Agenda

• Blockchain Fundamentals and Benefits
• Blockchain Reference Models
• Blockchain Interoperability Definition
• Timing and Blockchain DLT
• **Trusted DLT Timing** Reference Framework
• Key Takeaways

**Note:** Distributed Ledger Technologies (DLT) is the technical term that defines this technology, where blockchain is the main type of DLT.
Blockchain Fundamentals and Benefits

**Benefits**

- Trustable
- Transparent
- Traceable
- Immutable
- Decentralized (ownership)
- Auditable

**Data Input**

1. **T1 hashes**
   - Block 1 Transactions
   - documents/transactions

2. **T2 hashes**
   - Block 2 Transactions
   - documents/transactions

3. **T3 hashes**
   - Block 3 Transactions
   - IoT data

**Ledgers**

2. DLT

**Blocks**

- Block 1 Header
  - Hash of Previous Block Header
  - Merkle Root
- Block 2 Header
  - Hash of Previous Block Header
  - Merkle Root
- Block 3 Header
  - Hash of Previous Block Header
  - Merkle Root
Blockchain DLT Reference: Key Principles

10 Best Principles & Recommendations

- Open Standards
- Secure
- Technology Agnostic
- Future Proof
- Interoperable
- Scalable
- Modular
- Manageable
- Reliable
- Inclusive

"Open" and Interoperable DLT/Blockchain Standards-Based

Recommended Approach
Decentralized Applications - dApps

1980-2019

Centralized Cloud-Centric

ISP

ISP

ISP

(centralized) Apps

1980-2019

Decentralized Applications (DApps)

2019 ➔
Blockchain DLT (BDLT) System-of-Interest (per IEEE 42010)

- Blockchain-IoT Reference Architecture, based on IEEE 42010 framework (undergoing)
- All alternatives included - considers more than Blockchain as technology enabler
- Addresses key domain/layer levels
- Includes (most) Blockchain/DLT technologies elements
Defining Key Blockchain-DLT Layers (BDLT)

The building layers of Blockchain DLT systems need to be defined to categorize its key elements, independent of the DLT technology adopted.

- **NETWORK** (connectivity, runtime, cloud infrastructure and/or P2P)
  - Things

- **DATA MODELS**
  - Things

- **APPLICATIONS**
  - Things

- **SERVICES**
  - Things

- **PROCESSES**
  - Things

- **TRANSACTION**
  - Things

- marketplace, monetization layer
- decentralized apps (Dapps)
- transactions/contract, tokens
- consensus algorithms
- block, chain structure, cryptography, hashing
- node, OS, VM/kubernetes, P2P messaging/discovery
- IoT, OS, UID
Blockchain “Tower of Babel”
The need for Blockchain DLT Interoperability

- Corda
- Quorum
- EEA permissioned
- Hyperledger consortium A
- Hyperledger consortium B
- Ethereum main net permissionless
- NEO
- EOS
- Multichain
- Bitcoin permissionless
- permissioned blockchain
Permissioned Blockchain “Silos”
Single company, intra- and inter-companies blockchain consortium silos
Blockchain DLT Interoperability Definition

“Blockchain DLT Interoperability is the ability of distributed ledger computing systems to interconnect multiple intra and inter-DLT blockchain sub-systems and systems to create, destroy, modify, change, transfer, register and validate digital assets and transactions and its states, across multi-ledgers in a secure, scalable, trusted and consensus-based approach.”

BEC, September 16th 2019

3 important blockchain design criteria

- open-protocols
- multi-chain, multi-ledger frameworks
- 2P2S (privacy, performance, scalability & security)
Blockchain in Telecom Multi-Layer Design

Blockchain in Telecom requires “carrier-grade” design principle

- National Wide Backbone
- Regional Backbone
- Metro Networks
- Access Networks (micro, pico, nano, femto)
- Home-Local Networks

trusted synchronization network +
Blockchain DLT Interoperability Layers

There are different levels of Blockchain DLT interoperability

- Semantic Interoperability
- dApps, Smart Contract Interoperability
- Multi-Ledger Interoperability
- Middleware Layer Interoperability
- Multi-Cloud/P2P Network Interoperability
Blockchain DT Interoperability Techniques and Use Cases

- Notary schemes
- Relays and sidechains
- Hash-locking

Use cases:
- Asset portability
- Atomic swap
- Cross-chain oracle
- Cross-chain contracts

Requires network timing/synchronization
3 Main Domains of Blockchain DLT Systems

The first design criteria for permissioned DLT systems is to identify which DLT category applies for a particular application.

There isn’t a “one-size fits all” solution in Blockchain design.
Multi-Cloud, Multi-Ledger Interoperability

**OPTION A**
multi-cloud, single-vendor single-ledger

<table>
<thead>
<tr>
<th>DLT Ledger</th>
<th>AWS cloud</th>
<th>AWS cloud</th>
<th>AWS cloud</th>
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</table>

**OPTION B**
multi-cloud, multi-vendor single-ledger

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<tr>
<th>DLT Ledger</th>
<th>AWS cloud</th>
<th>Google cloud</th>
<th>Azure cloud</th>
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</table>

**OPTION C**
multi-cloud, multi-vendor multi-ledger

<table>
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<tr>
<th>DLT Ledger 1</th>
<th>Interface</th>
<th>DLT Ledger 2</th>
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<tbody>
<tr>
<td>AWS cloud</td>
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<tr>
<td>Azure cloud</td>
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</tbody>
</table>
Next Step: Blockchain Interchain
Connecting Fragmented Blockchain Ecosystems

early days of Internet

with Blockchain Interoperability

Public Blockchain

Ethereum

Permissionless

Main Net

Enterprise Blockchain

Sidechain A

Sidechain B

Sidechain C

Sidechain D

Sidechain E

Blockchain gateway/bridge

INTERCHAIN

Intranet A

Intranet B

Intranet C

Intranet D

Intranet E

2018 Blockchain Fragmented Ecosystem

Ethereum

Permissionless

Main Net

Other Permissionless Networks

2018 Blockchain Fragmented Ecosystem

Other Permissionless Networks

DLT Interoperability Labs (DLT-i-Labs)

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Challenges of Blockchain Timing Manipulation

Blockchain is a decentralized, trusted and secure timestamping service where each block is associated with its timestamp ($T_i$) and related to the previous block.

BUT participants who can create new blocks can manipulate timestamps (not their order) there is no timing certification authority.
The Importance of “Timing” in Blockchain

Distributed Hash Ledgers

Immutability

- blocks sequence
- time
- space

- time must be precise
- provenance tracking
- authenticity
- verifiability

e.g. SONET/SDH Timing Synchronization

source: SONET-synchronization overview, J. Bourgeois

DIGITAL ASSETS
Atomic Clocks for Precise Timing

There are over 400 atomic clocks around the world used in calculation of Universal Coordinated Time (UTC)

source: NIST
Trusted DLT Timing Service Infrastructure (DLT-TSI)
Timing for Blockchain Interchain

TTA ID Management DLT
UTC Universal Coordinated Time
Validate IDs of TTAs and TTVs

TTA ID Management DLT

Distributed Trusted Timestamping Authority (TTA) Network
synchronized timing

Multiple Distributed Trusted Timestamping Validators (TTV)

Timestamp Verified DLT
publish TSA-timestamped verified transaction
Merkel Root
Merkel Root

(t'_i)
(t'_ii)

DLTs interoperability

TTA – trusted timestamping authority
TTV – trusted timestamping validator

Validate IDs of TTAs and TTVs

timestamp request
(t_i)
(t'_i)

timestamp confirmation
Key Takeaways

• Blockchain DLT silos and multi-ledger permissioned and permissionless technologies create a “Tower of Babel”, similarly to the early days of the Internet networks and protocols.

• Multi-cloud, multi-ledgers are the first interoperability layers to be considered.

• Blockchain-carrier/telecom-grade design – needs redundant, scalable, secure and high performance blockchain DLT, and eventually a trusted timing network.

• Blockchain DLT timing can be manipulated by participants.

• There is a need for a Trusted DLT Timing Reference Framework for interoperable DLTs.

• Blockchain DLT Interoperability and Trusted Timestamping Solutions are very important for global adoption of blockchain, and the IEEE standards will address these topics.
THANK YOU!

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