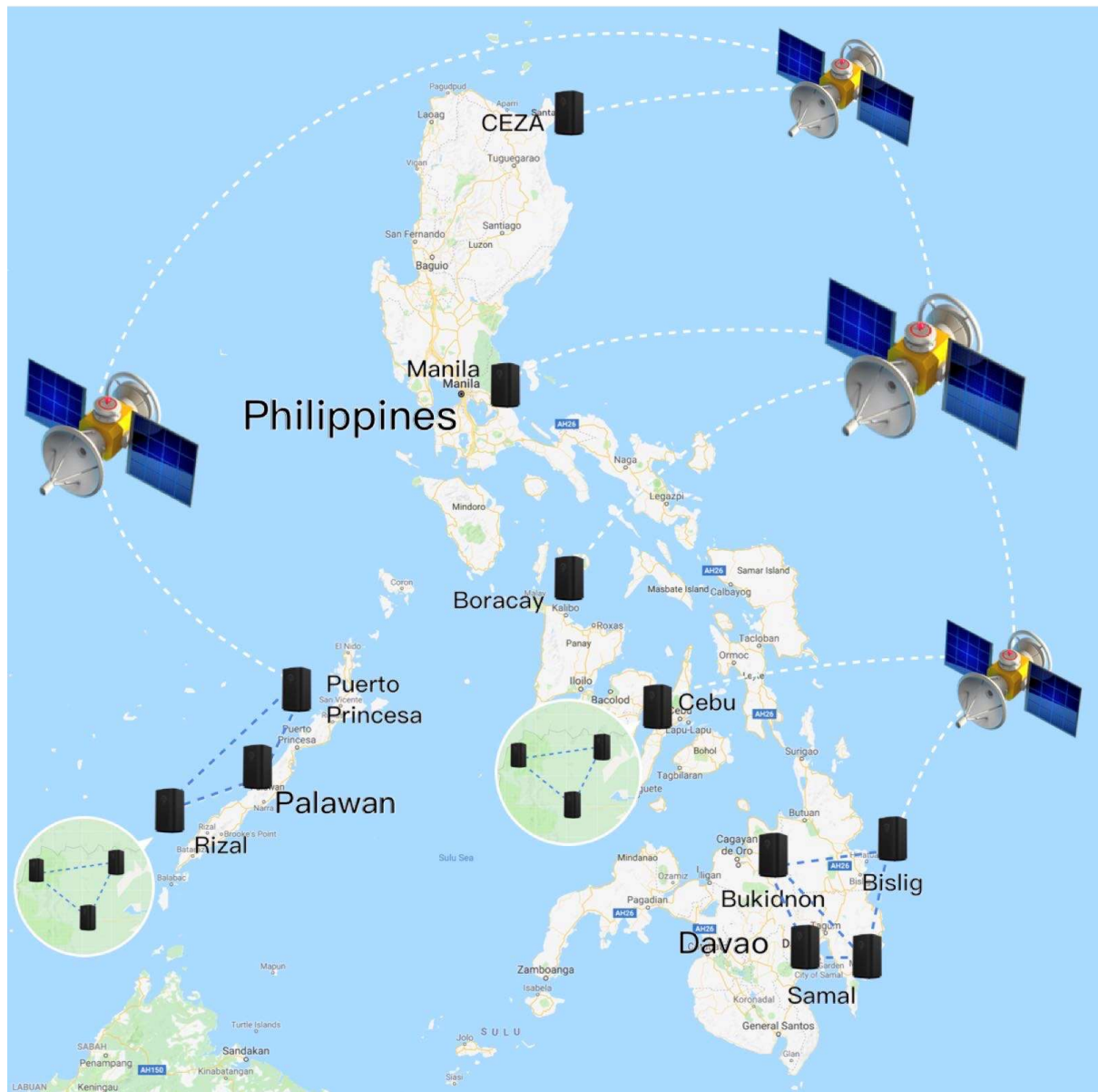

- H(10) = International Domain = Span multiple countries.   Initial focus is on China and the Association of South East Asian Nations (ASEAN) countries: Philippines, Indonesia, Brunei, Malaysia, Myanmar, Laos, Vietnam, Cambodia, Thailand, and Singapore.
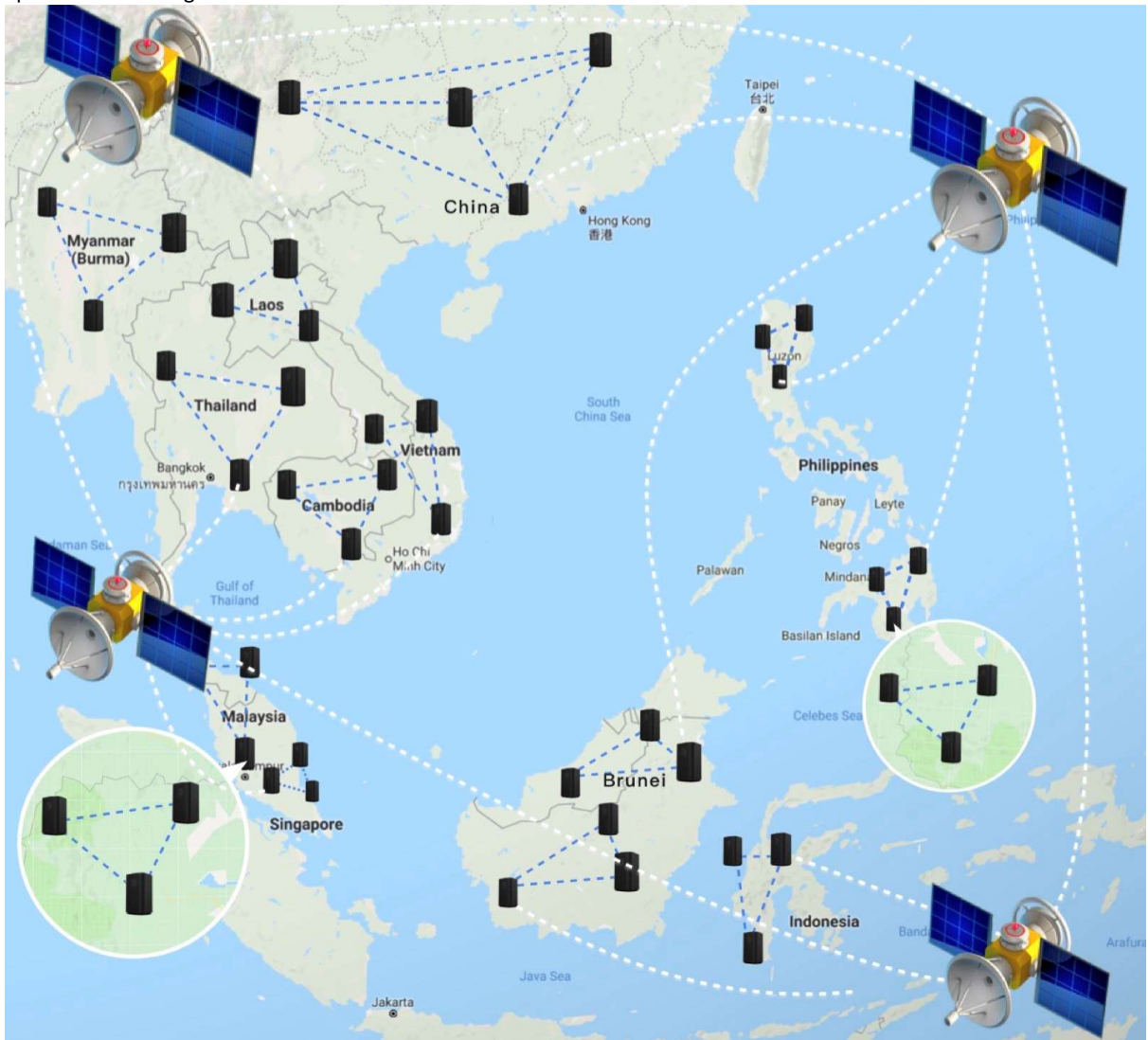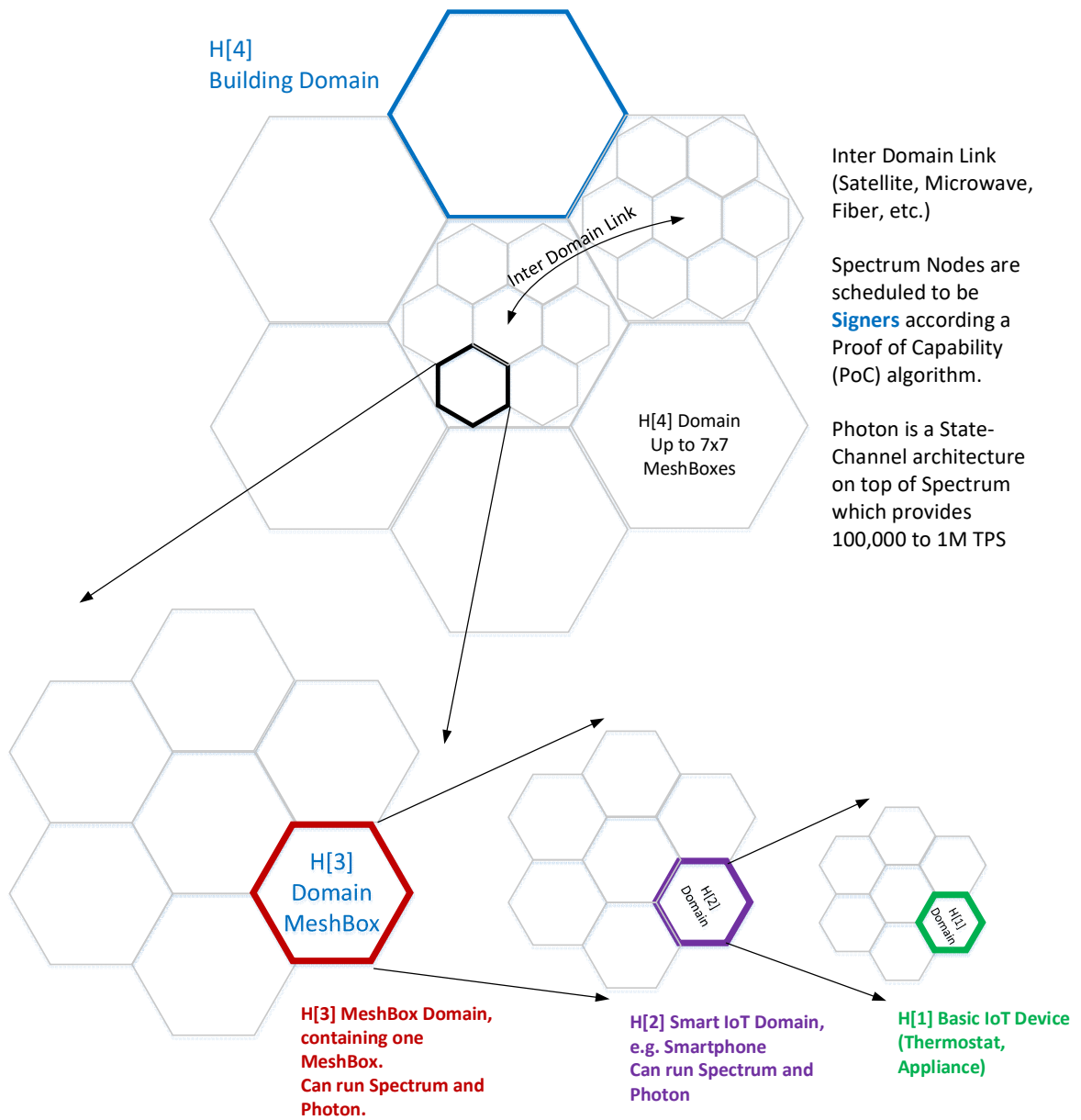
- H(9) = Country Domain = Spans a Country, such as those in Southeast Asia.

- H(8) = Region Domain = Spans Region (State or Province)
- H(7) = City Domain = Spans a City or Village
- H(6) = District Domain = Spans a district within a City
- H(5) = Community Domain = Spans a Community, which can be a block or a group of buildings managed by one entity, or jointly owned by a community.
- H(4) = Building Domain = Spans a building (or several inter-connected buildings)
- H(3) = Single MeshBox Domain
- H(2) = Smartphone Domain
- H(1) = IoT/User Domain

Satellite Internet can be used at hierarchy levels H(11) down to H(4), while the MeshBox-based Mesh networks can cover from H(7) down to H(1).

In the figure below, the Hierarchies from a Building Domain (H[4]) down to an IoT domain (H[1]) are shown.

H[4]
Building Domain

Inter Domain Link

H[4] Domain
Up to 7x7
MeshBoxes

Inter Domain Link
(Satellite, Microwave,
Fiber, etc.)

Spectrum Nodes are
scheduled to be
Signers according a
Proof of Capability
(PoC) algorithm.

Photon is a State-
Channel architecture
on top of Spectrum
which provides
100,000 to 1M TPS

H[3]
Domain
MeshBox

H[2]
Domain

H[1]
Domain

**H[3] MeshBox Domain,
containing one
MeshBox.
Can run Spectrum and
Photon.**

**H[2] Smart IoT Domain,
e.g. Smartphone
Can run Spectrum and
Photon**

**H[1] Basic IoT Device
(Thermostat,
Appliance)**

Each Hierarchy Domain is shown with 7 Sub-Domains.   However, the number of such
Sub-Domains can be up to 49 (=7x7) as shown below.
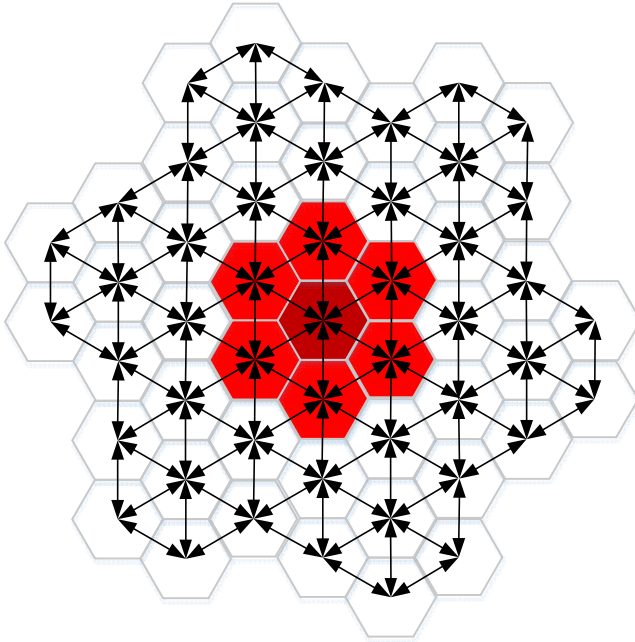
On such a Fractal network architecture, various networks are overlaid, including communication, Photon peer-to-peer payments, Wormhole Universal Channels for multi-blockchain token exchange, Energy Internet (Enernet), etc.   The exchange of various tokens, both fungible (monetary) and non-fungible (non-monetary, cyber-physical), are supported.

7.2 SGIN Economy of Scale Benefits

Business Synergies between Satellite Internet technology and SmartMesh /MeshBox include:
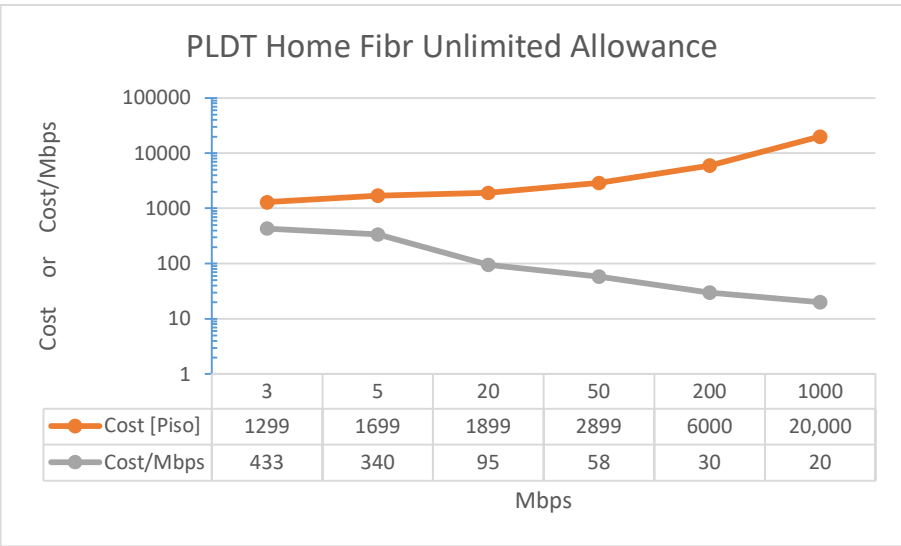
- SmartMesh and MeshBox could sell bundled Internet services using MeshBox for last-mile local network coverage in any geographic location, and Satellite Internet as the backhaul with world-wide Internet coverage.
- SGIN allows grassroots users to become Internet Service Providers. People are highly incentive to use SGIN, not only due to the resulting high-performance Internet connection, but also due to a **Shared ROI business model**, which is implemented on MeshBoxes.   Owners (e.g. farmers, shop keepers) or Investors of MeshBoxes receive ROI through
    - Revenue from other Customers/Owners/Investors accessing the MeshBox Wifi network and Internet.
    - Revenue from storage of audio/video content, websites, and community data, on the MeshBoxes' internal Disk Storage.
    - Targeted advertisement and location based services
    - IoT Sensor and Actuator networks using MeshBoxes as a control and data logging node.
    - Fees for exchanging of payments and value tokens between people and machines.

SmartMesh partners with Application developers such as global payment firms—banks, clearinghouses, network operators, and others which have blockchain, payment systems, insurance, and inclusive social banking applications. Such partners need the communications and data storage infrastructure provided by MeshBoxes being deployed by SmartMesh.

Especially in emerging markets, where internet is non-existent or intermittent, MeshBox hardware works with WAN technologies to provide local-area-network connectivity and internet access for the underserved, at a fraction of the cost of conventional cellular and wired networks.
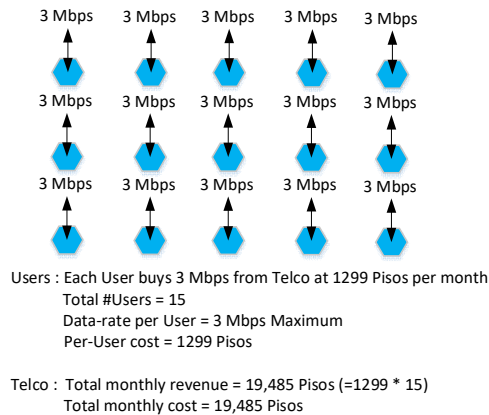
One of the target markets of SmartMesh and MeshBox is the developing country of the Philippines.   While the following shows the economic benefits for SmartMesh/MeshBox in the context of the Philippine Telco, PLDT, the scenario will be similar in any country due to basic Economy-of-Scale laws.

Consider PLDT Home Fibr [8] service plans, plotted below.   Note that as in most systems, due to Economy of Scale, the Cost per Mbps declines as the Data-rate [Mbps] increases.

PLDT Home Fibr Unlimited Allowance

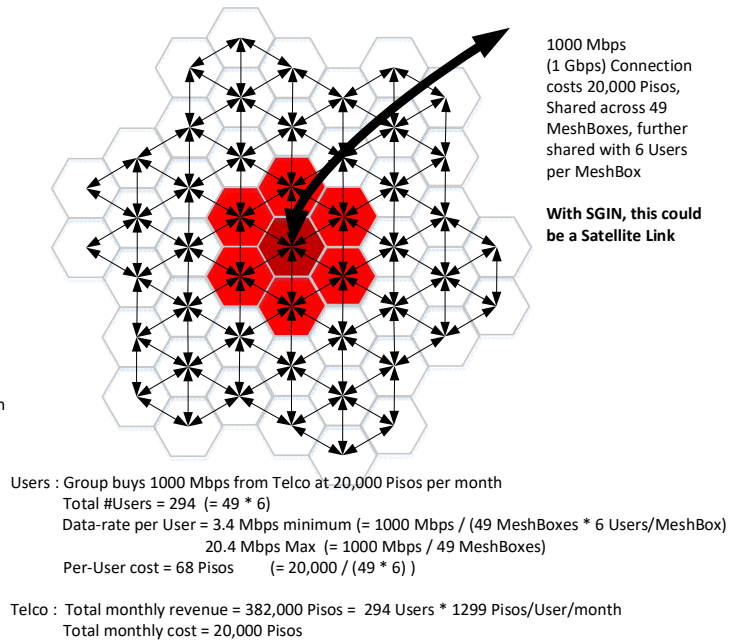| Mbps	3	5	20	50	200	1000
Cost [Piso]	1299	1699	1899	2899	6000	20,000
Cost/Mbps	433	340	95	58	30	20

Thus, it is more economical to purchase a high-speed speed connection, and then share it with the entire community, which the MeshBox network facilitates.

No Mesh, No Sharing

3 Mbps   3 Mbps   3 Mbps   3 Mbps   3 Mbps

3 Mbps   3 Mbps   3 Mbps   3 Mbps   3 Mbps

3 Mbps   3 Mbps   3 Mbps   3 Mbps   3 Mbps

Users : Each User buys 3 Mbps from Telco at 1299 Pisos per month
     Total #Users = 15
     Data-rate per User = 3 Mbps Maximum
     Per-User cost = 1299 Pisos

Telco : Total monthly revenue = 19,485 Pisos (=1299 * 15)
     Total monthly cost = 19,485 Pisos

Sharing through Mesh Network

1000 Mbps
(1 Gbps) Connection
costs 20,000 Pisos,
Shared across 49
MeshBoxes, further
shared with 6 Users
per MeshBox

**With SGIN, this could
be a Satellite Link**

Users : Group buys 1000 Mbps from Telco at 20,000 Pisos per month
     Total #Users = 294 (= 49 * 6)
     Data-rate per User = 3.4 Mbps minimum (= 1000 Mbps / (49 MeshBoxes * 6 Users/MeshBox)
          20.4 Mbps Max (= 1000 Mbps / 49 MeshBoxes)
     Per-User cost = 68 Pisos   (= 20,000 / (49 * 6))

Telco : Total monthly revenue = 382,000 Pisos = 294 Users * 1299 Pisos/User/month
     Total monthly cost = 20,000 Pisos

For instance, the cost for a single 1000 Mbps connection is slightly more than the cost 15 separate 3 Gbps connections, each costing 1299 Pisos.   The total paid by the 15 users is 19,485 Pisos for only 48 Gbps total.

For a 49 node MeshBox H(4) Domain, a high-speed link (such as 1000 Mbps) to the Internet can be provisioned with the MeshBox in the middle.

Then, the 49 nodes can share the bandwidth using the Mesh Network, with each Node receiving about 20 Mbps of service (=1000/49) for a total cost of 20,000 Piso's per month, plus the CAPEX cost for 49 MeshBox. This translates to 409 (=20,000 / 49) Pisos for each 20 Mbps of service at each MeshBox.   If a MeshBox has 6 active users, then the cost per user is only 68 Pisos (=409 / 6).   Compare the 68 Pisos per user for the MeshBox case, to 1299 Pisos for each of the 15 individual 3 Mbps connection to see that there are significant cost savings due to Economy of Scale for the MesBox case.

Similarly, to buy 49*6 connections of 3 Mbps each, the total cost would be 382,000 Pisos (= 49 * 6 * 1299) Pisos, compared to the single 1000 Mbps connection which costs only 20,000 Pisos.   If the MeshBox operator charged 650 Pisos per user (half of the 1299 Pisos) for the 3 Mbps connection, the operator would earn 191,000 Pisos per month, which is USD $3,800 per month, or $45,800 per year.

The CAPEX cost for the 49 MeshBoxes must be considered, and the $45,800 earned per year can be used to offset this CAPEX cost.   Also, since the operation of MeshBoxes provides the owners with tokens, the cost of the 49 MeshBoxes is re-couperated at a time even sooner than a year, so this CAPEX cost is returned to the owners, and MeshBox owners will begin earning positive revenue.
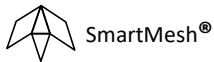
8. Summary

The human race is at a fork in the road in which existential threats loom, even while innovation provides us with the key to avoid extinction level events and strive towards a prosperous utopia. Everything we do has the potential to move us toward either a Utopian or Dystopian world.

SmartMesh and MeshBox, being Singapore registered companies are first building the SUNSHINE ecosystem in Singapore, with plans to expand the HyperMesh to other countries in need of Inclusive Banking, Connectivity, and Energy.

Such a HyperMesh infrastructure will greatly enhance inclusivity, by cost-effectively supporting Distributed Ledger Technology, Inclusive communications and connectivity, decentralized and secure data storage, and Cyber-Physical applications, developed by SUNSHINE.
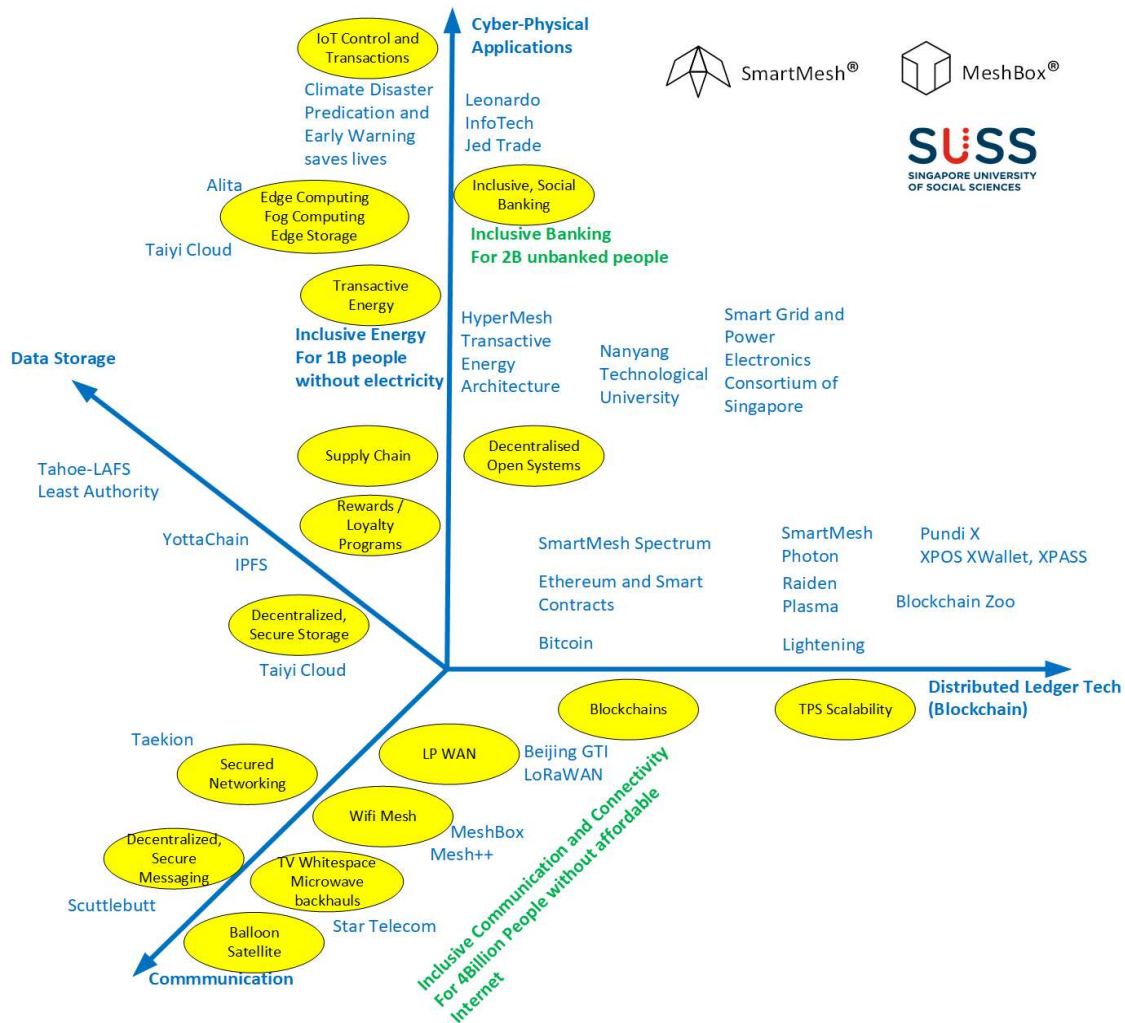
Space Ground Integration Network for SUNSHINE

The first basic integration is to support Inclusive Internet Connectivity through the MeshBox Wifi network, Internet access and storage services, with the Shared-ROI model via the SmartMesh protocols and commercial banking and payment networks.

Then, building on the baseline payment network and communications infrastructure, additional applications, such as those developed through the SUNSHINE Blockchain Living Lab at SUSS can be integrated, including machine-to-machine (IoT) payments, supply chain, and distributed storage.

With the launch of the IMDA Blockchain Challenge – Glowing and Connecting Blockchian Business Networks (https://www.imda.gov.sg/programme-listing/blockchain-challenge), SmartMesh has partnered with SUSS and MeshBox to invite potential ecosystem partners to participate in the Living Lab of interoperable blockchain-based technologies. We plan to further expand the relevant ecosystem business scenarios including: supply chain, education, and decentralized data storage, etc.   The above application projects not only use Spectrum mining incentives including SMT and MESH tokens, but also use cross-chain incentives including Bitcoin and Ethereum via the SmartMesh's Atmosphere Cross-Chain Interoperability Architecture.

SmartMesh's and MeshBox's long term goals are to build out the HyperMesh Infrastructure, which leapfrogs that found in developed countries, through a social-economic paradigm shift.

9. APPENDIX: Background on SmartMesh Foundation

9.1 SmartMesh Ecosystem

SmartMesh® Foundation promotes an ecosystem, aiming to bridge the growing Divide between the developed and developing countries. There are currently 3.9 Billion people without internet access, 2 Billion people who are unbanked, and 1.2 Billion without access to electricity [Paygo].

SmartMesh® Foundation works with Meshbox® Foundation and other Ecosystem partners to address the Divide by providing hardware and software applications to build the HyperMesh Infrastructure.

MeshBoxes have been optimized to run a Mining node of the SmartMesh Spectrum blockchain, which is light enough to run on low-cost CPUs and disk drives, thereby minimizing the cost of MeshBoxes. Users run Distributed Apps on their smart-devices to access banking features such as secured transfers over Spectrum, or making P2P payments to each other through Photon, even with intermittent internet connectivity. Such P2P Photon payments are executed much faster and with highly scalable Transactions per Second (TPS) than possible on conventional blockchains.

Also, even with intermittent connection to the Internet, which is common in remote and developing areas, users access the MeshBox network, to make such payments, as well as securely access data and local websites on a reliable data storage system.

9.2 Spectrum Blockchain

SmartMesh has deployed the Spectrum Blockchain protocol, which runs on generic Miner and special Beacon nodes on the Internet, but is also optimized to run on a decentralized Mesh network, implemented with MeshBoxes, to realize the blockchain of the Internet of Everything.

The Spectrum public blockchain supports the SmartMesh Token and MESH tokens.
- SmartMesh Token coin, listed on Huobi.pro and Gate.io, and used for Spectrum blockchain.
- MESH tokens, listed on FCoin.com and HitBTC, and used for the Content Delivery Networks, supporting video streaming.

The consensus mechanism of the Spectrum chain is an innovative Proof Of Capability (POC) algorithm. Nodes that contribute resources (staking tokens, sharing internet access, sharing disk space, signing blocks correctly, etc) to the system can obtain higher Capability weights, which make the blockchain more fair. The SmartMesh protocols also support mobile devices to run Spectrum light nodes.
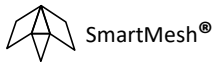
9.3 Photon Payment Network

The Photon Payment network, a secondary layer Smart-Contract, built on top of Spectrum has been deployed by SmartMesh.   Since Photon supports P2P concurrent transactions, the TPS scales with the number of Photon nodes to hundreds of thousands and even millions of TPS.

With MeshBox support, Photon nodes can execute offline payment transactions without a network (such as when not connected Spectrum through the Internet).   Photon thus realizes decentralized, real-time, safe, convenient, low-fee, off-chain and off-internet transfer of tokens.   Photon is light enough to run on Android, iOS, Mac, Windows, Linux and other platforms.

9.4 Atmosphere Cross-Chain Exchange and Wormhole Universal Channels

There are numerous blockchains in the world. If each blockchain is like a river, providing essential resources to the people and land around it, then to achieve interoperability between blockchains would mean re-routing all the rivers on earth to be connected to each other.   This is clearly impossible...

Or is it?   Is there a way in which all rivers can be connected?

Yes! All rivers are linked through the water cycle, in which water from rivers evaporates into the Atmosphere, forms clouds, which rain water on the ground, which flows down into rivers.

Thus, the Atmosphere is the superhighway in the sky that links all bodies of water, such as rivers, all over the Earth. Our Atmosphere facilitates the grand water cycle on earth.
This is the rationale to name the SmartMesh Spectrum Blockchain Interoperability project "Atmosphere".

Since Atmosphere is based on SmartMesh's Spectrum blockchain as the main chain.   The choice of the underlying main chain of the Interoperability is crucial because all other blockchains will be sidechains to this main chain.   The main chain must satisfy important goals for emerging applications in order to provide a solid foundation, on which other (sidechain) blockchain will be interfaced in order for the entire Interoperability architecture to be effective.   Such goals are the inclusive goals listed in the table.

Atmosphere is built upon the SmartMesh Spectrum Public Blockchain which has been engineered for energy-efficiency and emerging IoT applications.   Spectrum's scalability strategy is a secondary architecture called Photon Network, which is designed for light-speed fast peer-to-peer and machine-to-machine payments needed for transactive IoT. In terms of interoperability, Spectrum uses the Smartmesh Token (SMT) as the underlying coin.   Spectrum also supports transfers of the MESH (owned by MeshBox Foundation). Interoperability with other blockchains ecosystems, and associated tokens, are made possible through Atmosphere.
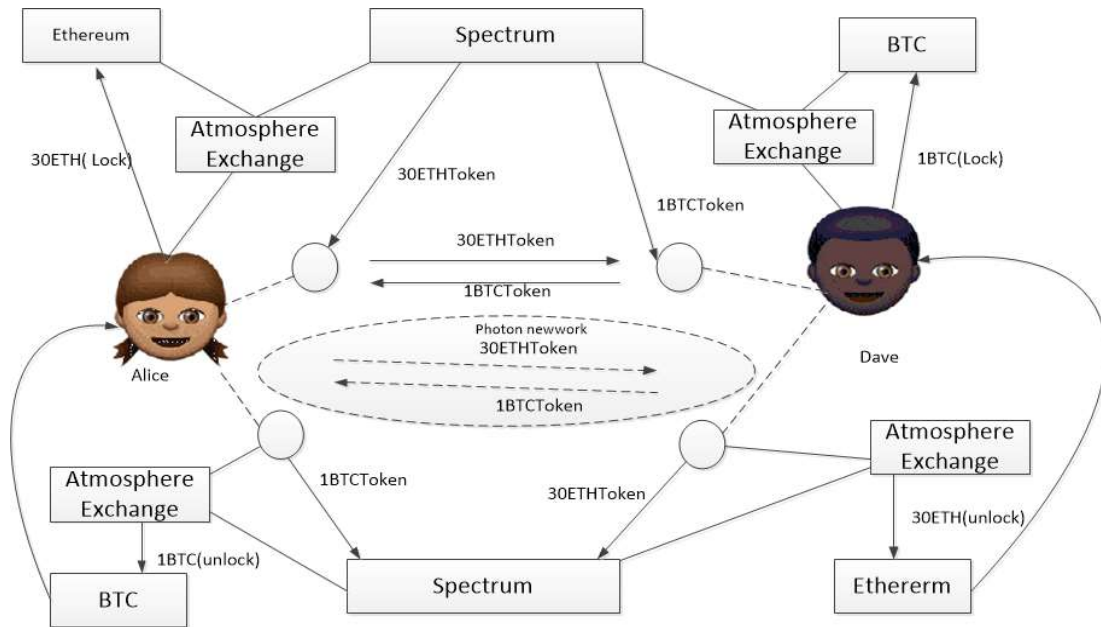
Atmosphere's cross-chain technology supports the dynamic transfer of tokens in the Spectrum public chain ecosystem with other public chain ecosystems. Cross-chain transactions are a set of clearing mechanisms to support accurate accounting.

In order to scale the Transactions per Second (TPS), an important performance metric, Wormhole Universal Channels provide an extension of Photon Channels, enabling the transfer of between various types of tokens, such as SMT, MESH, ERC-20, BTC, and LTC tokens.

10. APPENDIX: Background on MeshBox Foundation

## 10.1 MeshBox : Building-Block of the HyperMesh Infrastructure

SmartMesh® Foundation and MeshBox® Foundation are bridging the growing Divide between the developed and developing countries.   Meshbox® and SmartMesh® Foundations address the Divide by synergistic co-optimization of hardware resources and software applications, to build the HyperMesh Infrastructure.

Numerous Inclusive Apps have been developed by SmartMesh and Ecosystem Partners to promote inclusivity.   However, such Apps cannot function without network connectivity, a CPU to process applications, and Disk Space to hold blockchain, IoT and user data.   As such, MeshBoxes play a vital role, providing the underlying hardware on which such applications run.

10.2 MeshBox Mesh Wifi Nodes

MeshBox Foundation sells a family of indoor MeshBox and outdoor MeshBox++ Wifi Routers, which interface to various broadband Internet backhauls such as Space-Ground Integration Network with Satellite Internet, Fiber/Coax/DSL modems, TV Whitespace, and Cellular networks.

MeshBox incorporates Disk Space to support the Spectrum blockchain and applications such as Inter-Galactic-File-System, which uses encryption and redundancy to support reliable data storage, content delivery, and offline-data access.   MeshBoxes are used to form large, highly-scalable Wifi Mesh Networks, over which Smartmesh's blockchain technology is layered. Also, MeshBox is the gateway between the Internet and IoT networks such as LoRaWAN.
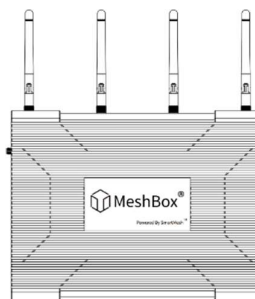
Indoor MeshBox

MeshBoxes have been optimized to run a Mining node of the SmartMesh Spectrum blockchain, which is light enough to run on low-cost CPUs and disk drives, thereby minimizing the cost of MeshBoxes.   Even with intermittent connection to the Internet, Users connected to MeshBoxes can still make payments, and securely access data and local websites on a reliable data storage system.

Outdoor MeshBox++

MeshBoxes are used to form large, highly scalable Wifi Mesh Networks spanning both indoors, and outdoors, over which SmartMesh 's blockchain technology is layered. The solution does not require additional wires for communications, since the Mesh network nodes are connected wirelessly.

As long as some of the MeshBoxes are connected to the internet (via cellular network, wired, microwave, or satellite backhaul), all MeshBoxes in the network, and thus the users connected to such MeshBoxes, are also connected to the Internet.

Also, no power cables need to be installed for the outdoor MeshBox++, which saves a great deal of cost since the Outdoor MeshBox++ are self sufficient with battery and solar technology.
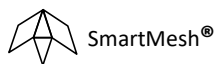
Deployment of MeshBox is incentivized through a Return-on-Investment model in which MeshBox Owners (e.g. home-owners, shop-keepers) or Investors of MeshBoxes receive revenue, in the form of SmartMesh Tokens (SMT) or MESH Tokens, for sharing various communication, disk space, and financial services with community members.

10.3 Supported Applications

- Off-Internet token payment to merchants and individuals
- Accessing local content served from MeshBox(++) hard-disk, even when MeshBox(++) is not connected to the Internet.
- Streaming video
- Sharing of pictures, documents, and other media.
- Incentived deployment, allowing individuals and entrepreneurs to become network operators, receiving a Return on Investment by earing SMT and MESH tokens when sharing network and Disk space resources.

10.4 MeshBox Tesla Specification and Differentiation

MeshBox Tesla	Ordinary Mesh Routers

CPU	Intel	ARM
RAM	4 GBytes	256 MBytes
Hard Disk	256 GBytes SSD Drive	None
Interface	• 4 LAN Gigabit Ethernet • 1 USB3.0 • 1SATA3.0	3 Gigabit Ethernet
WIFI BAND	2.4GHz and 5GHz	2.4GHz and 5GHz
Wi-Fi Standards	802.11 a/b/g/n/ac	802.11 a/b/g/n/ac
Wireless Security	WPA/WPA2-PSK	WPA/WPA2-PSK
Mesh Networking	802.11s	Wi-Fi SON
Spectrum Blockchain	Supported	Not Supported
Photon Payment Network	Supported	Not Supported
Payment for Internet Access	WeChat、SMT	WeChat

11. APPENDIX: HyperMesh Applications

SmartMesh and MeshBox Foundations target aim to help the underserved globally, as well as move everyone towards a sustainable HyperMesh Infrastructure.   The issues which need to be solved are:

- 4 Billion People in the World Remain without Internet Access
- 2 Billion people without banking services
- 1.3 Billion people without electrical power [Paygo]
- Majority of information is processed through centralized servers
- Existing bandwidth and technology is not being optimally used and distributed.
- Currencies are likewise centralized and border contained.

11.1 Financial Inclusion

2 billion people have no access to banking services.   Financial inclusion, where digital currency offers great promise, has the ability to reach people and businesses in remote and marginalized regions.

11.2 Security and consumer protection

The second benefit of digital currency relates to security and consumer protection. Private firms may under-invest in security to the extent they do not measure the full cost to society of a payment failure. Resilience may also suffer—with only a few links in the payment chain, the system may stop working if one of these links breaks. Think about a cyber-attack, a glitch, bankruptcy, or a firm's withdrawal from the local market.

Regulations may not be able to fully address these downsides. A digital currency could offer advantages, as a backup means of payment. And it could boost competition by offering a low-cost and efficient alternative.

11.3 Privacy

The third benefit of digital currency lies in the privacy domain. Token, of course, allows for anonymous payments. Tokens can be used to protect our privacy for legitimate reasons: to avoid exposure to hacking and customer profiling, for instance.

11.4 Climate Change Action

UN SDG Goal 13 is Climate Action. In line with the agreement adopted in Paris in December 2015, Singapore has made a further commitment to reduce our Emissions Intensity by 36% from 2005 levels by 2030, and stabilise our greenhouse gas emissions with the aim of peaking around 2030. [SCAP]

SINGAPORE'S PLEDGE

Emissions Intensity (kgCO₂e/S$GDP)

To reduce our Emissions Intensity (EI) by 36 per cent from 2005 levels by 2030, and stabilise emissions with the aim of peaking around 2030.

2005 **0.176** ↓ 36% 2030 **0.113**
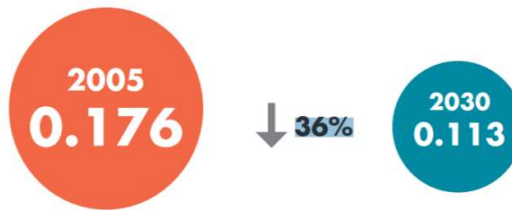
Due to Singapore's heavily urban, dense population setting, and small land area, most of Green House Gasses (GHGs) are due to the energy sector. However, for the rest of the world, Energy accounts for only ~25% of the total top 20 potential CO2 reduction techniques. Since Singapore's contribution to climate change is only 0.11% of the total world contribution, even if Singapore succeeds in achieving its internal goal, the world as a whole may be well on its way to a climate change catastrophe.

The best approach is for Singapore to develop the architecture, design, and implementation best practices for a global, comprehensive solution to reverse climate change. Along these lines, the Climate Action initiative focuses on the top 30 global Drawdown paradigms in order make the most impact on CO2 emissions reduction within the next decade.

SEGMENT ==>	MATERIALS		ENERGY		FOOD		LAND USE		WOMEN AND GIRLS			
Top 20 Solutions		GT CO2		GT CO2		GT CO2		GT CO2		GT CO2	GT CO2 = Giga Tons (GT) of CO2 reduced by 2050 Comment	
1	Refrigeration	89.74										
2			Wind Turbines (Onshore)	84.6							Wind energy is at the crest of initiatives to address global warming in the coming three decades. Today, 314,000 wind turbines supply nearly 4 percent of global electricity, and it will soon be much more.	
3					Reduced Food Waste	70.53					The food we waste is responsible for roughly 8 percent of global emissions. Beyond addressing emissions, food-waste targets and policies can also help to meet future food demand.	MeshBox, Spectrum blockchain for Internet-of-Food (IoF) supply-chain
4					Plant-Rich Diet	66.11					Plant-rich diets reduce emissions and also tend to be healthier, leading to lower rates of chronic disease.	IoF
5							Tropical Forests	61.23			In recent decades, tropical forests have suffered extensive clearing, fragmentation, degradation, and depletion of biodiversity. While destruction continues in many places, tropical forest restoration is growing and may sequester as much as six gigatons of carbon dioxide per year.	
6									Educating Girls	59.6	Education is one of the most powerful levers available for avoiding emissions by curbing population growth. Education also shores up resilience and equips girls and women to face the impacts of climate change.	MeshBox, with Cached content on disk drives supports inclusive education for all.
7									Family Planning	59.6	Securing women's right to voluntary, high-quality family planning around the world would have powerful positive impacts on the health, welfare, and life expectancy of both women and their children. It also can affect greenhouse gas emissions.	
8			Solar Farms	36.9							Solar farms can be found in deserts, on military bases, atop closed landfills, and even floating on reservoirs, deploying silicon panels to harvest the photons streaming to earth. They operate at a utility scale like conventional power plants in the amount of electricity they produce, but dramatically differ in their emissions.	HyperMesh Transactive Energy System (HTES)
9					Silvopasture	31.19					Silvopasture is an ancient practice that integrates trees and pasture into a single system for raising livestock. Silvopasture averts and sequesters emissions, while protecting against changes that are now inevitable.	IoF
10			Rooftop Solar	24.6							Photovoltaic (PV) panels require no fuel and produce clean energy. Small-scale solar systems, typically sited on rooftops, accounted for roughly 30 percent of PV capacity installed worldwide in 2015.	HTES

#	MATERIALS	ENERGY	FOOD	LAND USE	WOMEN AND GIRLS	Description	Addressed by SUCCEED
11			Regenerative Agriculture 23.15			Regenerative agriculture enhances and sustains the health of the soil by restoring its carbon content, which in turn improves productivity. Bringing the carbon back to the soil through regenerative agriculture is one of the greatest opportunities to address human and climate health, along with the financial well-being of farmers.	IoF
12				Temperate Forest 22.61		The world's 1.9 billion acres of temperate forests are a net-carbon sink. Temperate forests continue to be fragmented by development, which can push them beyond their capacity for resilience.	
13				Peatlands 21.57		Peatlands, also known as bogs or mires, are neither solid ground nor water but something in between. Peat is a thick, mucky substance made up of dead and decomposing plant matter. Although these unique ecosystems cover just 3 percent of the earth's land area, they are second only to oceans in the amount of carbon they store—twice that held by the world's forests, at an estimated 500 to 600 gigatons.	
14			Tropical Staple Tree Crops 20.19			Staple foods from trees include starchy fruits such as bananas and breadfruit, oil-rich fruits such as avocado, and nuts such as coconut and Brazil. Tropical staple tree crops can reverse erosion and runoff and create higher infiltration rates for rainwater.	IoF
15				Afforestation 18.06		Afforestation can take a variety of forms—from seeding dense plots of diverse indigenous species to introducing a single exotic as a plantation crop, such as the fast-growing Monterey pine, the most widely planted tree in the world. Whatever the structure, afforestation creates a carbon sink, drawing in and holding on to carbon and distributing it into the soil.	
16			Conservation Agriculture 17.35			Conservation agriculture was developed in Brazil and Argentina in the 1970s, and adheres to three core principles:Minimize soil disturbance: absent tilling, farmers seed directly into the soil; maintain soil cover: farmers leave crop residues after harvesting or grow cover crops; manage crop rotation: farmers change what is grown and where.Conservation agriculture keeps the soil together as a living ecosystem that enables food production and helps redress climate change.	IoF
17			Tree Intercropping 17.2			Like all regenerative land-use practices, tree intercropping—intermingling trees and crops—increases the carbon content of the soil and productivity of the land. The arrangement of trees and crops varies with topography, culture, climate, and crop value.	IoF
18		Geo-thermal 16.6				Geothermal power—literally "earth heat"—taps into underground reservoirs of steamy hot water, which can be piped to the surface to drive turbines that produce electricity. Geothermal is reliable, abundant, and efficient.	
19			Managed Grazing 16.34			Managed grazing addresses two key variables: how long livestock grazes a specific area and how long the land rests before animals return. Improved grazing can be very good for the land and sequester from one-half to three tons of carbon per acre.	IoF
20		Nuclear 16.09				Nuclear plants use fission to split atomic nuclei and release the energy that binds protons and neutrons together. Greenhouse gas emissions are calculated to be ten to a hundred times higher for coal-fired plants than for nuclear.	
TOTAL [GT CO2] ==>	89.74	178.79	262.06	123.47	119.2	773.26	383.16
%	12%	23%	34%	16%	15%	100%	50%
	MATERIALS	ENERGY	FOOD	LAND USE	WOMEN AND GIRLS	TOTAL	Addressed by SUCCEED

11.5 Transactive Energy

Transactive energy combines information and energy sources to enable energy trading which implements highly coordinated self-optimization.
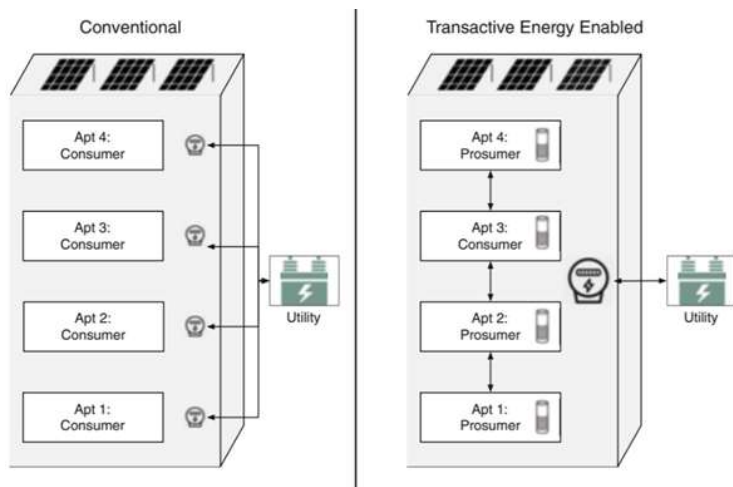

Figure 1.   A use case comparison between a conventional and an eIoT transactive energy-enabled apartment building

The Smart Grid Dictionary defines Transactive Energy (TE) as follows: "A software-defined Grid, managed via market-based incentives to ensure grid reliability and resiliency. This is done with software applications that use economic signals and operational information to coordinate and manage devices' production and/or consumption of electricity in the grid. Transactive energy describes the convergence of technologies, policies, and financial drivers in an active prosumer market where prosumers are buildings, EVs, microgrids, VPPs or other assets." [Liu]
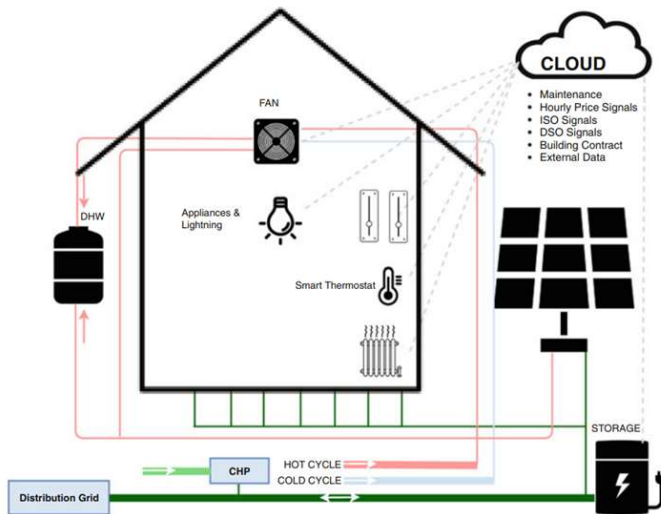
Figure 2. An example eIoT-enabled smart home: DERs are connected to the grid through a cloud-based framework. [Liu]

The GridWise Architecture Council defined Transactive Energy as follows: "A system of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter." [Liu] In a Transactive Energy network, price signals embedded throughout the energy system enable a kind of electronic commerce for energy. The universal language of price bridges all kinds of devices and institutional boundaries, making possible distributed decision-making that optimizes use of resources. [Liu]

TE is commonly viewed as a collection of techniques to manage the exchange of energy in business transactions. A utility, or any other private jurisdiction can implement TE between its various customers in industrial, commercial, and residential environments to manage Distributed Energy Resources (DER). TE applications incorporate the new Energy Internet of Things (eIoT)-based activities for utilities, and industrial, commercial, and residential consumers. The result is better management of resources, successful integration of renewable energy, and increased efficiency in grid operations. In many ways, TE is seen as an effective way to manage the technical and economic performance of various grid operations at all levels of control—commercial, industrial, or residential. [Steffi]
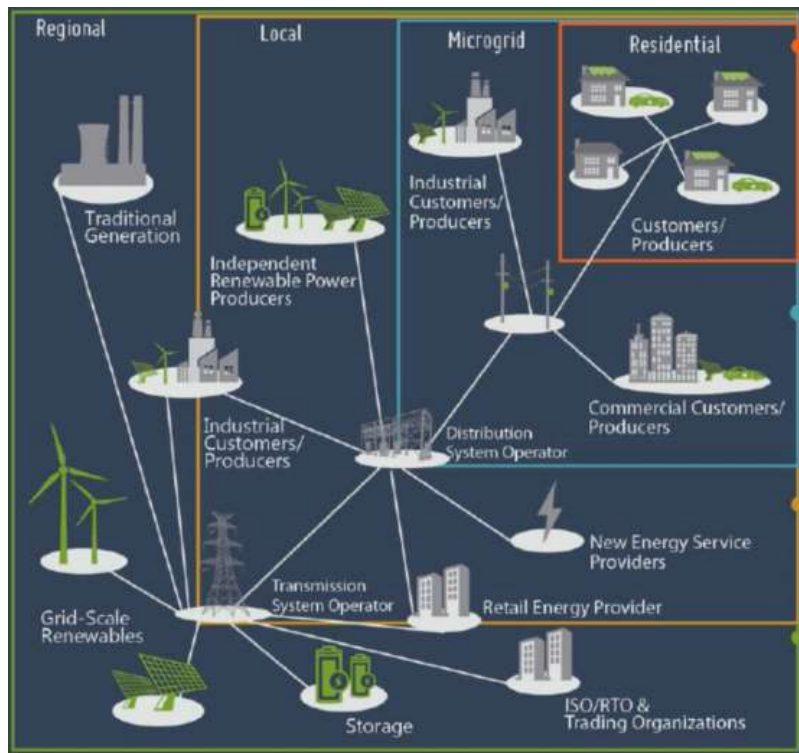
Figure 3 Levels of Energy Smart Grid [Steffi]

TE is expected to offer increased efficiency to the power system and help maintain much needed reliability and security. TE is, further, enhanced by its ability to engage both the technical and economic objectives of the grid in order to solve multi-objective control and optimization challenges. DERs such as intelligent loads, storage, and distributed generation require more sophisticated control approaches than conventionally non-networked loads. As more DER assets and their owners participate in the operational, economical, and semantic aspects of the grid, their activities must be optimally coordinated to align values and incentives among all stakeholders. [Steffi]

TE frameworks provide a systematic alignment of these incentives to favorably achieve grid objectives throughout central operations and peripheral additions. As a design rule, TE architectures must also account for the heterogeneity in the nature of transactions by providing the necessary definitions and guidelines. Recognizing the heterogeneous nature of operations provides the option to expand both the number and types of applications that can be added or removed from TE platforms. Consequently, heterogeneous operation includes making economic decisions that depend on local factors such as the levels of smart metering integration and DER penetration in the region. Future TE development will rely on clear definitions of the transacting parties, the type of information to be exchanged, the transaction terms, what is being transacted, and the transaction mechanisms used by the system. [Steffi]

Blockchain has emerged as a new internet encryption technology that enables distributed pricing. Blockchain is a distributed cyber tool for communicating unique information publicly

and securely. Distributed, shared data repositories are protected from interference through encryption so that there is no need for extraneous bodies to enforce security. At its core, a blockchain creates a "distributed ledger" as an immutable public record of transactions in a computer network and entirely eliminates the need for a middleman. [Steffi]

Transaction rates are determined by the size of distributed data sets, or "blocks," and the time interval for which the chain of data sets is periodically synchronized. TE frameworks and enabling technologies are a force of decentralization that empowers DER management across energy customers. As a technology, blockchain shows great promise in enabling decentralized and distributed exchanges in TE applications. At the moment, blockchain protocols face scalability constraints that may slow transaction rates. This is addressed by Photon Network, which supports P2P payments, which take place off-chain, but use the Spectrum blockchain to solve any disputes between the Peer to Peer parties. [Steffi]

11.6 Internet of Food (IoF)

Food security is a major issue, which will become even more urgent and critical in the next decades due to the expected increase of the world population and the growing economic wealth of emerging economies.   In the meantime, we have already exceeded the carrying capacity of planet Earth with the current way of agricultural production. Further globalization, climate change, a shift from a fuel-based towards a biobased economy, and competing claims on land, fresh water and labor will complicate the challenge to feed the world without further pollution or overuse. [Harald]
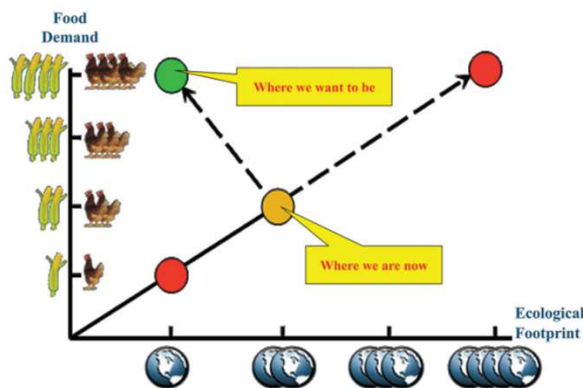

Figure 4 Food demand vs ecological footprint. [Herald]

Our challenge will be: more than doubling of the agri-food production while at the same time at least halving our ecological footprint. [Herald]
- Increasing consumer concerns about food safety by the continuing sequence of food calamities, which have required massive product recalls, sometimes even on a European scale. Recent examples include the horsemeat scandal and the E. coli outbreak. [Herald]
- Agri-food supply chains are characterized by complex network structures where many small and medium enterprises (farms and parts of the processing industry) trade with huge multinationals in the input and retail sector. At this, agri-food

products are often considered as commodities with cost-leadership as the dominant marketing strategy, resulting in low profit margins. [Herald]

- Sustainable food chains are becoming 'license to deliver': roughly one third of food produced for human consumption is lost or wasted globally and food products account for an important part of the emissions produced by the transportation sector. The society does no longer accept the extremely high waste of food and the big CO_2 footprint of food products. • Growing attention for impact of food on health: consumers and society are increasingly aware that there is a strong relation between food consumption and so-called diseases of civilization, including obesity and food allergies. [Herald]

The Internet of Food is poised to undergo rapid advancement due the recent maturity of several technologies which can be synergistically combined to produce a cost-effective, highly optimized system which efficiently manages the production, delivery, and consumption of food.

The following are potential solutions for the specific issues and the corresponding technology which can help:

Challenge	Problem	Functional Solution	HyperMesh Technology Solution
Food Security	Need to feeding a growing population while reducing ecological impact	Automation and improved observability and controllability of farm operations	IoT Sensors and Actuators linked through LoRaWAN to MeshBoxes, which run Edge-computing applications for farm management
Climate Change Footprint	Decrease climate change footprint without impacting timely supply and quality	Improve efficiency of food transport and refrigeration	Supply-Chain scheduling with hard and soft deadlines
Food Safety	Making sure food is free from contaminants and spoilage	Track food sources and supply chains in order to pinpoint and shut down problem areas without having to ban widespread sources	IoT 8-Factor tracking to pinpoint areas of trouble and filter out only food coming from such areas.
Sustainable Food Chains	Decrease the current one-third wastage of food	Real-time scheduling of food transport and better monitoring of food quality	IoT 8-Factor tracking and real-time scheduling of Food from Farm to home (refrigerator)

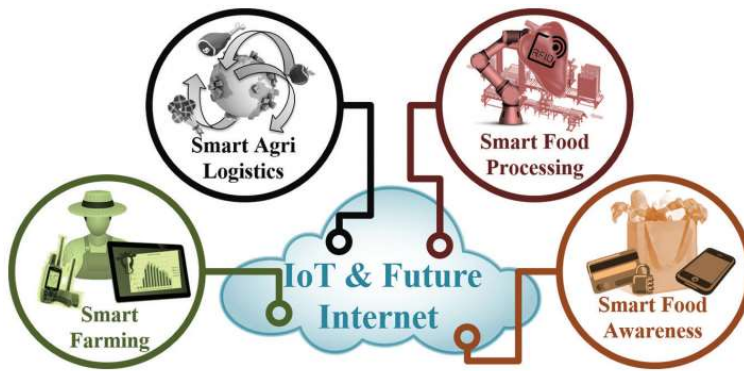| Food Nutrition and Consumer Health	Correlation between food condition and health		
Social Impact on Farmers and Rural Communities	Welfare of farmers and the rural community		

Figure 5 The various smart agri-food domains are increasingly integrated by the IoT and Future Internet technologies.
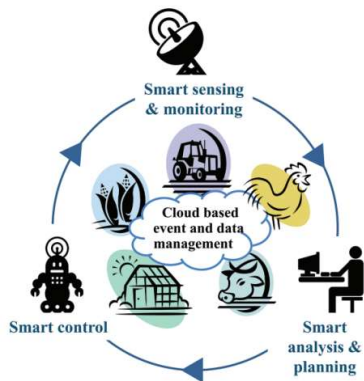
[Herald]

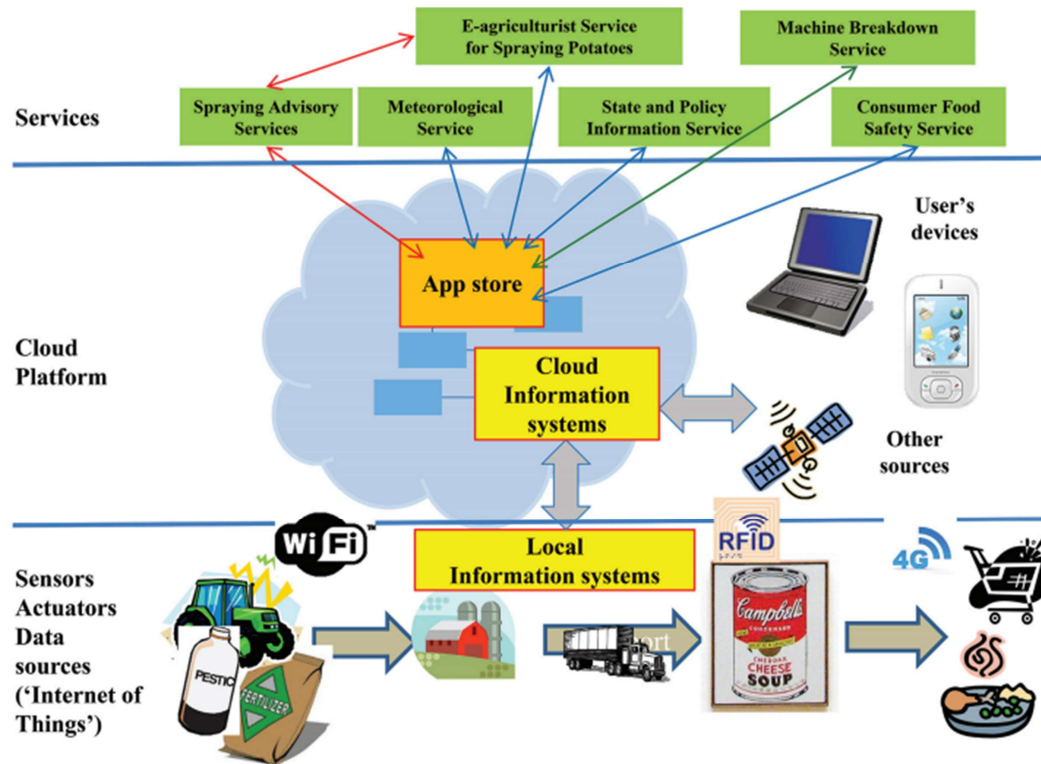**Figure 6 The cyber-physical management cycle of smart farming enhanced by cloud-based event and data management.**

[Herald]

Figure 7 Conceptual architecture for the internet of food and farm as developed in the SmartAgriFood project. [Herald]

12. References

[UNSDG] https://www.un.org/sustainabledevelopment/sustainable-development-goals/

[SCAP] Singapore's Climate Action Plan: Take Action Today, For a Carbon-Efficient Singapore Published By: National Climate Change Secretariat Prime Minister's Office, Singapore www.nccs.gov.sg

[ELE] Gerardo Ceballos, Accelerated modern human–induced species losses: Entering the sixth mass extinction. June, 2015.

[Harald] Sundmaeker, Harald, et al. "Internet of Food and Farm 2020 - IoF2020." Internet of Food and Farm 2020, IoF2020, www.iof2020.eu/.

[Liu] Z. Liu, Q. Wu, S. Huang and H. Zhao, "Transactive energy: A review of state of the art and implementation," 2017 IEEE Manchester PowerTech, Manchester, 2017, pp. 1-6.doi: 10.1109/PTC.2017.7980892, URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7980892&isnumber=7979746

[Naam] Ramez Naam, The Infinite Resource: The Power of Ideas on a Finite Planet, April, 2013

[Grameen] Mohammad Yunus, A World of Three Zeros: The New Economics of Zero Poverty, Zero Unemployment, and Zero Net Carbon Emissions, September 2017.

[Seba] James Arbib and Tony Seba, Rethinking Transportation 2020-2030, The Disruption of Transportation and the Collapse of the Internal-Combustion Vehicle and Oil Industries. May 2017

[Steffi] Muhanji, Steffi O., et al. EIoT: the Development of the Energy Internet of Things in Energy Infrastructure. Springer, 2019.

[Paygo] UN Climate Change Newsroom, Using Pay-As-You-Go Solar Home Systems in Sub-Saharan Africa, March, 2017