JPEG White paper: Towards a Standardized Framework for Media Blockchain and Distributed Ledger Technologies

An initiative exploring opportunities in media blockchain and distributed ledger technologies and impacts on JPEG standardization.

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Executive Summary

Fake news, copyright violation, media forensics, privacy and security are emerging challenges in digital media. JPEG has determined that blockchain and distributed ledger technologies (DLT) have great potential as a technology component to address these challenges in transparent and trustable media transactions. However, blockchain and DLT need to be integrated closely with a widely adopted standard to ensure broad interoperability of protected images. JPEG has engaged industry, other standardisation bodies and academic experts through four workshops on Media Blockchain to define use cases and requirements to driving the standardization process. JPEG identified two types of potential requirements which are expected to be addressed inside and outside the scope of JPEG.

1. Introduction

JPEG (Rec. ITU T.81 | ISO/IEC 10918) is the most dominant still image format across the world[1] and the standardization committee continues to work on improving various components of the standard. This includes incorporation of new technologies addressing current challenges related to transparent and trustable media transactions such as JPEG Privacy and Security[2].

Blockchain, on the other hand, emerges to be a useful technology for many applications that require accountability of transactions [1]. Recently noticeable interests were observed in industries as well as in academia using blockchain as a solution to transparent media distribution, copyright management and verification of media integrity for authentication [2] [3] [4] [5]. The main aim of this white paper is to explore opportunities in media blockchain and DLT to understand their impacts on JPEG standardization, for instance in addressing privacy and security issues.

During its 78th JPEG meeting (February 2018), the JPEG committee organized a special session on blockchain and its impact on JPEG standards. As a result, the committee decided to explore use cases and standardization needs related to blockchain technology in a multimedia context. JPEG is actively seeking inputs from experts to define these use cases and to explore eventual needs and advantages to support a standardization effort focused on the application of blockchain in media[3].

JPEG Privacy and Security defines a new standard to increase the reliability of encoded images and associated metadata. This standard will enable applications and services to have better protection ability of image content and associated metadata when publishing, sharing, or distributing via the Internet. The features are classified into two categories, a) protection and b) authenticity. By using tools such as encryption, hash signatures and watermarking parts of any type of JPEG images and/or associated metadata can be protected. Authenticity is an essential feature in many use cases to ensure and check the integrity of image data and/or embedded metadata to establish the rightful claim of all stakeholders of any digital asset. Together these features also enable trust among the users in the backdrop of emerging fake image/news related issues. Several JPEG Privacy and Security features could potentially be improved by using the emerging blockchain technology. In addition, blockchain technology may also have an impact on other JPEG standards beyond JPEG Privacy and Security.

The main objectives of this white paper are a) to discuss industrial needs based on existing solutions, b) identifying relevant standardisation activities in blockchain, c) defining uses cases and functionalities for media blockchain and d) providing an outline for potential requirements in standardisation of media blockchain within and outside JPEG. Additionally, this paper also provides background and generic description of relevant JPEG activities and blockchain as a distributed ledger technology.

[1] https://jpeg.org/jpeg/index.html
[2] https://jpeg.org/items/20150910_privacy_security_summary.html
[3] https://jpeg.org/items/20180213_press.html

2. Background: Relevant JPEG Activities

This section provides a generic overview of JPEG in general and a brief description of JPEG activities relevant to the aim and objectives of this white paper.

2.1. JPEG

JPEG is the image coding format of choice for applications as diverse as photography, web, medical imaging, and public records, named after the original International Standards Organization (ISO) / International Telegraph and Telephone Consultative Committee (CCITT) Joint Photographic Experts Group, established in November of 1986. The group developed the technique in the late 1980s and produced the international standard, formally known as International Telecommunication Union (ITU)-TT.81, in the early 1990s [6].

The JPEG standard (ISO/IEC 10918) was created in 1992 (latest version, 1994) as the result of a process that started in 1986. Though this standard is generally considered as a single specification, in reality, it is composed of four separate parts and an amalgam of coding modes. Part 1 of JPEG (ISO/IEC 10918-1 | ITU-T Recommendation T.81) specifies the core coding technology and it incorporates many options for encoding photographic images. Part 2 defines the compliance testing. Part 3 defines a set of extensions to the coding technologies of Part 1, and via an amendment, the SPIFF file format was introduced. Part 4 focuses on the registration of JPEG profiles, SPIFF profiles, SPIFF tags, SPIFF colour spaces, SPIFF compression types, and defines the Registration Authorities. And lastly, Part 5 specifies the JPEG File Interchange Format (JFIF). Without any doubt, it can be stated that JPEG has been one of the most successful multimedia standards defined so far. JPEG (Rec. ITU T.81 | ISO/IEC 10918) is still the most dominant still image format around[4].

2.2. JPEG Systems Layer

In addition to the original JPEG file format (ISO/IEC 10918-1), which recently celebrated its 25th anniversary, the JPEG committee has introduced several other image standards, such as JPEG 2000 (ISO/IEC 15444-1), which has been successful in several markets such as digital cinema, broadcasting (content distribution networks), medical imaging, remote sensing and archival.

New initiatives for image coding are currently ongoing such as JPEG XS, JPEG Pleno and JPEG XL. While each format has its own purpose, there are still common features across these various formats. For this reason, JPEG initiated the JPEG Systems (ISO/IEC 19566) activity with the main aim to align system related features across JPEG standards.

The original JPEG file format supported APP marker segments to allow for new features or embed additional information into images. APP marker segments are used for example to embed EXIF metadata. JPEG 2000, on the other hand, uses a more modern box format. This is a flexible syntax where additional information or features can be encapsulated in a binary structure. The box format is also used by various other media formats such as JPEG XR (ISO/IEC 15444-2:2004/AMD3:2015) and MPEG-4 (ISO/IEC 14496-12).

[4] https://jpeg.org/jpeg/index.html

To align the APP marker segment and box based approaches, the JPEG XT file format defines a structure to embed boxes into APP11 app marker segments. This allows to define system level boxes that can be used consistently in all formats. In addition, new functionalists and frameworks can be built on top of this generic notion of boxes.

In the past, several alternatives have been used to embed metadata in JPEG images. Unfortunately, not all have been standardized, leading to a fragmented scene that can lead to inconsistencies or metadata that is not retained when transferring images from one application to another.

While JPSearch introduced a uniform way to embed any type of metadata, it also imposes some additional restrictions. For example, it is required that an image should embed at least a JPSearch Metadata Schema instance. In addition, JPSearch was defined years before JPEG Systems and JPEG XT and uses APP3 marker segments with a custom format to embed metadata. Therefore, JPEG decided to define a JPEG Universal Metadata Box Format (JUMBF). JUMBF allows to embed any type of metadata in all box based JPEG file formats as well as the original JPEG format using the JPEG XT approach.

Many new image features (e.g. 360) are heavily metadata driven and often combine metadata and associated image data. Therefore, on top of an embedding syntax, JUMBF provides a mechanism to reference metadata via URLs. This allows to make references from textual metadata (such as XML) to associated image metadata.

2.3 JPEG Universal Metadata Box Format

The Universal Metadata Box Format (JUMBF) defines a generic box that can encapsulate any type of metadata (textual or binary) and provides a mechanism for referencing via a URL schema. A JUMBF box provides additional information about the type of metadata that is embedded and can associate a label to be used for referencing.

The JUMBF specification defines how to embed common types of metadata such as XML, JSON, UUID boxes and image codestreams. In addition, other standards or third-party applications can define their own types for dedicated use cases. For example, JPEG 360 (ISO/IEC 19566-6) defines a custom type to embed 360 metadata as well as associated image data. The same approach is followed by JPEG Privacy and Security.

It is quite common that new extensions rely on a combination of textual metadata and binary image data. In these cases, there is a need for a way to reference the binary image data from the textual metadata. Therefore, JUMBF allows associating a text label to its content. JUMBF defines a URL schema that can then be used to make references from within the image or to make an external reference or request directly to the embedded metadata rather than to the encapsulating image. As an alternative to textual labels, JUMBF also supports binary IDs as a more efficient alternative for binary formats that need references.

2.4. JPEG Privacy and Security

JPEG Privacy & Security aims at developing a standard for realizing secure image information sharing, capable of ensuring privacy, maintaining data integrity and protecting intellectual property rights. This activity is not only intended to protect private information carried by images – *i.e.* in the image itself or its associated metadata – but also to provide degrees of trust while sharing image content and metadata based on individually set policies.

Every use case needs specific dedicated protection tools. For example, in some cases, invisible watermarks or fingerprints could be more suited than traditional encryption. However, it is important to note that JPEG does not intend to standardize any of the underlying technologies but rather aims to formalize the way these are signalled and applied to JPEG images. As such, users will have the flexibility to choose and adopt the tools best suited to their specific scenarios. When defining the signalling syntax, backward compatibility with the legacy JPEG and JPEG 2000 code streams will be provided as well as with other existing standards and frameworks (e.g. those by SC 27, SC 29, and W3C).

The features are classified into two basic categories: protection and authenticity. Protection features include:

- protection tools to protect parts of any type of JPEG images and/or associated metadata independently, while ensuring backward and forward compatibility with JPEG coding technologies;
- handling of hierarchical levels of access and multiple protection levels for metadata and image protection;
- file carving systems (e.g. resynchronisation points).

Authenticity features encompass:

- integrity check of image data and/or embedded metadata;
- avoidance of stripping off metadata, especially IPR information;
- versioning and/or tracking changes of an image and/or associated metadata and solutions to support embedding provenance information;
- embedding of traceable information to allow identification and assessment of the master image and identify derivatives or modified versions of the master image.

3. A Brief Overview of Blockchain and DLT

This section presents a brief overview of blockchain and DLT as well as some of its applications related to imaging.

3.1. Blockchain and Distributed Ledger Technology

Blockchain technology [1] is an open distributed ledger technology (**DLT**) that records details of all transactions in chained and signed 'blocks'. DLT provides a platform to record and share data in a distributed manner[5].

[5] http://www.worldbank.org/en/topic/financialsector/brief/blockchain-dlt

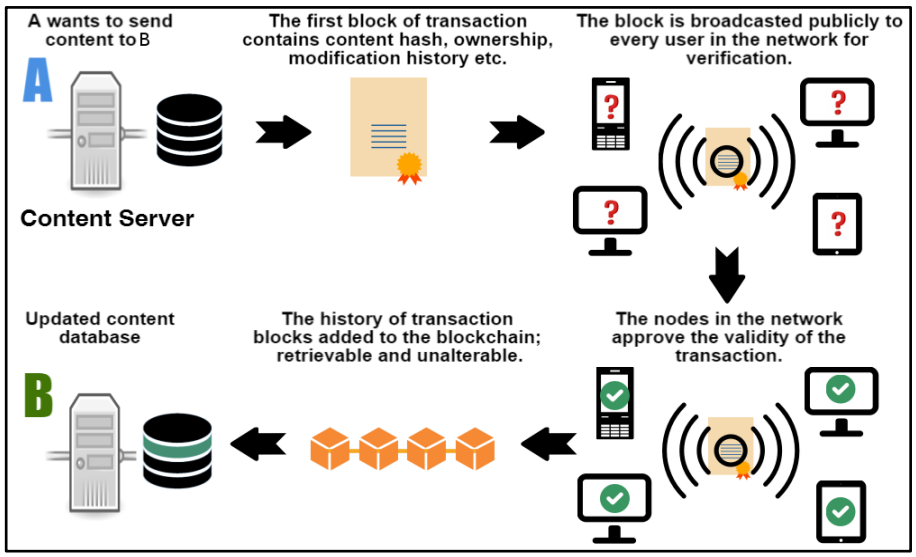

Figure 1: Overview of the blockchain working principle [2].

Blockchain is a subclass of DLT containing a particular type of data structure that allows storing and transmitting data in the form of ***blocks*** that are linked to each other in a digital ***chain***. A key component of blockchain is the use of cryptographic and algorithmic methods to record and synchronise data across all participating nodes in the network in an immutable manner. Therefore, one can conclude that all blockchains are DLTs, in fact, a specific type of DLT. But not all DLTs are Blockchains. There are other DLTs for example, RadixDLT[6], Directed Acyclic Graph (DAG) - IOTA[7], NANO[8] etc.

Blockchain technology allows transactions to be verified without using a central organisation to process the transaction [7]. Conceptually it works by connecting or chaining blocks of information about the transactions and storing them together in a chronological order and hence called blockchain. Within a blockchain network, each record or block is timestamped, linked to a previous block and resilient to modification of the data. Therefore, blockchain is considered to be a trusted and secured mechanism for transactions between two or more entities in an efficient, verifiable and permanent way. An example is depicted in Figure 1. Increasing interests in this technology were noticed from various organisations, e.g., Hyperledger[9] that intend to adopt the concept to provide a secure and publicly verifiable transaction mechanism.

3.2. Application Areas

Blockchain technology is currently adopted in a number of application areas outside crypto-currency, such as, financial management (e.g., interbank payment, clearing and settlement, audit, etc.), healthcare (pharma, biotechnology and medicine), government and public sector (e.g., taxes, voting, land registry, intellectual property management etc.) and many others including manufacturing, energy, retail and supply chain management. Recently, emerging number of use cases are noticed in the multimedia domain that use blockchain for media distribution. Potential scenarios include media transactions [2], hardware and software wallets,

[6] https://www.radixdlt.com/
[7] https://www.iota.org/
[8] https://nano.org/en
[9] https://www.hyperledger.org/

and transaction management [8]. Essentially blockchain is relevant to anything that requires transaction verification or a signature leading to authenticity and trust. Recent efforts were noticed in multimedia applications, for example by Fujimura et al. [9] where the copyright information was added as part of blockchain transaction. A multimedia blockchain framework was recently proposed [2] that keeps all records of the media transactions (e.g., ownership, licenses etc.) and offers a mechanism for tamper-proof verifiable integrity of the media enhancing trust among stakeholders.

4. Example Systems Relevant to Media Blockchain

This section captures example solutions of blockchain technology used in multimedia and imaging applications. While many cases are focused on multimedia distribution and copyright management as the primary application area, different challenges were attempted to be addressed leveraging blockchain technology.

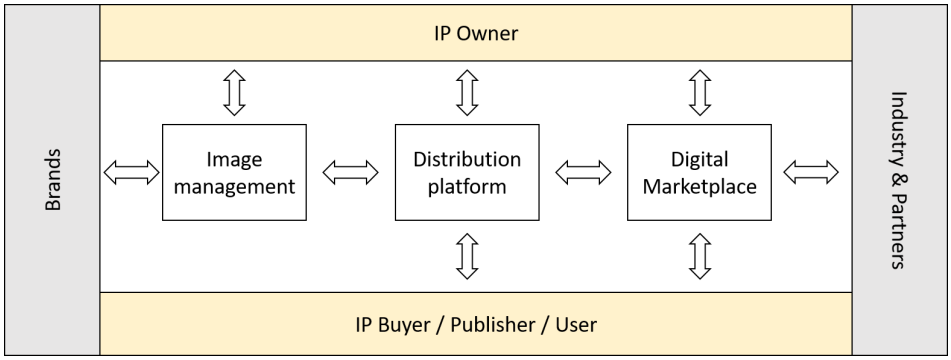

Figure 2: Overview of KODAKOne blockchain platform.

4.1. KODAKOne and KODAKCoin

KODAKOne[10] image rights management platform and KODAKCoin, a photo-centric cryptocurrency to empower photographers and agencies are aiming to take greater control in image rights management using Blockchain technology. It intends to have a digital ledger of rights ownership for photographers to register both new and archive work that they can then license within the platform.

The main objective of KODAKOne is to provide a platform to the photographers for easily uploading of images to a cloud infrastructure and enable them blockchain-rights protected and commercially licensable. An overview of this platform is shown in Figure 2. This could potentially open up opportunities for photographers, image agencies and photo archive companies. With KODAKCoin, participating photographers can receive payment for licensing their work immediately upon sale. It also expects to continuously crawl the web to monitor and protect the IP of the registered images. KODAKOne Platform intends to enable WENN Digital to track licensing and illegal uses of the images.

[10] https://kodakone.com/

This platform also pitched that there is an industry-wide lack of transparency means that photographers are not able to verify their royalty statements. Therefore, this platform can address this issue by using the to-be-developed blockchain accounting and contracting system where every transaction and license agreement will be immutably stored in our decentralized registry.

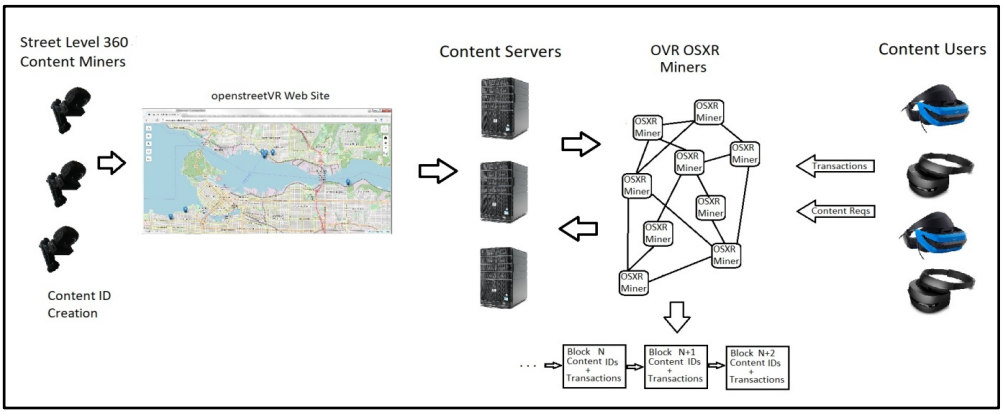

Figure 3: OVR geo-located VR content blockchain plant.

4.2. OpenstreetVR: A Blockchain based 360 Image View for Virtual Reality (VR)

openstreetVR (OVR)[11] is a geo-located street level WebVR based online community that relies on a custom designed blockchain and eco-power friendly, highly scalable, decentralized, merit based consensus engine for content identification, tracking and transfer of 360 panorama stills, videos and soon live streams XR media (Virtual, Augmented and Mixed Reality). Uploaded content is converted to JPEG2000 (J2K) format allowing real time Region of Interest (ROI) extraction and display of ultra high resolution (>8K) images to VR headsets ensuring a truly immersive experience. OVR is built using Babylon.js (a high performance, GPU enabled, open source WebVR gaming engine) allowing display of animated virtual objects integrated with 360 content directly in the Windows Edge browser without the need for a custom app. OVR rewards users with geoStreet tokens for capturing and uploading street level 360 views of the world's 39 million kilometres of roadways and paths.

OVR implements a blockchain to lock down and track all content transactions on the site and a cryptocurrency to incentivize users for creating the immersive 360 street level content. OVR blockchain miners are rewarded OSXR coin for maintaining the ledger of uploaded content and token transactions. A geoMarket token powers the e-commerce side of the site. The overall workflow is depicted in Figure 3.

4.3. Multimedia Blockchain Framework

The multimedia blockchain framework [2] proposes a distributed and tamper proof media transaction framework based on the blockchain model. The authors describe a proof of concept where the blockchain contains copyright related information about the images and produces a cryptographic hash for every transaction. Current multimedia distribution does not preserve self-retrievable information of transaction trails or content modification histories.

[11] http://www.openstreetvr.com/

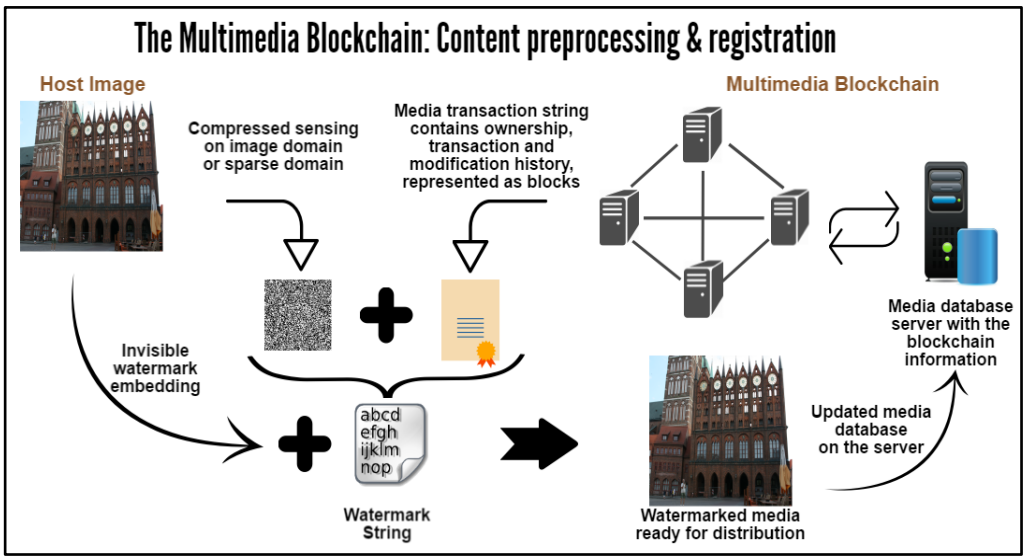

Figure 4: Overview of the multimedia blockchain framework [2].

For example, digital copies of valuable artworks, creative media and digital archives (e.g., books) are distributed for various purposes including exhibitions, library archival or gallery collections. In another scenario, original media (document, image or video) is often edited for creative content preparation or tampered with to fabricate false propaganda over social media.

There is no existing trusted mechanism available that can easily retrieve either the transaction trails or the modification histories. This work proposes a watermarking based Multimedia Blockchain framework that can address such issues. The unique watermark information contains two pieces of information: a) a hash containing transaction histories (blockchain transactions log) and b) an image signature preserving retrievable original media content. Once the watermark is extracted, the former segment is passed to a distributed ledger that can retrieve the historical trail and the latter part is used to locate and reconstruct the edited/tampered regions. The reconstruction of the original content is achieved by finding an optimal solution using a compressive sensing algorithm. The concept is shown in Figure 4. This work outlines the requirements, the challenges and demonstrates the proof of the concept.

4.4. *Current*: An Incentivized, Blockchain Enabled Multimedia Ecosystem

Current[12] is a blockchain (Ethereum) based platform. It creates a digital token that uniquely rewards a person's time, money spent, and data shared during the media streaming experience. It intends to consolidate popular media networks into one place which effectively allows users to purchase a broad range of products, services, and in-platform advertising. Current already provides users with convenient search and discovery experiences. This platform intends to combine and exploit behavioural data such as the types, times, and topics played by each person across multiple networks to serve up better recommendations.

The use of blockchain technology aimed at transparent accounting that is needed for the instant valuation of time, data, and attention. The platform claims that consumers get more

[12] https://cdn.current.us/whitepaper.pdf

choice in how they pay for media; creators and curators get a new form of compensation, and advertisers get more transparent accounting and audience information. The protocol interacts within the *Current* platform in addition to any other host media network. This introduces a new revenue stream and incentive mechanism for the host network giving it the ability to scale effectively. Over time, developers will leverage the identity profiles created for future blockchain based systems.

The main objective of the *Current* protocol is to facilitate transfers of value between media services by partnering with media networks. The blockchain will play a central role by capturing user activities at the conclusion of a track play, analyzing the play for legitimacy and fraud detection then, applying a series of network and individual influenced coefficients. This will derive a reward value using the credit system within *Current*'s platform.

4.5. eWitness: Media Authentication for Evidentiary Purposes

eWitness[13] is a blockchain based ecosystem that proves the authenticity of any digital media taken from smart phones and cameras. As soon as someone uses eWitness to take a picture or video, a hash of the media and the EXIF metadata is sent as a smart contract transaction to an Ethereum based blockchain, forming a proof of origin and integrity of the media. The blockchain, potentially managed by a consortium of journalistic organizations, civil liberties units and other similar non-government/government entities, can maintain this proof so that the media can be used as evidence at any point thereafter.

The purpose of eWitness is to create islands of trust, as it becomes non-trivial to create fake media and to alter facts in legitimate media using Artificial Intelligence tools. As such, there has been an abundance of disinformation on social networks, in the form of media created from computer programs, causing a visual pollution. Therefore, the existing practice in responsible journalism is to perform thorough fact checking through a digital forensics examination of any user generated content found on social networks or obtained from semi-trusted informants. This process often takes 2 or more days and might often be repeated, at the same time, by several organizations before their respective fact-checkers can accurately report on an emerging story. eWitness not only eases this pain for reporters but also reduces the spread disinformation by promoting legitimate footage of any incident against edited and altered versions.

In addition, eWitness established credibility for freelance reporters, human rights activists and citizen journalists. Potentially, eWitness can provide a single click verification of all media taken within the eWitness ecosystem, thereby establishing credibility for most content curators on the Internet.

4.6. Po.et: Decentralized Protocol for Content Ownership, Discovery and Monetization in Media

Po.et[14] offers a number of decentralized protocols and applications for media content ownership, discovery and monetization. Po.et offers services using blockchain framework to

[13] https://ewitness.commons.gc.cuny.edu/
[14] https://www.po.et/

record metadata and ownership information for digital creative assets. It aimed at three key attributes including 1) Ownership (owner of the digital media asset); 2) Utilization (user verifiable licensing information); and 3) History (tracing the origin of this asset and its trajectory). It targets three different categories of stakeholders: a) Publisher; b) Editor; and c) Content Creator.

4.7. IBM: Enforcing Accountability in Media | How Blockchain Technology can Work for Media and Entertainment

IBM[15] started providing blockchain infrastructure in media and entertainment (M&E) industry for a) effective media asset management at reduced costs, b) reducing copyright infringements and disputes and c) reducing ad fraud and intermediaries. According IBM statistics 62% of surveyed M&E executives believes commercial blockchain based media supply chain is "somewhat" to "very important" and 73% envisage partnering with technology providers for blockchain based solutions to the industry.

Mediaocean[16] in collaboration with IBM offers blockchain based media supply chain for advertising. The framework offers transparency and accountability including smart contracts in advertising ecosystem.

4.8 Content Blockchain

Content Blockchain[17] project is an open blockchain ecosystems that provides a decentralized, global, digital infrastructure for the creative community to discover, register, navigate, offer, sell and license digital media content and otherwise exchange value over the network. It was created in 2016 by a consortium of publishing, law and IT companies. This offers the blockchain infrastructure that helps for content identification through content hashing, enables content versioning and proof of data possessions.

In addition to above mentioned examples, a number of large media players already considered blockchain in the eco system. These includes Blockchain Insights Platform by Comcast for clients such as NBC Universal, Disney, Channel 4 and others. Spotify acquired Mediachain Labs to facilitate artists and other right holders to Spotify's services[18].

5. Current Blockchain Standardisation Efforts and Initiatives

There are a few standardization efforts and initiatives carried out to provide internationally approved specifications for blockchain and distributed ledger technologies. However, none of them are particularly focusing on applications to media. This section briefly describes these standardisation activities and initiatives.

[15] https://www.ibm.com/downloads/cas/6146Z4JE
[16] https://www.mediaocean.com/products/blockchain-for-media
[17] https://content-blockchain.org/
[18] https://www.forbes.com/sites/hughmcintyre/2017/04/27/spotify-has-acquired-blockchain-startup-mediachain/#6797366f69ee

5.1 ISO TC 307 Blockchain and Distributed Ledger Technologies

The ISO TC 307 on blockchain and DLT is the main technical committee that aims to set the future course of standardization in blockchain, DLT and related areas. This TC was created in 2017 by ISO and has its secretariat in Australia. The TC currently has 35 participating and 13 observing members. This consists of five key study groups for standard development including reference architecture, taxonomy and ontology, use cases, security and privacy, identity and smart contracts. The TC covers a relatively large scope of activities. Current SGs and WGs under TC307 are:

ISO/TC 307/AG 1	SBP Review Advisory Group
ISO/TC 307/AHG 1	Liaison Review Ad Hoc Group
ISO/TC 307/CAG 1	Convenors coordination group
ISO/TC 307/JWG 4	Joint ISO/TC 307 - ISO/IEC JTC 1/SC 27 WG: Blockchain and distributed ledger technologies and IT Security techniques
ISO/TC 307/SG 7	Interoperability of blockchain and distributed ledger technology systems
ISO/TC 307/WG 1	Foundations
ISO/TC 307/WG 2	Security, privacy and identity
ISO/TC 307/WG 3	Smart contracts and their applications
ISO/TC 307/WG 5	Governance
ISO/TC 307/WG 6	Use cases

Currently, the objectives are to create the following specifications which are under development:

ISO/CD 22739	Blockchain and distributed ledger technologies -- Terminology
ISO/DTR 23244	Blockchain and distributed ledger technologies -- Overview of privacy and personally identifiable information protection
ISO/DTR 23245	Blockchain and distributed ledger technologies -- Security risks and vulnerabilities
ISO/NP TR 23246	Blockchain and distributed ledger technologies -- Overview of identity management using blockchain and distributed ledger technologies
ISO/CD 23257	Blockchain and distributed ledger technologies -- Reference architecture
ISO/WD TS 23258	Blockchain and distributed ledger technologies -- Taxonomy and

	Ontology
ISO/AWI TS 23259	Blockchain and distributed ledger technologies -- Legally binding smart contracts
ISO/PRF TR 23455	Blockchain and distributed ledger technologies -- Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems
ISO/NP TR 23576	Blockchain and distributed ledger technologies -- Security of digital asset custodians
ISO/NP TR 23578	Blockchain and distributed ledger technologies -- Discovery issues related to interoperability
ISO/NP TS 23635	Blockchain and distributed ledger technologies -- Guidelines for governance

5.2. CEN-CENELEC Focus Group on Blockchain and Distributed Ledger Technologies

CEN and CENELEC have been supporting Europe's digital transformation for many years, producing European Standards and ICT standardization solutions in various sectors such as manufacturing, machinery, energy, health or transport. In light of this, and in order to contribute even more actively to our stakeholders' digital transformation, CEN and CENELEC have created a new CEN-CENELEC Focus Group on Blockchain and Distributed Ledger Technologies (DLT).

Blockchain and DLT's new developments in the field of ICT promise to make great contributions to the sharing of data and the managing of transactions in a controlled manner. Blockchain and DLT technologies have a large potential to transform business operating models in the long term and can be integrated in multiple areas, with applications in the finance, insurance, energy, health, manufacturing and e-government sectors. Blockchain and DLT have also great potential to provide an infrastructure for trusted, decentralised and disintermediated services beyond the financial sector.

The objectives of the Focus Group, among others, will be to identify potential specific European standardization needs, notably in support to the current standardization activities being developed in ISO/TC 307 'Blockchain and DLT'. CEN and CENELEC look forward to contributing to the further advancement of Europe's digital transformation. The Focus Group aim to address the needs of European businesses with a particular focus on SMEs and to encourage increasing European participation in ISO/TC 307. This focus group initiated work in line with the work items of ISO/TC 307 including reference architecture, security and privacy, identity, governance, and smart contracts.

5.3. ITU-T Focus Group on Application of Distributed Ledger Technology (FG DLT)

The ITU-T focus group on the application of DLT was established in May 2017 and it is chaired by Switzerland. Its objectives are to identify and analyse DLT-based applications and services, to draw up best practices and guidelines which support the implementation of those applications and services on a global scale; and to propose a way forward for related standardization work in ITU-T Study Groups.

FG DLT will develop a standardization roadmap for interoperable DLT-based services, taking into consideration the activities underway in ITU, other standards developing organizations, forums and groups.

5.4. IEEE Blockchain Initiative

The IEEE Future Directions Committee, represented by the societies of the IEEE, has approved the formation of the IEEE Blockchain initiative (BCI) effective January 1, 2018. The BCI will be the hub for all IEEE blockchain projects and activities. The BCI encompasses a comprehensive set of projects and activities supported by the following core subcommittees: Pre/Standards, Education, Conferences and Events, Community Development and Outreach, Publications, and Special Projects.

6. JPEG Workshops on Media Blockchain

In order to clearly identify the impact of blockchain and distributed ledger technologies on JPEG standards, the JPEG committee has organised several workshops to interact with stakeholders in the domain. The programs and proceedings of these workshop are accessible on the JPEG website:

- 1st JPEG Workshop on Media Blockchain Proceedings, ISO/IEC JTC1/SC29/WG1, wg1n81033, Vancouver, CAN, October 16th, 2018 [19]
- 2nd JPEG Workshop on Media Blockchain Proceedings, ISO/IEC JTC1/SC29/WG1, wg1n82017, Lisbon, Portugal, January 22nd, 2019 [20]
- 3rd JPEG Workshop on Media Blockchain Proceedings, ISO/IEC JTC1/SC29/WG1, wg1n83044, Geneva, Switzerland, March 20th, 2019 [21]
- 4th JPEG Workshop on Media Blockchain Proceedings, ISO/IEC JTC1/SC29/WG1, wg1n84024, Brussels, Belgium, July 16th, 2019 [22].

6.1. Excerpts from JPEG Media Blockchain Workshops

Each workshop consisted of overview presentations on JPEG standards with a specific focus on privacy and security as described in the earlier part of this document. This is followed by a number of presentations by external experts and a panel discussion. This section briefly describes the outcome of the workshops organized by JPEG on Media Blockchain.

[19] https://jpeg.org/items/20181023_blockchain_workshop_vancouver.html
[20] https://jpeg.org/items/20190201_blockchain_workshop_lisbon.html
[21] https://jpeg.org/items/20190325_blockchain_workshop_geneva.html
[22] https://jpeg.org/items/20190724_blockchain_workshop_brussels.html

6.1.1. Workshop 1: Vancouver

The workshop discussed several topics including: a) the opportunities of media blockchain to facilitate micropayments to the stakeholders, monetization opportunities of creative content, advertising for targeted media usage and addressing copyright infringement and piracy; b) managing tamper resistant digital information and evidence and ensuring integrity and authenticity; and c) various consensus models.

6.1.2. Workshop 2: Lisbon

Three major potential use for blockchain were discussed: a) use of private and public blockchain in the context; b) opportunities for data retrieval; and c) smart contracts. The discussion also focused on the standardization activities from other organizations mainly ISO/TC 307. TC 307 made effort to standardize core blockchain architecture including terminologies, structure for privacy aware personally identifiable information, reference architecture, taxonomy and ontology, security management of digital assets etc.

6.1.3. Workshop 3: Geneva

The speakers presented a number of current challenged and potential use cases where blockchain is potentially useful in the media and entertainment industry. For example, solutions were discussed on a) privacy preserving photo sharing; b) adopting blockchain for media security through copyright management and integrity verification; c) blockchain for privacy and data protection; d) addressing fake media verification, e.g., frauds in insurance claim, document signature, banking and other certificate documents through blockchain traceability; and e) asset monetization through a tokenized economy. Similar to the previous workshop standardization efforts within ITU-T FG DLT are discussed, e.g., terms and definitions, applications scenarios, technical and reference framework and policy framework. To date other standardization focused on application agnostic blockchain architecture.

6.1.4. Workshop 4: Brussels

Significant focus was noticed in blockchain and privacy issues, e.g., implication of GDPR and rights to be forgotten. A good number of existing cases are presented, for example a) trusted archive for digital public records, e.g., supreme court ruling videos, are fingerprinted and stored in a tamper proof way with the use of deep learning based media processing and a blockchain framework; b) traceable content licensing for journalism; and c) a number of use cases for media and entertainment industry. The latter use cases attempted to address current challenges related to IPR protection, rights management, contract management, e-payments and certification and distribution managements.

7. Use Cases and Functionalities for Media Blockchain

With a critical evaluation of the example solutions in Section 4 and the outcome of the previous workshops in Section 6, two categories of use cases were identified: a) enabling trust, privacy and security in the media consumption chain and b) empowering transparent and trusted media distribution eco system in the creative sector. In this section, the holistic understanding of both categories and their required functionalities is discussed.

7.1. Trust, Privacy and Security in Media Consumption Chain

Within this category, it is strongly emerged that media blockchain can provide an efficient solution to issues related to trust, privacy and security in the consumption chain. Required functionalities or features are:

Digital rights management	A globally acceptable and seamlessly accessible mechanism to create and manage rights of media assets through blockchain.
Copyright protection	Provision to securely preserve copyrights information within a trusted infrastructure where the data can be retrieved easily.
Integrity	With the emergence of fake news and doctored media, it is important to have a mechanism to verify the integrity of the media in question.
Authenticity	This includes source verification, ownership authentication etc.
Traceability	Mechanism to trace the modifications and involved stake holders or identifying source of piracy.
Privacy compliance (GDPR)	Recording assets meta information such as copyright, content signature or any other identifiable information within the blockchain can be challenging due to non-compliance of privacy regulations of different countries, e.g., GDPR in the Europe. Thus the functionalities should consider this within any framework.

7.2. Transparent and Trusted Media Distribution Eco System

While ensuring privacy and security enables a trusted media consumption chain, it is also important that the media blockchain should provide a transparent and trusted media distribution eco system empowering creative content creators or publishers. This demands a number of functionalities/features as listed below:

Seamless asset distribution and monetisation	An infrastructure to enable creative content creators to distribute and monetize their assets without the need of centralised licensing organisations. Facilitation requires for a seamless creator to consumer distribution system that is transparent.
Rights management	A mechanism to generate and maintain digital rights of the asset at a global scale conforming laws of the land. This also includes certificate/license generation, distributions and management.
Contract management (smart contract)	A tool (e.g., smart contract within blockchain) that enables automatic contract generation and exchange between the seller and the buyer.
Consensus model	A protocol that enables validation of media asset transactions across the participating stake holders in a decentralised way.
Content versioning	New versions of an asset can be created and linked back to the original asset ensuring traceability and managing stakeholders.
Micropayments	All stakeholders should be rewarded for their contribution. Functionality such as a scalable mechanism for micropayments is required for this purpose.

7.3. User Groups and Attributes

Four user groups of media blockchain have been identified: a) content creators; b) publishers; c) consumers; and d) digital archives. While there are overlapping interests, it is believed that the requirements for each group are distinct as identified below:

	Content creators	**Publishers**	**Consumers**	**Digital Archives**
Content protection	X	X		X
Copyright management	X	X	X	X
Seamless asset distribution	X	X		X
IPR protection and management	X	X		X
Micropayment to stakeholders		X		
Transaction registration and management		X	X	
Integrity			X	X
Authenticity			X	X
Traceability			X	X

8. Next Steps

The current efforts in JPEG Privacy and Security are certainly relevant to blockchain and DLT. However, a larger scope of specifications in JPEG Systems currently under development as well as past standards such as JPSEC (Secure JPEG 2000) could be also impacted. Likewise, several future standards in coding but also search, retrieval and annotation can be relevant to both blockchain and DLT. A list of such standards should be identified along with their potential relevance.

Based on the analysis made on existing standardization efforts, it seems that there are no current activities in standardization of multimedia specifications to make them more efficient to be used in blockchain nor specific architectures and tools for multimedia applications.

As far as JPEG position regarding blockchain and DLT is concerned, three potential outcomes are possible:

1) Not-active

JPEG users would integrate JPEG standards with blockchain and DLT standards without any involvement from the JPEG committee to facilitate such an effort.

2) Reactive

JPEG committee would refer to blockchain and DLT standards developed by other standardization groups, e.g. ISO/TC307, and would develop additional JPEG mechanisms to make the ecosystem more integrated and powerful.

3) Pro-active

In addition to reactive, JPEG committee attempts to influence the blockchain and DLT standards developed by other standardization groups, e.g. by bringing media related uses cases, in order for these standards to become more aware of media related applications and to better respond to media related specific needs

As media contents are increasingly managed on blockchain and DLT, the issue of interoperability, tracking and exchange of such contents become important and could be addressed by the JPEG committee.

Moving forward, JPEG identified the following steps as future activities towards a standardised framework for media blockchain applications:

Inform and engage	JPEG intends to inform and engage all relevant stakeholders about its current activity on blockchain. JPEG also plans to organise more workshop(s) on multimedia blockchain in future meetings.	Ongoing
Collect additional use cases	JPEG calls for participation from industry and other standardization committees to help and define additional multimedia use cases that will drive the standardization process.	Ongoing
Assess use cases	An in-depth assessment of the collected use cases will aim to identify key features of the media blockchain use cases from both business and technical perspectives.	Ongoing
Define requirements	The outcome of the use case assessments will be used to define the relevant requirements. Two types of requirements are envisaged, notably to be addressed inside and outside JPEG.	Planned
Initiate standardisation process	A formal Call for Proposals may be issued if there are justifiable requirements to be addressed by JPEG.	Planned

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