SmartMesh

SPECTRUM
WHITE PAPER

Parallel Internet Value Transfer Protocol and DAPP Platform

Spectrum Foundation

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The team retains the right to iterate the description of the white paper.

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1.Abstract

Spectrum is a Proof-of-Capability blockchain wherein nodes which contribute resources to the system earn a higher Capability metric, which allows them to have a greater chance of adding blocks to the the blockchain.

Since all SmartMesh Tokens are pre-mined, the Signing node does not receive any new SMT tokens for Signing a new block, but does receive gas from each of the transactions included in the block. While many blockchains are based on the rich getting richer, Spectrum allows those without monetary wealth to still participate as a Signer since good behavior (producing a good block) is rewarded with a higher Capability metric.

SmartMesh Foundation currently has the SmartMesh Token (SMT) as an ERC-20 token running on the Ethereum blockchain. In addition, SmartMesh has launched the Spectrum public blockchain using the SMT coin. The SMT coin will be listed on exchanges.

MeshBox Foundation has developed a family of indoor (MeshBox) and outdoor (MeshBox++) wifi routers. When owners of a MeshBox(++) contribute network bandwidth and/or Hard Disk storage space, the associated node's Capability metric is also increased.

Spectrum is supported by a strong ecosystem of Mesh Networking hardware, partnering Blockchains and Cryptocurrencies, Decentralized Applications, and Cyberphysical systems, which together makeup a Self-Sustainable Internet of Value Infrastructure (SSIoVI).

The Spectrum blockchain and secondary architectures are highly robust, yet flexible, due to the ability to operate:

- 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.

Thus, Spectrum is an effective building block for SSIoVI, which can be deployed in the harshest and most remote environments.

Smartmesh, MeshBox, and associated partners are in a unique position of being able to synergistically optimize a leap-frogging Infrastructure for the billions of people without access to the Internet, banking, and electricity.

2.Spectrum Introduction

In the following, the various properties of Spectrum are described using an analogy to Graphene material.

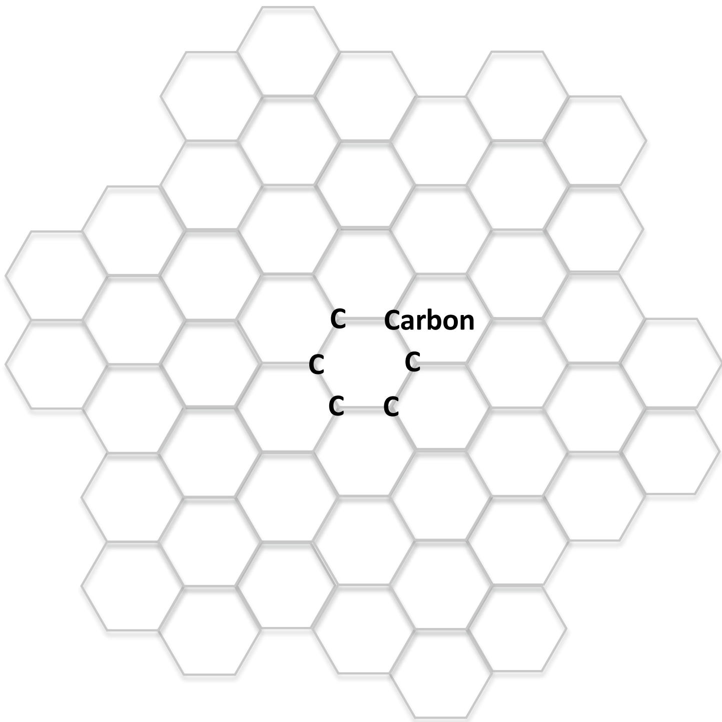
2.1 Spectrum Properties and Parallels with Graphene Material

Graphene is a new wonder material, made of a single atom thick layer of carbon atoms, which will revolutionize many industries bringing about an abundant, self sustainable world for all to enjoy [Graphene]. Similarly, the SmartMesh Spectrum blockchain enables a Self-Sustainable Internet of Value Infrastructure for humankind. The following are properties and features of Spectrum, which are similar to that of Graphene material.

2.2 Highly Robust in Hostile Environments

Graphene is immensely tough. Graphene is 10 [Bulletproof] to 100 times [Graphene] stronger than steel and incredibly flexible.

Graphene is strong due to its structure. Graphene sheets are composed of carbon atoms linked in hexagonal shapes with each carbon atom covalently bonded to three other carbon atoms. Each sheet of graphene is only one atom thick, and is considered a single molecule [nanotech].

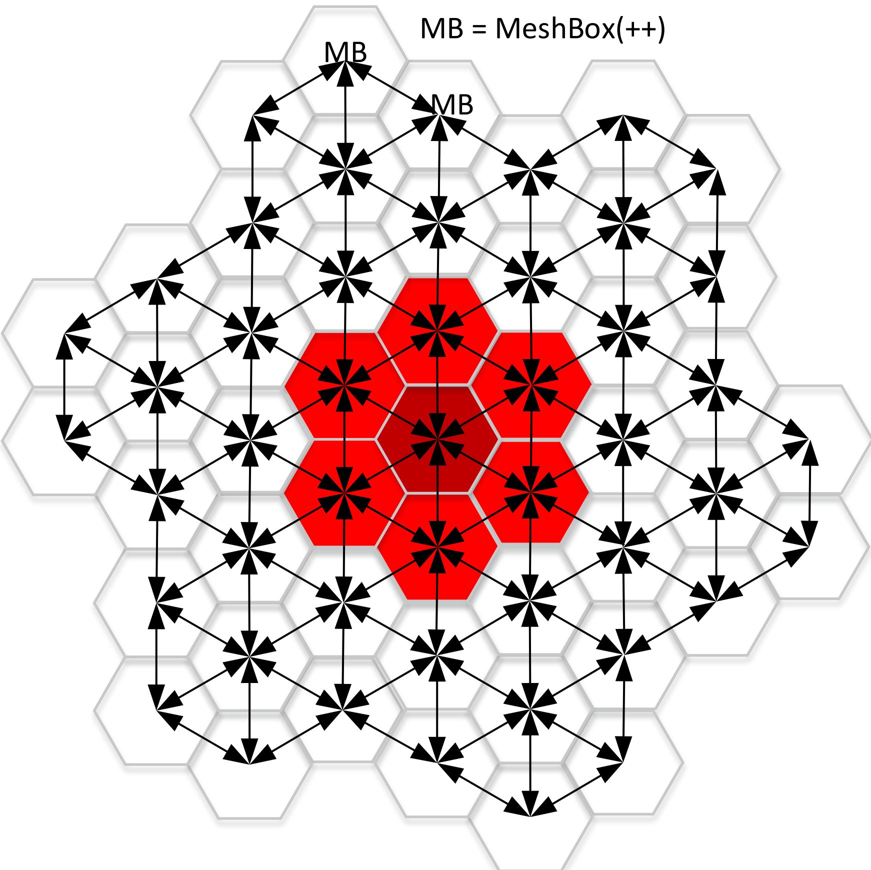


The Spectrum blockchain is similarly strong, and highly robust, yet flexible, due to the ability to operate:

- 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.

Thus, Spectrum is the ultimate building block for SSIoVI, which can be deployed in the harshest and most remote environments, while leap-frogging traditional infrastructure. MeshBox Foundation has developed a family of indoor (MeshBox) and outdoor (MeshBox++) wifi routers.

Similar to the structure of Graphene material, MeshBox nodes are arranged in a hexagonal tessellation (which is also a common design for Cellular networks) with three dimension links between such nodes as shown below. In the Mesh Network, there are a maximum of 49 (=7 x 7) MeshBox nodes. The maximum number of hops between MeshBoxes is eight in the Figure, which is at the limit of feasibility due to throughput loss at each hop due to Wifi interference issues.



Each MeshBox connects with up to 6 other MeshBoxes. A Hierarchical Geometric Sharding approach is used in which each shard can contain up to 49 nodes.

There are multiple paths to traverse from each initiator to each target, which makes the network to be highly fault-tolerant to failures in any of the nodes, as well as interference on any of the links.

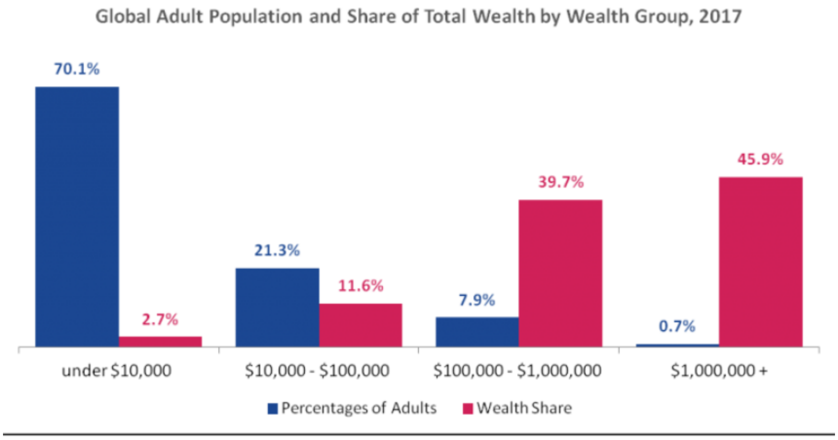
2.3 Lightweight Footprint

Graphene is ultralight and the thinnest material possible (1 atom thick)

Spectrum is also lightweight, using a Proof of Capability (POC) selection of nodes, and can be implemented even on Smartphones and MeshBox, whereas most blockchains are heavy and waste a great deal of resources with Proof of Work.

The Spectrum Consensus algorithm is based on Proof of Capability (PoC) which is motivated by a vision for Universal Connectivity and Consensus and draws from swarm intelligence mechanisms such as exhibited in Bee Hives, Ant Colonies, and Bird flight patterns. All of these systems are characterized by decentralized control, in which individuals work together and contribute to the collective in order to strengthen the entire system.

The motivation behind POC is illustrated by the following graph [GlobalWealth]



Source: Credit Suisse Global Wealth Report, 2017

From the above graph it is observed that

- 8.6% of world's wealthiest (>$100,000 assets) own 85.6% of world's wealth.
    - 70% of world's adults (< $10,000 assets) owns 2.7% of world's wealth.

Thus, the rich get richer and the poor get poorer. This is not fair, and is not sustainable, since, without justice, there is no peace.

This top-heavy wealth distribution is illustrated by a picture of Mushroom. The top 5 richest people in world own more than the bottom 50% of people. [Grameen]

POC consensus algorithm aims for Universal Connectivity and Consensus in that a node which contributes to the system has a higher chance of being a Signer to place the next block on the blockchain. Whereas Proof-of-Work and Proof of Stake allow the rich to become richer, thus widening the gap between rich and poor, Proof-of-Capability measures how much the owner of a node contributes to the system. Such Capability contributions are not only monetary, but include how many times that node does the right thing (produces a correct block), as well as what non-monetary resources are contributed to the system.

Capability is thus defined as a weighted-sum metric of various factors including

- whether the node is running on MeshBox (and therefore how much communication bandwidth, data storage, and transactive energy is shared with the system),
- token investment,
- and the frequency that the node has helped the system, including how many times the node was a successful signer, or produced a bad block.

See Section 3 for more details on the Spectrum consensus algorithm.

2.4 Fast Response Time

Graphene is the ultimate conductor, able to transfer electrons at a much faster rate compared to silicon. It can conduct at the speed of 1000 Km/sec which is about 30 times faster than silicon.

Analogously, Spectrum uses Photon secondary architecture, which boosts throughput to hundreds of thousands of Transactions per Second (TPS), through highly parallelized state-channels, which can be overlayed on top of Mesh-Networks.

Furthermore, transactions through Raiden and Photon flow very quickly through the network from initiator to target.

2.5 Robust Security

Graphene functions as a perfect barrier to certain chemicals, while letting water pass through easily.

Analogously, Spectrum is highly secure, and impervious to attacks such as DDOS and double-spending. Through SmartMesh/MeshBox innovations and UCCO partnership technologies, Spectrum will achieve:

- Statistical Signer selection and purging, with future versions using Artificial Intelligence and Machine Learning.
- Truly random number generation through quantum technology, which provides unbreakable encryption (StealthGrid).

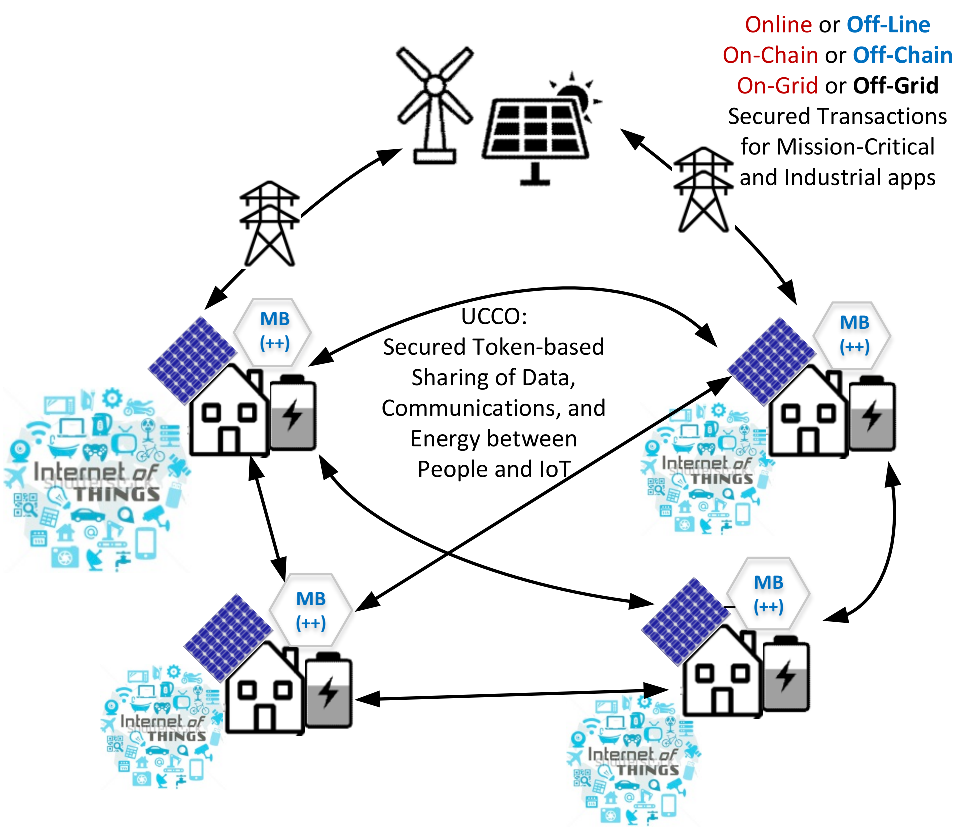
- Multi-layer security Funnel with AI/ML continuous optimization (Dcntral).

2.6 Spectrum Applications

Graphene is a fundamental material for wide variety of applications such as flexible displays (OLEDs, LCDs), RAM, energy efficient transistors, energy storage devices, textile electrodes, nanowires, thermal management, spintronics etc. Graphene can be used in the most popular markets including those of smartphones and wrist watches, flexible electronic newspapers, foldable televisions etc. [Graphene]

Similarly, Spectrum is a fundamental building block of a Synergistic Open Garden Optimized (SOGO) system. SmartMesh/MeshBox is in unique position in offering products which span:

- Communications: Wireless Mesh Networking with MeshBox
- Mobile Applications: SmartMesh social media, O2 Crypto Wallet, and TrustMesh off-internet financial system.
- Blockchain and Crypto-currency Fintech: Smart Raiden, Photon, and dynamic token switching technology.
- Cyberphysical Infrastructure : Transactive energy products for electric Home and electric transportation.



This places SM/MB in a unique position to optimize all such components, synergistically. However, unlike Apple, and other closed ecosystems, which have created a walled garden, SM/MB has formed UCCO, in order to provide open standards and interfaces, an Open Garden.

3. Spectrum Consensus Algorithm

The Spectrum Consensus algorithm is based on Proof of Capability (POC), which is motivated by a vision for Universal Connectivity and Consensus.

POC is fair in that the higher capability a node has, in terms of sharing resources with the network, the more often it will be selected to create the next block. Although Signing produces no additional SMT for the Signer to earn, the Signer does earn gas fees (in SMT) associated with each transaction placed into the block.

3.1 Uniform Chance to Contribute Blocks to Blockchain

Spectrum Nodes are divided into four groups. Each group has a list data structure.

- Signer Nodes take turns to be the Signer to place a block on the Blockchain
- Volunteer Nodes are promoted to be Signers
- Normal Nodes are promoted to be Volunteers
- Misbehaving Nodes

To become a Volunteer node, a Normal node makes a communication connection to a Signer. Among the Normal nodes connected to each Signer, the Normal node with the highest Capability is chosen and promoted to the Volunteer list.

All Volunteer nodes have a chance (through a Round-Robin scheduler) to be added to the list of Signers (which place a block on the blockchain). Each Volunteer node has a parameter TurnsLeft (initially 5) which tracks how many more opportunities that node has to be a Signer. Nodes in the Signer list have an equal statistical chance (with a few exceptions when Signers misbehave) to be a Signer for a block.

3.2 Proof of Capability and DifficultyWeight

In order to speed up consensus finality, each block has a DifficultyWeight. Any branch which has a higher sum of the DifficultyWeights (of all blocks in that branch) will be the one which will win out. The first Signer which is supposed to produce the next block will be given DifficultyWeight =3 which is the highest level. If this first Signer fails, a second node from the Signer list will submit the correct block, receiving DifficultyWeight = 2. If this second try fails, then the third node is chosen based on a distributed Leader-Election protocol. For instance, the hash of the previous block, XORed with each node’s public address, with a masking of some number of bits, and the node with the lowest of such a result will be the winner to take up the task, receiving DifficultyWeight = 1.

Capability is thus defined as a weighted-sum metric of various factors which are based on resources which the node shares with the network.

- Whether the node is running on MeshBox (and therefore how much communication bandwidth, data storage, and transactive energy is shared with the system)
- Token investment (LockedDeposit, or Photon Payment Channel)
- Frequency that the node has successfully signed a block

More specifically, a vector representation of Capability is used in which the elements of the vector include the following resource metrics.

- RunningOnMeshBox = Whether node is running on a MeshBox [Boolean], and if so:
  - Communication BW passing through the Node [bits per second]
  - Storage Space (on MeshBox) being used for IPFS [Bytes],
  - Storage Space disk bandwidth (on MeshBox) [bits per second]
  - Transactive Energy generated and shared [Watt hours],
- Token Investment
  - LockedDeposit = Amount of SMT token in a locked deposit [SMT tokens]. A LockedDeposit of at least one SMT is needed for a node to become a Volunteer.
  - Amount of deposit into Photon Payment channels [SMT tokens]
- Frequency that the node has helped the system, including how many times the node was a successful Signer (positive points), or produced a bad block (negative points).

The Capability metric is defined as the weighted sum (with weight constant W_R for resource R) of the various resource metrics (above).

Since several of the resource metrics change with time, statistical techniques such as IEEE 802.1Qau sliding window averaging can be used to determine the value used in the above equation.

$R(t+1) = [(B-1) * R(t)] + [B * R(t-1)]$

Where $0 <= B <= 1$ is used to weight the previous and current values of the resource metric.

Thus, the Capability is given by:

$$\begin{aligned}
\text{Capability} = {} & (W_{MB} * \text{OnMeshBox}) * [\, (W_{CBW} \times \text{CommBW}) \\
& + (W_S \times \text{Storage}) + (W_{SBW} \times \text{StorageBW}) + (W_E \times \text{Energy}) \,] \\
& + (W_{LD0} * \text{SMT LockedDeposit}) + (W_{LD1} * \text{Token 1 LD}) + \ldots + (W_{LDN} * \text{Token N LD}) \\
& + (W_{PD} * \text{Sum of all Photon Deposits associated with the node}) \\
& + (W_{SS} \times \text{SuccessfulSigning})
\end{aligned}$$

For each time a node successfully Signs for a block, SuccessfulSigning increments by 1. However, if that node fails to produce a good block, SuccessfulSigning decrements by a large number, such as 10 as a penalty.

As can be seen from the above even if the owner of the node has no financial resources (MeshBox or deposits), it can still increase its Capability by producing a correct block when given the chance to be a Signer.

In order to keep the quantities manageable, some of the above quantities could be changed to their log function and be capped at a maximum.

The weighting constants above must sum to not more than 1.

$W_{MB} + W_{LD0 \ldots LDn} + W_{PD} + W_{SS} <= 1$

And the MeshBox resource weights must similarly sum to not more than 1

$W_{CBW} + W_{S} + W_{SBW} + W_{E} <= 1$

The above weights will be adjusted to optimize system performance.

3.3 Proof of Capability Phase 1 Implementation

Some of the resource metrics can be securely determined, since they are based on blockchain constructs. These include:

- RunningOnMeshBox (which will have a LockedDeposit on the blockchain)
- LockedDeposit into an address associated with the node
- Photon Deposit into a channel associated with the node

Initially, only the weight for RunningOnMeshBox be non-zero. The other factors will be considered later.

So, initially, only the weight of W_{MB} will be non-zero.

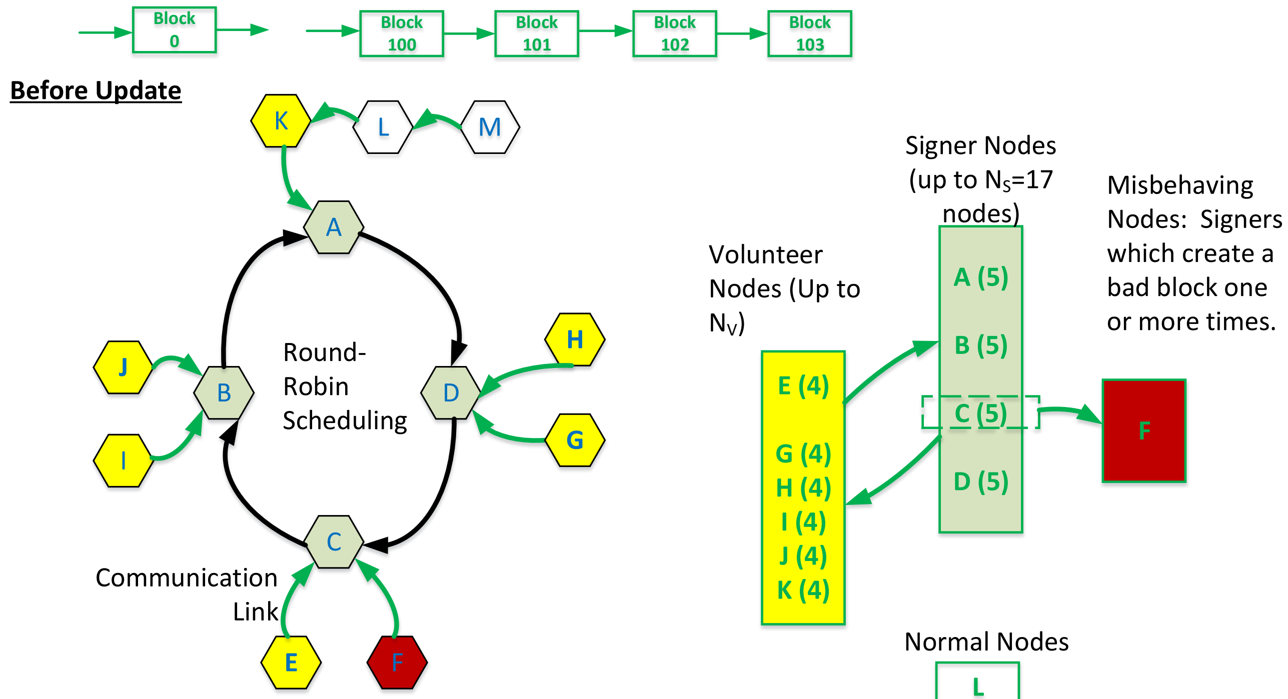
3.4 Proof of Capability Phase 2 Implementation

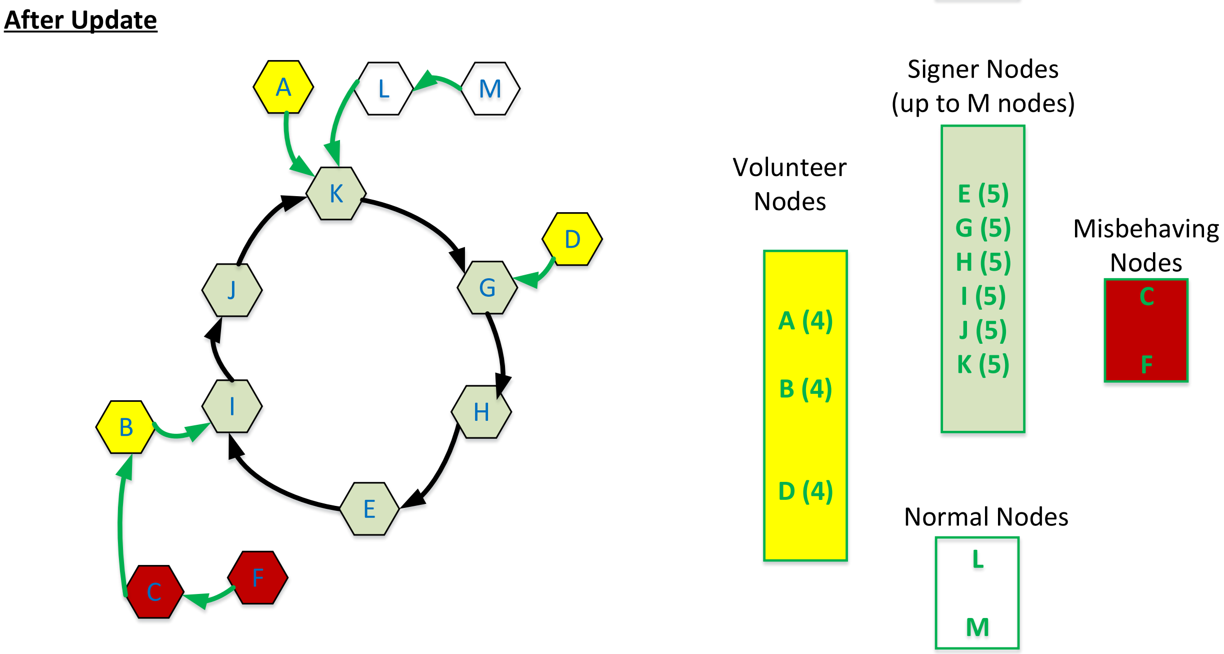
The other resource metrics require a secure consensus algorithm to be securely calculated. Such an algorithm is based on a simplified peer-to-peer verification algorithm using multicast. After such an algorithm is implemented, the following weights can be non-zero:

- W_{LD} for LockedDeposit (at least 1 SMT is enough to be qualified as a Volunteer)
- W_{PD} for Photon Payment Channel Deposit associated with the node
- W_{CBW} for CommunicationBW
- W_{S} for StorageSpace
- W_{SBW} for StorageSpaceBW
- W_{SS} for SucessfulSigning
- W_{E} for Energy

3.5 Node Categorization

The following gives an example of Spectrum operation.





3.6 Node Transitions Between Categories

The following describe the conditions under which nodes transition from one category to another.

- Normal to Volunteer: Spectrum nodes begin as Normal nodes.
    - If a Normal node's LockedDeposit is positive, and the node has made a connection to a Vounteer or Signer node, then the node is considered to be added to the Volunteer list, based on the Capability metric.
    - A Volunteer or Signer considers all the Normal nodes connected to it and chooses the Normal node with the highest Capability metric.
- Volunteer to Signer:
    - Volunteer nodes are selected to be Signers based on a TurnsLeft number which starts at 5 and decrements by one each time the node has become a Signer and has signed one block.
    - Up to N_S Volunteer nodes which have the highest TurnsLeft number (e.g. 5) are promoted to the Signers list when all Signers have gone through one round of being Signers (SignerRound).
- Signer to Volunteer:
    - During each block time (15 seconds), a winning Signer is selected from the list of Signer Nodes to create the next block to be added to the Blockchain.
    - Each Signer has equal probability of being chosen and take turns (round-robin) to be the winning Signer.
    - Once all Signers have had a turn (a complete SignerRound), the entire group of Signers has their TurnsLeft decremented by 1 and are moved to the Volunteer List.
- Signer to Misbehaving
    - Nodes which have exhibited bad behavior when chosen as a Signer (failing to create a block, or creating a bad block when scheduled as the winning Signer), are moved to the Misbehaving List.
    - Such a node will have their SucessfulSigning number (part of the Capability metric) decremented a significant amount.

In the example above

- At the end of a SignerRound, Volunteer nodes E, G, H, I, J, K (with TurnsLeft=5) are added to the Signer nodes list.
- Signer C has misbehaved and is therefore moved to the Misbehaving nodes list in the Update process.

When a Signer wins the right to produce the next block, this block is communicated to the other Signers, which then check this block.

- If this block is correct, then it is added to the Blockchain with Difficult-Weight = 3.
- Else, (block turns out to be incorrect, and that Signer becomes a Misbehaving node) the next Signer in the Round-Robin circle will submit that block.
    - If successful, then that block will be added to the Blockchain with Difficult-Weight = 2.

- Else (block incorrect, Signer to Misbehaving list), the next Signer in the Round-Robin circle will submit that block
    - If successful, then that block will be added to the Blockchain with Difficult-Weight = 1.
    - Else (block incorrect, Signer to Misbehaving list), this blocktime is considered to be unsuccessful and the same process repeats at the next Blocktime, for the same block.

At the end of each SignerRound (NS = 17 block times)

- Step 1: All Signers are moved to the Volunteer List (usually done at the end of each SignerRound)
- Step 4: Up to N_S =17 Volunteers are moved to the Signers List (usually done at the beginning of each SignerRound) based on the largest TurnsLeft metric.

A statistical update of the nodes in each Category is also carried out for each Epoch. Define an Epoch period of time, which could be constant (e.g. 24 hours), or can vary randomly (e.g. normal distributed with mean 12 hours and standard deviation of 8 hours). When such an Epoch period of time has elapsed, a statistical update process is done in order to prevent malicious nodes from taking over the system.

- Step 1: All Signers are moved to the Volunteer List (usually done at the end of each SignerRound)
- Step 2: Up to half of the Volunteers are moved to the Normal list (based on the lowest TurnsLeft metric
- Step 3: All Volunteers have their TurnsLeft number kept the same.
- Step 4: Up to N_S =17 Volunteers are moved to the Signers List (usually done at the beginning of each SignerRound) based on the largest TurnsLeft metric.

4.Spectrum and Applications

Spectrum is a public blockchain which uses the Smart Mesh Token (SMT) as the fee for services such as token transfers and data communication.

Along with the Spectrum blockchain, a secondary architecture has been built which implements State-Channels for increased Transactions per Second (TPS). Smart Raiden, which works with the Ethereum blockchain, has been carried over as the Photon State-Channel architecture for the Spectrum blockchain.

Further optimizations can be made with MeshBox hardware, which is a mesh Wifi router product sold by Meshbox. The following describes the scenarios with, and without the MeshBox hardware.

4.1 Without MeshBox

From experience with Smart Raiden, it was observed that payment throughput performance can be significantly increased with the dimensioning of a Core-Network. The Core-Nodes (similar to conventional user nodes, except instantiated with a large Deposit of SMT tokens) can exist anywhere in the Internet (when Photon is connected online).

Benefits include:

- Internet of Value Infrastructure (IoVI) can be deployed quickly using the Internet.
- Control over Core-Network topology, with a uniform tessellation such that routing algorithms are simplified and optimized.
- High-deposit payment-channels which allow large token transfers with low-probability of failure of finding a route for mediated-transfers.
- SMT/MESH gas charged for various types of resource usage, using a standardized architecture.

4.2 Optimization with MeshBox

The MeshBox Wifi Access Points products include an Indoor and Outdoor version with the following specifications:

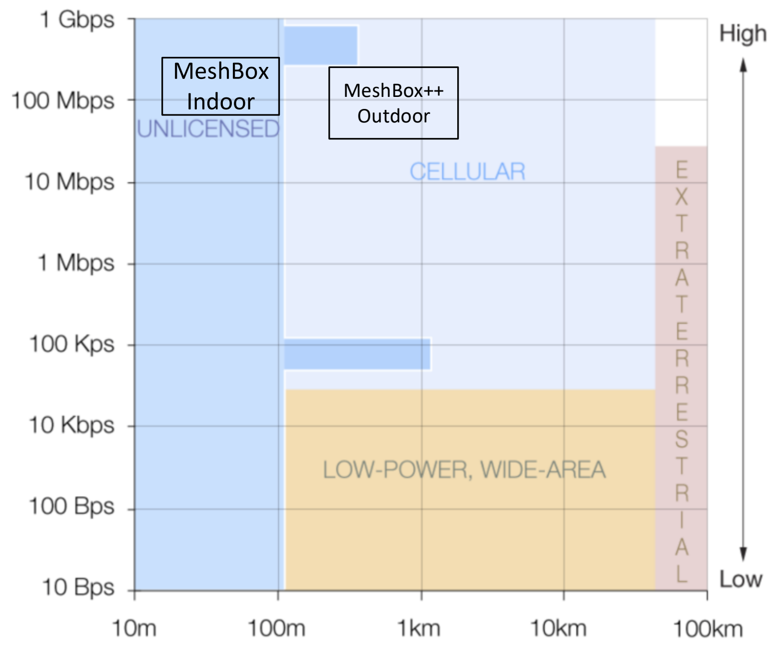
MeshBox Indoor:

- 1W, 2.4 GHz and 5GHz Unlicensed bands.
- 100m Omni-Directional antennas.
- Up to 400 Mbps full-duplex.

MeshBox++ Outdoor:

- 1W, 2.4 GHz and 5GHz Unlicensed bands.
- 300m Omni-Directional and 1200 m Directional antennas.
- Up to 350 Mbps full-duplex

The following shows the Data-rate and Range (Radius) of communication for the Indoor MeshBox and the Outdoor MeshBox++.



MeshBox and MeshBox++ provide greater geographical coverage and high bandwidth compared to most Wifi routers.

In addition to the above benefits, when MeshBox is deployed, Photon Core-Nodes can reside in MeshBoxes (without or without Internet connections). MeshBoxes can be leveraged as hardware infrastructure in order optimize the performance of Spectrum, when Spectrum is implemented within MeshBox. The following benefits are realized with or without the Internet.

Optimization Benefits include:

- Internet of Value Infrastructure (IoVI) can be deployed quickly even without an Internet connection.
- Each MeshBox can be a Shard, where the blockchain associated with the Shard is maintained by MeshBox. Transactions with other Shards are managed with Smart Contracts associated with each Shard, which talk to other Agents in a peer-to-peer manner.

The following shows how SMT, MESH, and future Transactive Energy tokens are rewarded to the owner of each MeshBox.

Various types of resources are used, with corresponding Fees (using SMT) as well as Gas (also using SMT) charged to an account, and earned by the MeshBox owner. The account can belong to some combination of the Initiator of the transaction, an Advertiser, or the IoVI provider. For instance, the Advertiser could pay 80% while the Initiator user can pay 20%.

- Data Packet communication incurs a Communication-Fee
- Token Transfers incurs Payment-Fee as well as a Communication-Fee (for the control messages associated with the Token Transfer).
- IPFS usage incurs a MESH Storage-Fee as well as a Communication-Fee for the packets being stored.
- Transactive-Energy transfer incurs an Energy-Fee (SMT or new Energy-Token) as well as a Communication-Fee for the control packets needed for Transactive Energy auctioning.

4.3 Targeted Advertisment

With MeshBox, it is possible to implement targeted advertising, based on the location of the user, which can be determined by which MeshBox the user is close to, and potentially triangulation methods. Then, merchants in that area can offer advertisements and incentives for people, based on proximity. Proximity-based services are needed for disaster recovery and transportation (uber, didi) type services as well.

Further, targeted advertisement can be structured based on personal information of the user, including age, sex, and purchase history (using the SmartMesh wallet). MeshBox could gather this information, and generate helpful statistics to advertisers, while being careful about privacy.

Instead of users getting charged in tokens to use the MeshBox resources, the advertiser could pay a portion or all of the tokens.

MeshBox can collect personal information from the SmartMesh application (if such collection is enabled by the user) and anonymize such info as "class of user" statistics. The SmartMesh app could also compile a "credit report" which must be validated through Spectrum consensus. Such a credit-report can be enabled to be shared with the MeshBox, which aggregates such data, and provides such data to advertiser in order for them to determine what kinds of Advertisements should be sent to each "class of user".

4.4 Quality-of-Service (QoS) Scheduling

This approach implements the “time is money” philosophy that people are willing to pay more tokens to have a better Quality-of-Service. For instance, users can subscribe to various Class-of-Service levels (analogous to being a regular member, or gold/premier member). It is possible for users to pay more tokens for faster service or first access to resources.

4.5 Data Packet Communication

Whenever packets are received or transmitted by MeshBox, link bandwidth is used on MeshBoxes, and SMT Gas is paid by the transmitter (a1 in the example). Examples of Packets include:

- All messages associated with token transfers (mediated, refund, secret request, secret reveal, secret, ACK)
- Data packets (voice, video, data)

- Packets exchanged for IPFS, and other protocols which transmit/receive packets, whose data is stored on the MeshBox hard disk.
- There are several alternatives (choose one) for how to charge Gas for such packets:
  - Per-Account basis: Gas is charged for each packet, based on the packet length, to an account. Such an account can be either the Initiator (e.g. a1 or a2) connected to the Core-Node with a payment channel, or an investor or advertiser which is paying for such packet transfers, in exchange for the user having viewed an advertisement.
  - For finer granularity, instead of all packets from an Initiator node, it is possible to keep track of Packet Sessions, since different sessions may require different QoS, and may therefore be charged accordingly.
    - For instance, all packets belonging to a particular token transfer belong to one Session, and gas is charged for that entire Session.
    - It is possible for all packets in a flow for a particular QoS (e.g. one streaming media session) from one transmitter to one receiver to be categorized as one Session. The total number of bytes from all such packets can be counted during a period of time, and this bandwidth can be used to determine the Gas charged for that session.
  - For Receive or Transmit queue backlogs. Using QCN 802.11Qau, a sliding-window statistic is calculated for queue lengths, where each Session is mapped to a particular Queue.

4.6 Token Tansfers

Token Transfers use the SMT Token-Transfer Fee similar to Photon Direct and Mediated Transfers. In addition, Communication-Fees are incurred for the protocol messages associated with the Token Transfer.

4.7 Inter-Planetary-File-System (IPFS) Application

There are two aspects of Storage: Space-Time buffer allocation, and memory bandwidth usage, both of which incur SMT Fees.

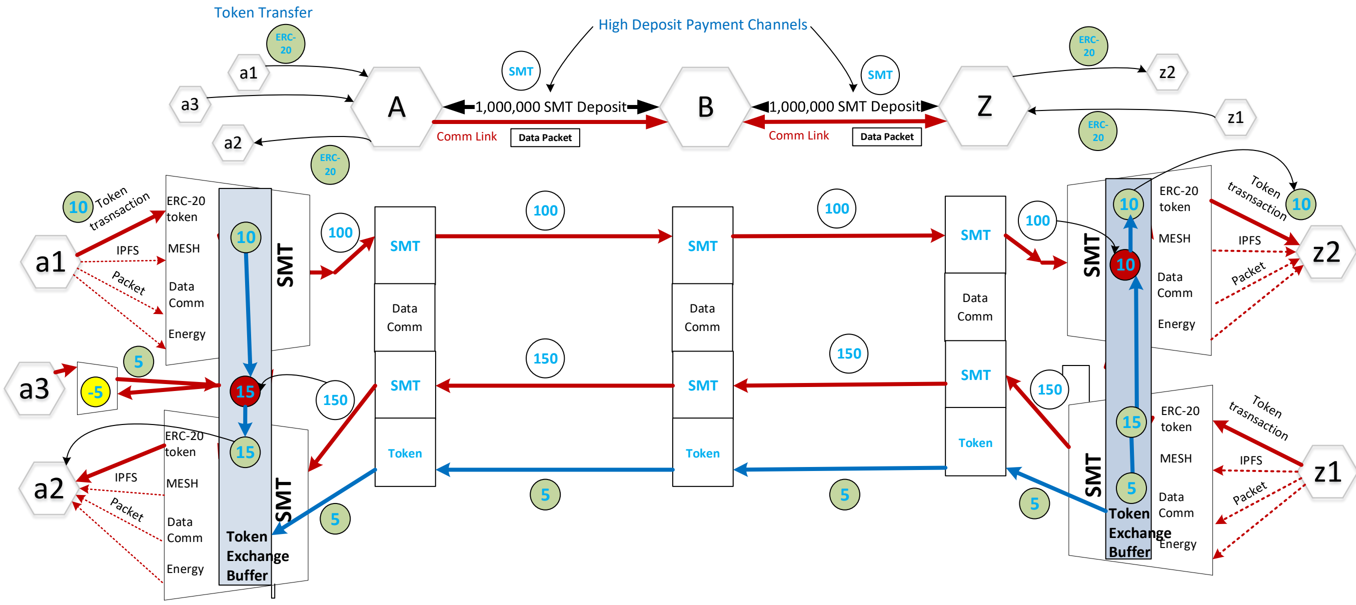
- Space-Time Buffer Allocation.
  - Keep track of (relatively) large buffers (on the order of several MBytes or GBytes) which are allocated per application.
  - For instance, for a particular IPFS application, some amount of SSD space is allocated and the space-time usage of such a buffer is accounted for, and MESH tokens are paid accordingly.
- Memory-Bandwidth
  - Whenever packets (e.g. Video or Data) are written to, or read from the SSD, MESH are charged.

5.Roadmap

The roadmap of Spectrum and associated technologies is described below.

5.1 Increasing TPS with Photon State-Channel Architecture

The figure below illustrates a network of three MeshBoxes (A, B, and C) with communication links between them.



Overlayed on top of the communication links, High-Deposit bi-directional payment channels are setup by MeshBoxes. The figure shows only uni-directional channels for simplicity. Such Deposits can be allocated by SmartMesh with an initial number of SMT tokens, which are to be used to create high-deposit channels. Alternatively, outside Investors can put in some portion or all of such deposits.

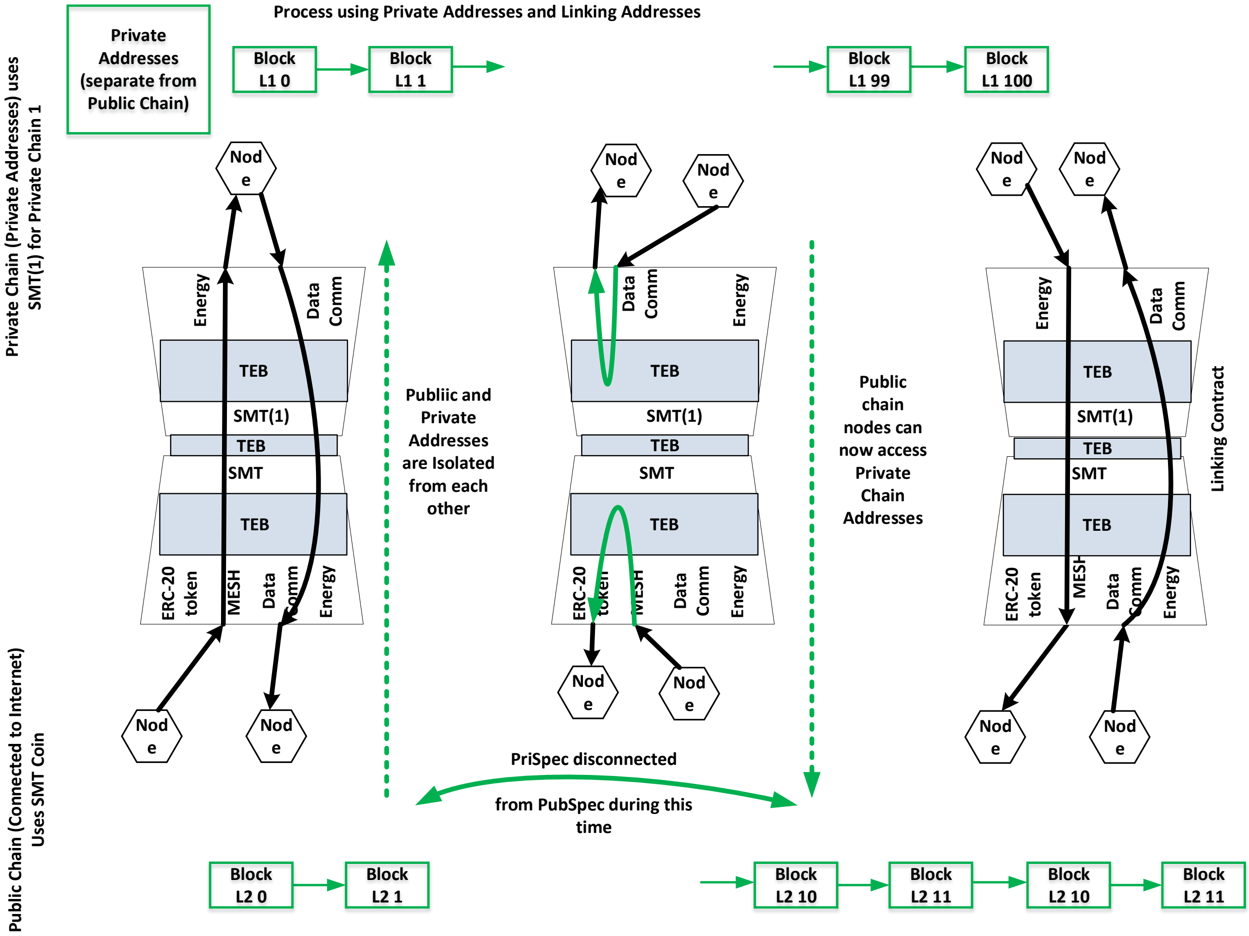
Various channels can be established through Photon including SMT Payment Channels, ERC-20 Payment channels, and Data Communication Packets, which use SMT as a fee to traverse every MeshBox hop.

While it is possible to support many types of channels, belonging to different tokens, such is not the best practice since performance will be low due to segmentation of Deposits across the multiple Channels.

Instead, performance is improved when SMT channels are mostly used, due to **Statistical Multiplexing**. This is achieved by combining otherwise various state-channels into a single SMT-based state-channel. When tokens, such as ERC-20 are to be transferred, such tokens are first converted to SMT and SMT channels are used to carry the payment. SMT is charged as the fee for routing services through the network.

In such an architecture, other tokens are converted to SMT by the Token-Exchange-Buffer block, which holds the token in a buffer and sends the equivalent amount of SMT through the SMT payment channels. Other transfers going in the opposite direction, which need to convert SMT to such a token, can use the tokens held in the buffer. In order to balance the tokens, the TEBs can exchange such tokens with each other through specific payment channels for such tokens.

5.2 Improving Robustness

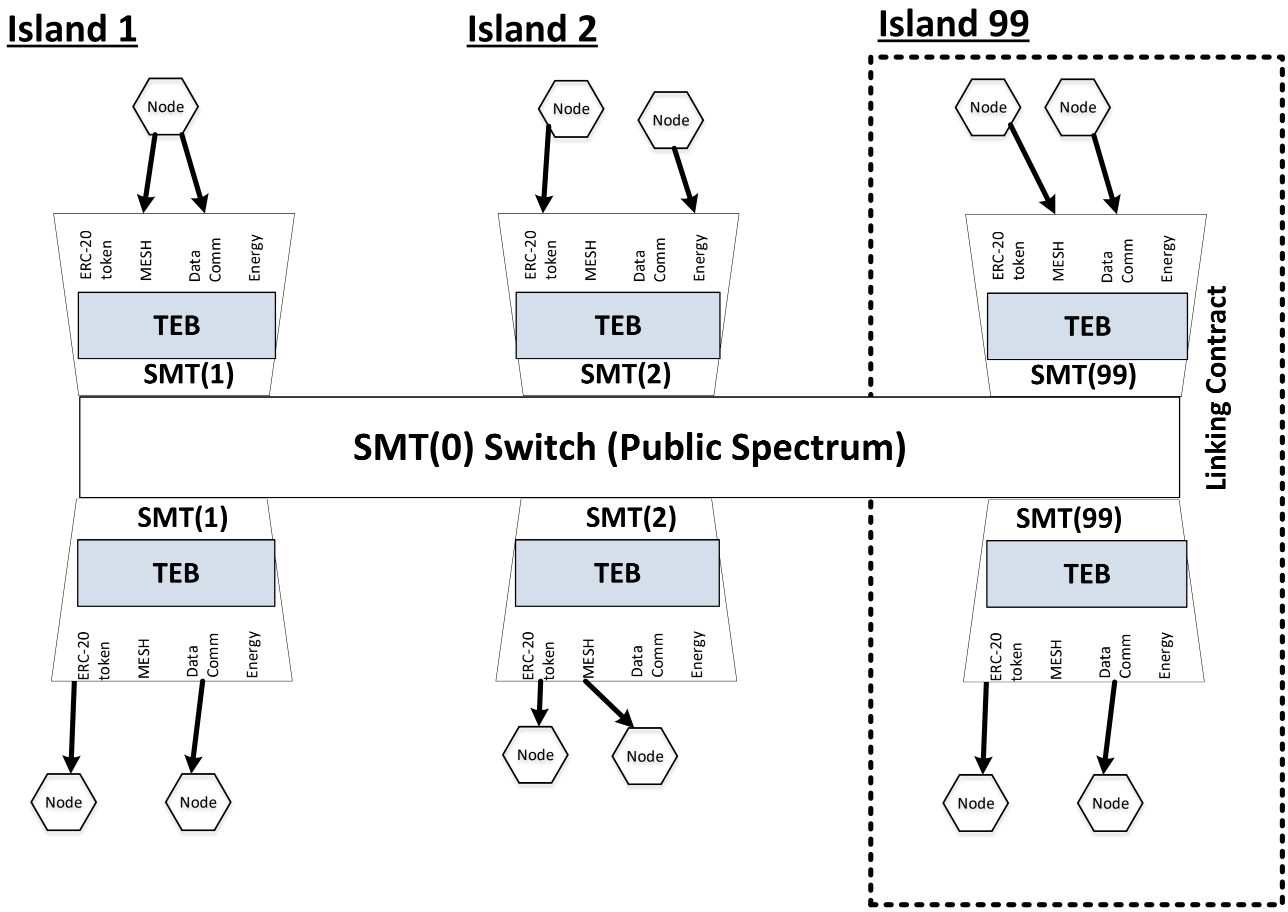


The figure shows how a Private Spectrum Chain can operate separately from (and in parallel) with the Public Spectrum Chain. At all times, even when the Islanded Spectrum is not connected with the Internet (and thus not connected with the Public Spectrum), the following are possible.

- The nodes in the Public Spectrum can access addresses associated with the Public Spectrum and the addresses in the Public portion of the Linking Contract.
- The nodes in the Islanded Spectrum can access addresses associated with the Islanded Spectrum and the addresses in the Islanded portion of the Linking Contract.

However, when the Islanded Spectrum is connected to the Internet, and thus to Public Spectrum, the Linking Contract can transfer transactions between the Addresses in the Islanded and Public portions of that Linking Contract.

The following shows multiple Islanded Spectrum Chains, each with their SMT token. Island(1) uses SMT(1), Island(2) uses SMT(2), and so on. The different tokens for each Island are needed since the value of the SMT on one Island can drift and become out of synchronization with SMT on other Islands, as well as the SMT coin (called SMT(0)) of the Public Spectrum chain.



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