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Developing an Automated Secure Chain of Custody Using AIDCT and DLT: Starting the Field of Sec COC Ops

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Abstract- Many domains have found a promising solution in Block chain technology, with financial reconciliation being the most popular. Every single day of the current human interaction cannot be explained without Auto-ID and Data Capture Technology, the most popular presently being the QR code, NFC, and UWB RFID. Maintaining and regulating the chain of custody is a crucial aspect of forensics where block chain and ADIC solutions can provide significant help. Although there have been many reflections on using block chains and RFID in digital forensic investigations, their application to physical evidence custody management has received little attention. Our research aims to study literature related to the use of block chain technology and AIDC technology in addressing issues with the chain of custody of physical evidence and developing the Block chain-AIDC-based solution for the same. In a systematic literature review, we examined 15 sources that discuss block chain-based solutions for chain of custody issues in evidence. These requirements could apply to both digital and physical evidence. There is a need for future research to address the lack of studies on using block chain technology to deal with issues related to the physical evidence chain of custody, as shown by the results. The solution for this will be provided through the use of Hyper ledger Fabric and RFID in this project. As of now, even though there have been several architectures suggested for the project, none has been made available for commercial use. This project will deeply analyze the sufficient architecture among the proposed ones and then develop a DLT-AIDCT Chain of Custody management solution using Go and Python programming languages.

Index Terms- DLT-AIDCT, NFC, UWB, RFID, Block chain, CoC Management, Physical Evidence, AIDC, Node JS, Python.

I. INTRODUCTION

Development of a digitally transformed, Automated, Green Chain of Custody (COC) Decentralized Application Chain code for the Age of Computational Exponentialism (ACE) using the Auto-ID and Data Capture Technology i.e., RFID and Permissioned Enterprise-Grade Distributed Ledger Technology i.e., Hyper Ledger Firefly.

II. PREFACE TO (COC) CHAIN OF CUSTODY

The chronological paperwork or paper trail that documents the sequence of custody, control, transfer, analysis, and disposition of accoutrements, including physical or electronic substantiation, is known as the chain of custody or chain of guardianship. The conception is particularly important in felonious cases, but it's also used in civil action and, more astronomically, in athlete medicine testing, for illustration, to ameliorate the traceability of food products or to give assurances that wood products come from sustainably managed timbers.

It's constantly a time - consuming process that has been needed for substantiation to be fairly shown in court. Still, with new movable outfit that permits dependable laboratory-grade results from the point of the crime, the chain of guardianship is constantly mainly shorter, inferring that substantiation can be attained more snappily and reused for courts.

1. Chain of Guardianship Crimes Frequently Include the Following

Defiled Crime Scene

Law enforcement may fail to duly secure a crime scene, performing in the outside public, or indeed individualities working on the case who shouldn't be in designated areas, polluting the substantiation at the crime scene.

Failure to Duly Document Substantiation

Law enforcement may fail to duly validate every piece of substantiation in their possession. like wise, they may fail to

duly identify the position it was set up in or the person it was set up on.

Law Enforcement May Also Inaptly Label the Substantiation as Commodity it's not.
This may include law enforcement failing to detail precisely where the substantiation was set up or what case it pertains to. Improper Handling of substantiation – Law enforcement may fail to duly handle physical substantiation with gloves, or fail to gather the substantiation with castrated outfit, rendering the substantiation defiled. Indecorous storehouse of substantiation – Law enforcement may fail to duly store substantiation in a place or manner in which it'll remain complete and untainted. This can be answered by Block chain and AIDC Tech combined.

III. PREFACE TO DISTRIBUTED LEDGER TECHNOLOGY (DLT)

In the absence of a centralized surveillance system, Block chain is a decentralized and distributed ledger that can be used to store information in multiple locations. This will allow information and currency to be kept and safely transmitted by individuals and businesses at the same time. With the use of block chain, information is exchanged without any intermediaries or intermediaries and peerto peer. Let's take a look at how our existing system works, which will help us understand it better. We use high-performance computers, referred to as servers owned by enterprises for transmitting information over the Internet. All of our communication is handled by these servers. It's the same with money transfers.
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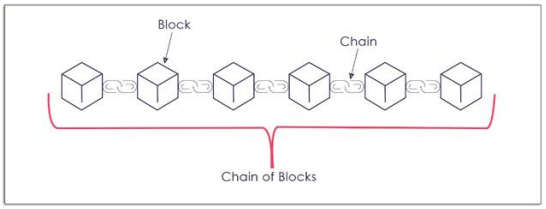

Figure 1: Block chain an illustration to the layman

All of our communication is handled by these servers. It's the same with money transfers. We rely on the banks for certification and verification of our transactions. In the course of our communications and transactions these servers, institutions, and businesses are an intermediary. These intermediaries will be deleted and a new form of communication introduced into the Block chain. Block chain got its name from the format it stores data. In block chain, the data is packaged into "blocks". The blocks later form a chain with other blocks of information, forming – block chain.

What Does a Block Contain?
Blocks contain information on transactions happening on a block chain.

What Does a Block Look Like?
A block contains a header and body. Transactions are stored in the body part and other details are in the header. It is a protocol for Peer to peer-to-peer networking with Confidentiality, Integrity, and Availability.

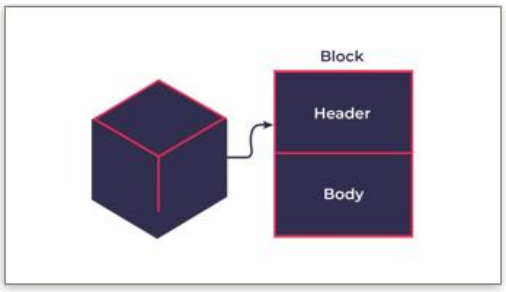

Figure 2: Block chain as Standard Protocol illustration

The blocks are cryptographically verified and chained up to form an immutable chain of blocks called the block chain.

Working on a Block chain

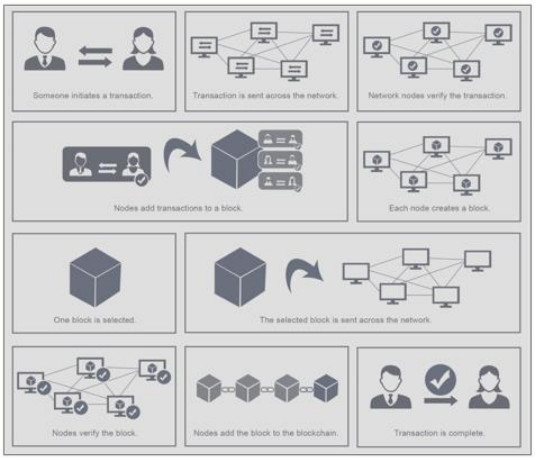
Figure 3: Block chain Transaction sharing across Peers (Depiction of steps)

Steps in Working on a Block chain
- The transaction will be transmitted over the Block chain network.
- This transaction will be checked to see if it is valid.
- A block is filled with the validated transaction.
- From the network, one block is selected.
- The block selected shall be added to the chain

What Is A Transaction in a Block Chain Used for a Chain of Custody?

A transaction on the block chain used to maintain the a record of the transfer of ownership or control of a piece of evidence. At present a Chain of Custody Form is used to maintain this. This form shall include, in so far as it includes the parties to the transfer, senders, receivers, and all witnesses: a special identification of an item or pieces of evidence. The date and time on which they are transferred. Any other pertinent information, e.g. where the transaction is taking place and the condition of the property or evidence.

A network of computers is verifying every transaction, and it's added to the block chain in chronological order. This results in a padlocked chain of custody record that is easy for authorized parties to verify.

Here is an example of how a block chain transaction could be used to maintain a legal chain of custody for a piece of evidence:

1. A police officer collects a piece of evidence at a crime scene.
2. The police officer creates a new block chain transaction and records the following information:

- The unique identifier of the piece of evidence (Serial number for Digital storage devices)
- The date and time of collection
- The location of the collection
- The condition of the piece of evidence

1. The police officer signs the transaction with their digital signature.
2. The transaction is broadcast to the block chain network.
3. The transaction is verified by the network and added to the block chain.

The block chain transaction now serves as a tamper-proof record that the police officer collected the piece of evidence at the crime scene on a specific date and time.

Block chain transactions can be used to maintain a legal chain of custody for any type of asset or piece of evidence, including:

- Physical evidence, such as weapons, drugs, and DNA samples
- Digital evidence, such as computer files, emails, and social media posts
- Financial assets, such as stocks, bonds, and cryptocurrencies

Preface to Hyper Ledger Fabric

Hyper Ledger-Fabric is a free and open-source Enterprise-grade permissioned Distributed ledger technology (DLT) stage, planned for utilization in endeavor settings, that conveys a few key separating capabilities over other prevalent disseminated record or block chain platforms.

One key point of separation is that Hyper Ledger was set up beneath the Linux Foundation, which by itself contains a long and exceptionally fruitful history of sustaining open-source ventures under open administration that develop solid, maintainable communities and flourishing environments.

Hyper Ledger is represented by a different specialized controlling committee, whereas the whole Hyper Ledger Fabric venture is dealt with by a diverse set of managers from many organizations. It features an advancement community that has developed into over 35 organizations and about 200 software developers since its most punctual commits. Fabric encompasses the profoundly secluded and configurable engineering, empowering advancement, flexibility, and optimization for a wide run of industry utilize cases counting keeping money, funds, protections, healthcare, human assets, supply chain, and indeed digital music delivery. Fabric is the primary dispersed record stage to bolster shrewd contracts written in general-purpose programming dialects such as Java script, Go, and Node.js, instead of compelled Domain-Specific Languages (DSL). Thus, This implies that most undertakings as of now have the expertise set required to create savvy contracts, and no extra preparation to memorize a modern dialect or DSL is needed.

The Fabric stage is additionally permissioned, meaning that, not at all like with an open permission less organize, the members are known to each other instead of mysterious and, thus, completely untrusted. This implies that whereas the participants may not completely believe one another (they may, for illustration, be competitors in the same industry), an organize can be worked beneath an administration demonstrate that's built off of what trust does exist between members, such as a lawful assertion or system for handling disputes. One of the foremost vital forces of the Hyper Ledger platform's differentiators is its bolster for pluggable consensus conventions that empower the stage to be more successfully customized to fit specific utilized cases and belief models.

For example, if a full Byzantine fault-tolerant agreement is conveyed inside a single organization or worked by a trusted specialist, it may well be seen as pointless and imposes a preposterous punishment on execution and throughput. In these situations, a Crash Fault Tolerant (CFT) agreement convention may be adequate, but for decentralized multiparty utilize cases, a more conventional Practical Byzantine Fault-Tolerant (PBFT) agreement convention may be required.

Preface to Hyper Ledger Firefly

Hyper ledger Fire Fly is a DLT that consumes Ethereum or Hyper ledger Fabric Nodes under its hood with its Orchestration and Developer Friendly Network Management capabilities and it makes the development of Web 3 Projects far easier and faster to host by reducing the need to generate each component needed for Web3 D App building, developing and

hosting process less complicated and more administrable, governable, compliant, risk management efficiency and speed to deploy fashion. Hyper ledger Fire Fly does this by reducing the Network Administration which developers also need to perform with most other D App Development for Web 3.0 Development on-premise or on-cloud development and production environments.

Hyper ledger Fire Fly is an organization's gateway to Web3 D App Development, including all the block chain ecosystems that they participate in.

Multiple block chains, multiple token economies, and multiple business networks. Plug-it; Play-it; Develop-new.
Fire Fly is a pluggable API Orchestration Container Engine with a Data layer, integrating into all of the different types of decentralized technologies that exist in Web3:

- Public Block chains, Layer 2 scaling solutions, Side chains, and App chains
- Permissioned Block chains and Distributed Ledger Technologies (DLTs)
- Decentralized storage solutions
- Token ecosystems and standards
- Smart Contracts, DeFi solutions and DAOs
- Private off-chain encrypted communication rails
- Advanced cryptography solutions
- Identity frameworks

Refer the given link for more learning resources and tutorials.
The methods of automatically detecting items, gathering data about them, and putting them directly into computer systems without human intervention are referred to as automatic identification and data capture (AIDC). QR codes, bar codes, Radio Frequency Identification (RFID), biometrics (such as iris and facial recognition systems), magnetic stripes, optical character recognition (OCR), smart

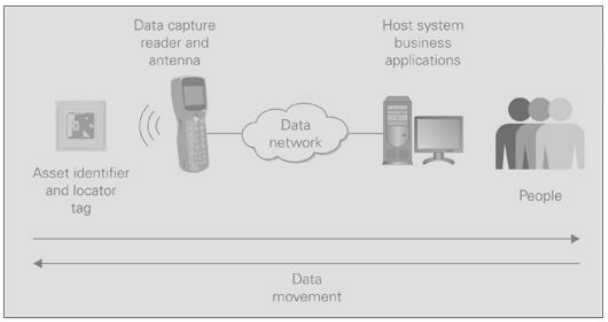

Figure 4: RFID A Bird's Eye View of Identifying process (Source: Brown M., Patadia S. – Mike Meyers' CompTIA RFID+ Certification Passport (2007)

Preface to Auto-ID and Data Capture (ADIC) Technology
Cards, and voice recognition are examples of AIDC technologies. AIDC is alternatively understood to be as "Automatic Identification", "Auto ID", or "Automated Data Capture".

AIDC is the method or means of obtaining Sensor-based data and Geo-Location data, most notably through image, sound, or video analysis. A transducer is used to capture data, which converts the actual image or sound into a digital file. The file is then saved so that it can subsequently be processed by a computer or compared to other files in a database to authenticate identity or provide authorization to enter a secured system. Data can be collected in a variety of ways; the ideal approach depends on the application.

In biometric security systems, capture is the acquisition of or the process of acquiring and identifying characteristics such as finger image, palm image, facial image, iris print, or vocal prints which involves audio sounds, and the rest all involve video files.

IV. RFID

RFID encompasses technologies that use electromagnetic (radio) waves, part of the electromagnetic spectrum, to identify individual items, places, animals, or people. RFID tags and readers can be appropriately implemented for many different uses. The most common is to use an identifying number (sort of a name) that uniquely identifies an object, place, animal, or person. The number is stored on an integrated circuit (IC) that is attached to an antenna.

Together, the Integrated Chip and the antenna are called an RFID transponder or tag. The RFID tag is attached to the object, place, animal, or person to be identified. A device called the interrogator or reader communicates with the tag and is used to read the identifying number from the tag. The reader feeds the number it reads into an information system, which stores the number in its database or searches its DB for the number and returns information stored therein about the object, place, animal, or person. The major difference between various Auto-ID Tech is in how the identifying number is stored and retrieved.

1. Working on RFID Technology
Nearly all automatic identification technologies, including RFID, consist of three key parts, which also comprise the systematic parts in AIDC:

Data Encoder
A code or cipher is a set of symbols or signals that usually represent digital alphanumeric characters.

When data are encoded, the characters are compiled into machine-code. A label or tag marker containing the encoded data is attached to the item that is to be identified.

Machine Reader or Scanner
This gadget scans the encoded data, converting them to an alternative form, typically an electrical analog signal.

Data Decoder
This component transforms the electrical signal into digital data finally back into the original digital alphanumeric characters.

2. Preface to Raspberry Pi 5
The Raspberry Pi has revolutionized the field of computing, offering a low-cost, accessible platform for education, hobbyists, and makers worldwide. With each iteration, the Raspberry Pi has consistently pushed the boundaries of performance and versatility, and the latest model, the Raspberry Pi 5, is no exception.

Unveiling the Powerhouse: A Quad-Core Processor and PCIe Interface
At the heart of the Raspberry Pi 5 lies a powerful quad-core Arm Cortex A76 processor, clocked at a blistering speed of 2.4GHz. This significant performance boost over its predecessor, the Raspberry Pi 4, enables the Pi 5 to handle demanding tasks with ease. Whether running resource-intensive applications, streaming high-definition media, or powering virtual machines, the Pi 5 stands ready to deliver.
Further enhancing its capabilities, the Raspberry Pi 5 introduces a PCIe interface, providing a high band width connection for peripherals such as graphics cards and storage devices. This expansion opens up a world of possibilities for users seeking to further enhance the Pi 5's performance and capabilities.

Dual 4K HDMI Output for Stunning Visuals
The Raspberry Pi 5 retains the versatility of its predecessors by supporting dual 4K HDMI output at 60Hz.

This enables users to connect the Pi 5 to multiple displays, creating an immersive multi monitor setup for enhanced productivity or entertainment.

Enhanced Wi-Fi and Bluetooth for Seamless Connectivity
The Raspberry Pi 5 boasts improved Wi-Fi and Bluetooth connectivity, ensuring seamless integration with various devices and networks. With support for dual-band Wi-Fi up to 5GHz and Bluetooth 5.3, the Pi 5 provides a stable and reliable connection for all computing needs.

A Real-Time Clock for Always-On Reliability
A unique feature of the Raspberry Pi 5 is its integrated real-time clock (RTC), powered by an external battery.

This ensures that the Pi 5 maintains accurate timekeeping even when power is disconnected, a crucial aspect for applications that require continuous operation or logging data.

A Platform for Infinite Possibilities
The Raspberry Pi 5 is not merely a computer; it's a platform for innovation and creativity. With its powerful hardware and versatile software ecosystem, the Pi 5 empowers users to build their projects, from retro game consoles and media centers to AI-powered robots and smart home devices.

For both a seasoned programmer and a curious beginner, the Raspberry Pi 5 offers a gateway to endless possibilities. Its combination of performance, versatility, and affordability makes it an ideal tool for learning, creating, and exploring the world of computing.

Outcome
The Raspberry Pi 5 represents a significant leap forward in the evolution of the Raspberry Pi series. With its powerful quad-core processor, PCIe interface, dual 4K HDMI output, enhanced Wi-Fi and Bluetooth, and integrated real-time clock, the Pi 5 is a powerhouse that empowers users to tackle demanding tasks and explore a vast array of projects. As the Raspberry Pi's journey continues, the Pi 5 stands as a testament to its commitment to innovation and accessibility, opening up new frontiers in computing and inspiring countless individuals to pursue their passions.

3. Preface to Green COC Using AIDCT-DLT
In this introduction, the discussion will be about how this idea was struck and its potential for digital transformation. We all know that amazon.com was inspired by Jeff Bezos Walmart with his Computer Science touch. Similarly, this idea was inspired by Walmart Canada's DLT-based Chain of Custody Management system which involved the IBM Food Trust Block chain. What they did was … "Walmart employed block chain, a distributed ledger technology, to create an automated system for managing invoices from and payments to its 70 third-party freight carriers." Walmart uses it to generate invoices, in this idea, we're going to introduce how the DLT-AIDCT combination in the chain of custody removes the documentation problems by providing an invoice and provides a more Green solution for the same.

4. Objectives of the Project
Chain of custody management based on DLT-AIDCT is a system that uses block chain to trace the movement of physical evidence through a chain of custody.

This technology has the potential to boost uncontaminated evidence analysis by providing real-time insight into the flow of evidence, increasing efficiency and lowering costs, reducing fraud and theft, and reducing fraud and theft. Chain of custody management based on DLT-AIDCT is a block chain-based system that records the movement of items along a supply chain. It enhances efficiency and decreases expenses, as well as reduces fraud.

5. Significance of the Project

Chain of custody management (CoC) based on DLT and RFID is a significant advancement in supply chain management. It uses distributed ledger technology (DLT) such as blockchain to establish a tamper-proof record of commodities movement along a supply chain. This data is then connected to RFID tags on the items, allowing for real-time tracking and visibility.

DLT-AIDCT CoC has several benefits over standard CoC systems

Improved Transparency and Traceability

The DLT record offers a comprehensive and verifiable record of commodities movement from point of origin to ultimate destination. This can aid in the identification and resolution of disputes, as well as the prevention of fraud and counterfeiting.
Cost savings: DLT-AIDCT-based CoC can assist in saving expenses related to CoC administration, such as paperwork and human data input.

Improved Efficiency

By automating operations and eliminating the need for manual involvement, DLT-AIDCT-based CoC can assist in streamlining the CoC process and enhance efficiency.

Immutability

In the block chain, every action shall be recorded and distributed. It's times tamped and encrypted using ciphers.
Decentralized: No one computer's going to store the data on the block chain. This way, they are sent and disseminated via the computer network.

Although DLT-AIDCT-based CoC is still in its early phases of development, it has the potential to transform supply chain management. It is ideal for high-value and delicate commodities like medications, food, and electronics.

6. Need for the Project

The need for a DLT-AIDCT-powered chain of custody can be summarized in three key points:

- To ensure the integrity and authenticity of Physical evidence in the Chain of Custody. DLT-AIDCT chain of custody can provide a secure and tamper-proof record of all transactions, from the point of origin to the point of consumption. This can help to ensure that goods are not counterfeit or tampered with along the supply chain.
- To reduce the risk of fraud and theft in the Chain of Custody. DLT-AIDCT chain of custody can make it more difficult for fraudsters and thieves to operate. By tracking the movement of goods in real-time, businesses can quickly identify and investigate any anomalies.
- To improve provenance, visibility, and transparency in the Chain of Custody. DLT-AIDCT chain of custody can provide real-time visibility into the movement of goods throughout the supply chain. This can help businesses identify and resolve bottlenecks and delays, as well as improve communication and collaboration between different stakeholders.

As an add-on to these three key points, DLT-AIDCT Chain Of Custody can also help to:

- Improve victim satisfaction by providing victims and suspects with confidence in the integrity and authenticity of the evidence submitted under the Court of Law.
- Increase accuracy and precision in Justice.
- Reduce costs and improve efficiency by automating manual processes and streamlining workflows.

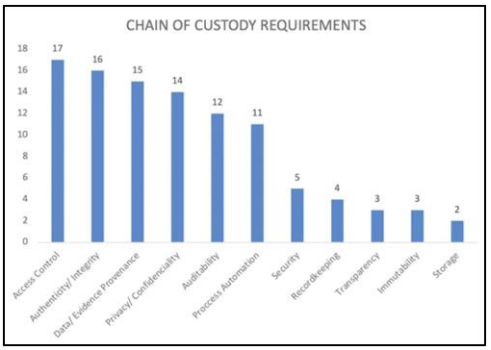

Figure 5: Figure representing the Principle Need for Chain of Custody

Overall, the DLT-AIDCT chain of custody D App is a valuable tool that can help Law enforcement agencies and governments improve their Chain of Custody Operations and protect their bottom line.

7. Limitations of the Project

Block chain-based supply chain (BCoC) has many advantages, but it also has some limitations. Limitations of Block chain and RFID Chain of Custody Provenance:

- **Cost:** Implementing and maintaining a BCoC system can be expensive, especially for small businesses.
- **Complexity:** Installing and managing BCoC systems can be complex and requires a high level of technical expertise.
- **Scalability:** Public block chains can experience scalability issues that can limit the number of transactions processed per second.
- **Privacy:** Public block chains are transparent, meaning anyone can see the block chains data. This can be a concern for companies that need to protect sensitive data.
- **Interoperability:** Different BCoC systems may not be compatible with each other, which can make it difficult to track goods across multiple supply chains.

In addition to these limitations, BCoC systems are also vulnerable to certain types of attacks, such as Sybil attacks and 51% attacks.

Despite these limitations, BCoC is a promising technology for supply chain management. It has the potential to improve the

visibility, transparency, and security of supply chains in many different industries.

Additional Restrictions

- BCoC systems cannot prevent physical theft or tampering. They can only detect them and provide evidence for the same.
- BCoC systems are not yet widely adopted, which may limit their usefulness.
- BCoC systems are still under development and new vulnerabilities may be discovered in the future. Overall, DLT-AIDCT CoC is a powerful tool for physical evidence chain of custody management, but it is important to be aware of its limitations before implementing it.

8. Review of Related Literature

- Harvard Business Review Report - https://hbr.org/2022/01/how-walmart-canada-uses-blockchainto-solve-supply-chain-challenges
- How Scan Trust Brought Transparency to the Supply Chain with Hyper ledger Saw tooth (pdf)
- How Walmart brought unprecedented transparency to the food supply chain with Hyper ledger Fabric (pdf)
- Circular achieves first-ever-mine-to-manufacturer traceability of a conflict mineral with Hyper ledger Fabric (pdf)
- UK digital identity and attributes trust framework beta version (0.3) - GOV (pdf)
- BC aims to cut government red tape with Hyper ledger Indy (pdf)
- Practical Byzantine Fault Tolerance and Proactive Recovery (pdf)
- World Bank Group | Distributed Ledger Technology (DLT) and Block chain (pdf)
- A Buyer's Guide to Law Firm Software | Practice Panther (pdf)
- Smart Contract-Based Access Control for the Internet of Things (pdf)
- Exploring Block chain Technology for Chain of Custody Control in Physical Evidence: A Systematic Literature Review: https://www.mdpi.com/1911-8074/16/8/360
- MF-Ledger: Block chain Hyper ledger Saw tooth-Enabled Novel and Secure Chain of Custody Multimedia Forensic InvestigationArchitecturehttps://www.researchgate.net/publication/353392971_MF-Ledger_Blockchain_Hyperledger_Sawtooth-Enabled_Novel_and_Secure_Multimedia_Chain_of_Custod_Forensic_Investigation_Architecture?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6Il9kaXJlY3QiLCJwYWdlIjoiX2RpcmVjdCJ9fQ
- An asset tracking system based on block chain + NFC | https://github.com/IoTone/ Block chain In A Box/issues/8
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9. Core Development Architecture

This can be implemented using the micro-fab of HyperLedger Fabric containerized using Docker and developed in Ubuntu Desktop 18 in Go and Python programming language. As the HyperLedger Fabric is at present only available for AMD Ryzen X and Intel iX architectures, these will be the predominant architecture for DApp development.

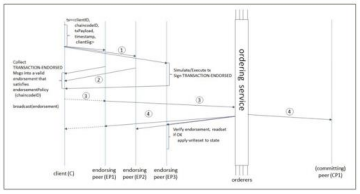

Figure 6: Figure representing the Hyper ledger fabric transaction steps in a Real-time scenario

Several ordering plugins are currently in development, including BFT Smart, Simplified Byzantine Fault Tolerance (SBFT), Honey Badger of BFT, and others. As a reference implementation, Apache Kafka is included with Fabric v1. Which plug-in to employ should be determined by the application's use cases and fault tolerance model.

Every non-malicious entity in a block chain network has the same block chain state. The conclusion for Hyper ledger Fabric is that the order service should be regulated collaboratively by network members using a BFT algorithm that is resistant to destructive operations by bad actors. The order cannot be controlled by only one organization (or one individual) since that organization (or one individual) may not be reliable in and of itself. After all, one of the reasons for using block chain is to enable collaboration between businesses that only have a limited level of trust for one another.

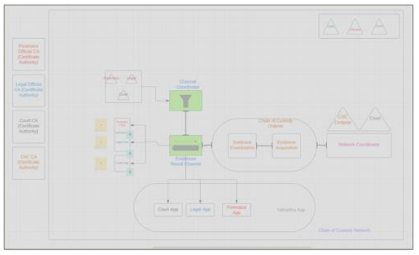

Figure 7: Suggested Architecture diagram for the DLT-AIDCT-based Yathartha app

10. New Age Idea Suggestion

As Raspberry Pi has a well-known Linux OS named Raspbian OS, This project will suggest architecture and submit the Python source code for building an RFID Machine reader and Data Decoder that will timestamp the location and the evidence unique identification details as events whenever the Packaged digital forensic Evidence is scanned using it and store the data of them all in a Postgre SQL Database. Then this database will be made in sync with the Postgre SQL Plug-in in the Hyper ledger Fire Fly to integrate a Web 2.0 App with a Web 3.0 D App in a user-friendly format.

V. CONCLUSION

In conclusion, this DLT-AIDCT Chain of custody management solution though has its limitations and advantages, it is overall a greener alternative to the traditional chain of custody forms written down on paper and manually comprehended. In the age of computational exponentialism, the digitally transformed and revolutionized chain of custody using DLT and AIDCT is a more green solution.

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