CRWORK Blockchain White Paper

An Open Network for Artificial Intelligence
Powered by a Crowdsourced Network of Human Experts

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Abstract

CRWORK is a decentralized, open-source blockchain protocol and ecosystem built on a consensus network of Artificial Intelligence (AI) computing resources and a community of human experts, used to generate normalized and enhanced metadata for video content. Developers can build Decentralized Applications (DApps) on top of the CRWORK protocol. Platform participants can either run AI nodes or provide expertise and be rewarded with AWO (CRWORK Tokens).

AI Computer Vision algorithms running on nodes using CPU/GPU resources will be used to scan media files, generate enhanced metadata including time-coded tags, classification, categories, transcripts and translations, and an index of the video objects. Humans with expertise in tagging, editing and translation can participate in the CRWORK shared economy to help with the verification, validation and/or creation of video metadata. AI Machine Learning algorithms will continually learn from the actions of CRWORK community to become better and smarter. CRWORK will empower the community with tools to enable the community to moderate, review, verify the meta-tags, categorize, transcribe and/or translate content, as well as provide economic incentives to encourage this activity thru AWO.

A key feature of this project is our trademark content safety index known as a ContentGraph. The CRWORK platform will use AI to define a confidence score for each of several content safety attributes, such as: nudity, adult, offensive language, hate speech, violence, guns, alcohol, religion etc. Similar to MPAA ratings for movies but more granular and covering online video content, these scores will then be combined into an array of numbers called a ContentGraph, which will enable programmatic determination of content suitability based on a numeric filter criteria. The content safety attributes are extensible and new attributes such as ‘gender bias can be added at any time the AI has capability to recognize such content.

The challenge for CRWORK is to decentralize operation of the AI and human expert community on top of a consensus protocol, so that all sorts of Decentralized Applications (DApps), whether free or commercial, can reap the benefits of the CRWORK protocol with much better metadata and ContentGraph. One of the first DApps to be built on top of the CRWORK protocol will be an Open Video Search Engine that will offer a transparent and ubiquitous index and search engine for online video curated and maintained by the community.

CRWORK will open this blockchain protocol and ecosystem for use by third-parties, including content distributors, publishers and advertisers. This will help CRWORK achieve broad adoption and network effects benefiting all participants. The blockchain implementation will achieve this with smart contracts between the content owners, advertisers, distributors and service providers. The smart contracts will maximize utilization by enabling dispatch of jobs to the most productive service providers and grant incentives to promote better quality.

1. Problem Statement

1.1 Video Content Is Everywhere

More than 4.3 million videos are viewed every minute on YouTube and over 1.1 billion hours of video are watched per day on Facebook and Google. But with this much access to content, how does anyone find content anymore? How can content producers improve the monetization of their content while also giving a better experience to users?

These are just some of the problems which have arisen due to the massive expansion of video use online. With the deluge of videos being uploaded and consumed, searching for and/or discovering content becomes harder and harder.

YouTube is the closest thing to a search engine for video today, but it relies on the uploading user to properly catalog, tag and provide descriptions for each of the videos that they upload. Obviously, this will result in inconsistent cataloging. And users searching for video content are limited to what has been uploaded and tagged on YouTube.

Yet, online video is everywhere and YouTube is no longer the only destination for online video. Facebook, Google Plus, Twitter and many other sites rely increasingly on video to attract users. And let's not forget viral video apps such as Instagram and Snapchat Stories. Video is becoming a standard component in most websites, indistinguishable from text and graphics. But sadly, most video is not indexed in any meaningful way.

1.2 Video Content Is Opaque And Not Searchable

Google, Bing and Yahoo search engines work by indexing the textual content of pages. These search engines have two major functions: crawling and building an index, and providing search users with a ranked list of the websites they've determined are the most relevant. The crawling function not only allows them to locate obscure content, but is able to rank it based on the number of inbound links or 'backlinks'.

But, when it comes to understanding video content, most search engines have no ability to interpret and rank videos on a page. Video is said to be 'opaque', meaning it is difficult to understand or explain. At the lowest level, video is just an unusually large file that can be described with ALT text or schema markups created by the author. The problem is that this metadata is limited and it can be misleading.

What is needed for working with the opaque content of video is the application of AI computer vision, such as facial recognition, to video indexing. Once the AI understands what a face is, a human can further guide the AI by teaching it to recognize specific faces (e.g. to associate different characteristics and details of each face with a specific tag, such as balding, or person's name). Once a dataset of faces is built, the AI can then compare video images with this dataset and identify specific faces, such as a popular celebrity or a known criminal. This same method can be used to recognize objects (such as a gun), landmarks (such as the US White House) and action scenes (such as man jumping).

Moreover, it is uncertain whether metadata accessible to a search engine applies to specific scenes or the video as a whole. This is due to lack of indexes at scene level which describe the content in temporal terms,

with timecode references for each categorization. In addition, many types of content do include closed captions, which are transcriptions of the audio portion of the content indexed with timecode and embedded into the video recording as machine readable data that can be displayed on screen. However, such transcription information doesn't usually play a role in metadata. Therefore, search technology can be applied to captioned videos to provide scene level indexing as well as to describe the content as a complete work.

1.3 Video Content Lacks Metadata

Metadata must also be normalized and standardized if it is to be used for better search and discovery. Because humans are biased with their own perspectives, each human looking at the same video will come up with different metadata information and tags for that video. AI, however, is more objective and will classify and create metadata information based on limited vocabularies. This is important because it means all videos processed by the same AI engine will come up with a normalized set of metadata. In other words, the AI sees all images and videos the same way and will, therefore, always come up with unbiased and normalized metadata information.

1.4 Content Safety for Viewers and Advertisers

One of the most challenging problems in the video industry is to ensure video content are safe for our children to watch and for brands to advertise on through access to metadata. Due to the number of online videos viewed daily especially by kids, the importance of video safety is becoming more and more important. For viewers like children, sometimes a video's title and description may be misleading causing inappropriate or malevolent content to be viewed by children because content is searched for or recommended based on source metadata. The context of the video cannot be defined in today's subjective, incomplete and inconsistent metadata. Besides the safety of our children, advertisers also require a level of safety to ensure their branding is not associated with any inappropriate content. Brand safety is a big issue for advertisers, which was brought to the forefront with various brand safety scandals on YouTube and Facebook in 2017.

1.5 Content Globalization and Localization

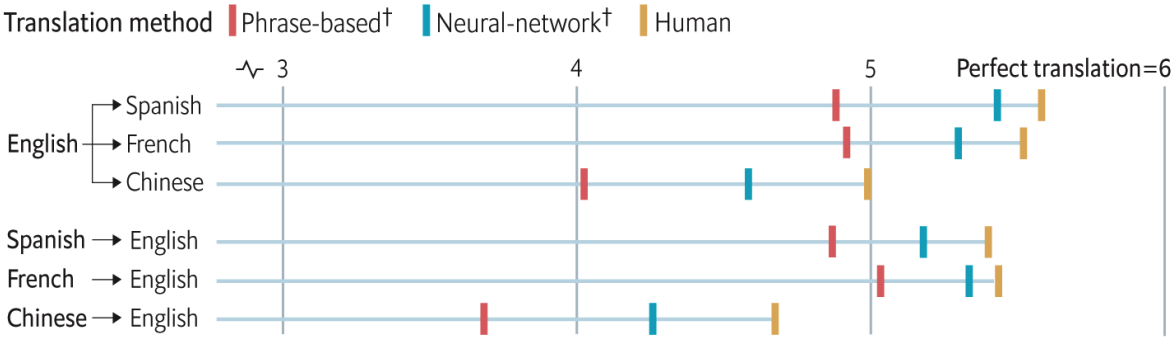
Another challenging problem within the video industry is that least 80% of content on the Internet is accessible in only one of 10 top languages. Most videos on the internet are only accessible in a single language, usually English. Aside from the broader issue that linguistic and cultural diversity are at risk, this is bad for content producers and advertisers. It means that video distribution is limited and much of the world is out of reach for content producers regardless of whether their videos are accessible through search engines and video platforms. Due to complications and costs of transcription and translation, many times content producers are restricted to distribution only in their own local market and maybe a few markets abroad for distribution.

1.6 AI Still Needs Human Intelligence

Artificial Intelligence (AI) is defined as "the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." In the past few years, there has been a rapid growth in the number of practical AI applications and smart services such as self-driving cars, face, object and voice recognition and text and image translation are just a few of the life changing applications AI is helping to enable. Advances in Machine Learning (ML), Computer Vision (CV) and Natural Language Processing (NLP) research combined with the adoption and advances in cloud computing have resulted in wide

adoption of AI in many industries and the birth of a multi-billion-dollar economy around AI-driven smart applications.

While AI is a game changer when it comes to normalized classification and tagging of video at scale, AI is not perfect and it still requires human intelligence for verification, validation and correction as well as training to teach it patterns of faces, objects, scenes, etc.



Machine Translation accuracy still at 60-80%

Speech recognition accuracy can be as high as 90% when a recording has one person in a quiet location speaking clearly using simple terms. But 70-80% is more common. Machine translation varies from 60 to 80%, which means 1-2 words out of 5 are not translated correctly. For facial recognition, even for the most accurate algorithms, subjects may be identified anywhere from around 60 percent of the time to more than 90%, depending on video or image quality, the comparison dataset and the algorithm's ability to deal with the given scenario.

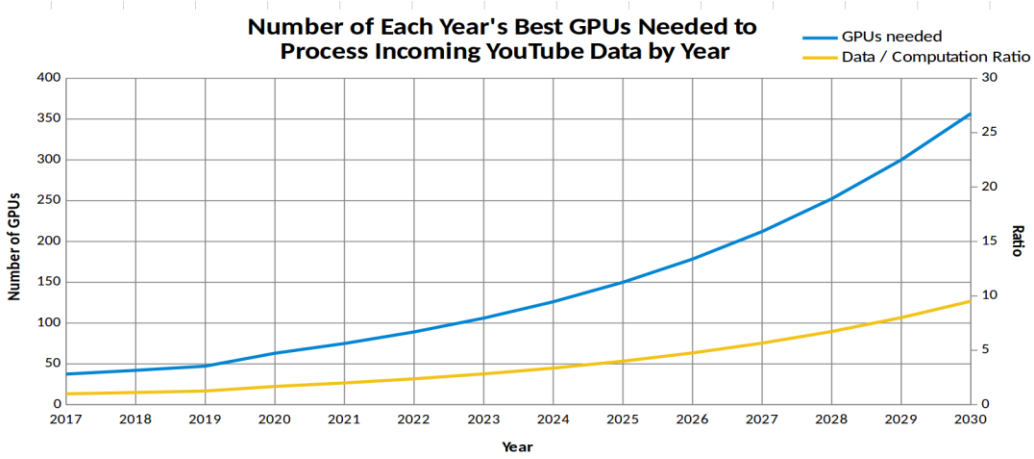
Humans, while limited by speed and dataset, are still better at comparing and identifying faces and objects to each other and humans can research what they don't know, while AI sticks to its programming. Humans, however, are slower than computers, costlier and don't scale. Therefore, a hybrid approach of combining AI with human verification and correction is the most optimal way of achieving AI computer vision at scale and accuracy.

YouTube employs AI machine learning plus human moderators. After various brand safety incidents, YouTube announced in December 2017 that it would hire 10,000 more moderators to check videos for brand safety and videos that might violate its policies.

> *"Human reviewers remain essential to both removing content and training machine learning systems because human judgment is critical to making contextualized decisions on content," YouTube CEO Susan Wojcicki wrote in a blogpost, saying that moderators have manually reviewed nearly 2 million videos for violent extremist content since June 2017, helping train machine-learning systems to identify similar footage in the future. "Since we started using machine learning to flag violent and extremist content in June [2017], the technology has reviewed and flagged content that would have taken 180,000 people working 40 hours a week to assess."*

So, we believe that the best solution to the challenge of indexing video for effective search, discovery and placement is a combination of AI and human experts.

1.7 AI Requires Computing Resources

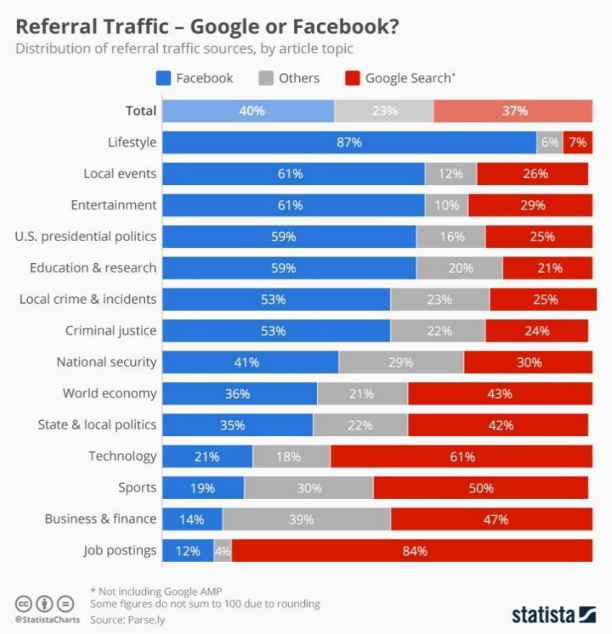


GPU Compute Resources Needed for YouTube Data

AI also requires a computational infrastructure capable of processing large amounts of data on Computing Processing Units (CPUs) or Graphics Processing Units (GPUs). Because of the amount of data, no one CPU or GPU can typically process all the data so the data must be broken up and distributed to multiple CPUs or GPUs for processing. The results must then be brought back together to return results. The intensive computing nature of AI makes it quite costly and requires a pooling of CPU or GPU resources which are not usually available from one source. We believe the best solution is to pool computing resources from the community.

1.8 The Internet and Online Video Need Decentralization

Today, everything we do online including online video is dominated by FAANG (Facebook, Apple, Amazon, Netflix, Google). Online video represents over 73% of all data traffic on the Internet in 2016 growing to 82% by 2021, of which Google and Facebook control over 1 billion video views a day. In premium online video and subscription services, Amazon and Netflix control over 69% of the 113.8 million subscribers for subscription video on demand (SVOD) services in the US and almost 60% of the $14.9 billion US SVOD revenues in 2017. If you want web traffic for your website or videos, over 70% of all Internet traffic comes from either Google or Facebook. If you want to monetize video, Google and Facebook represents 77% of all online advertising and 99.7% of all new online advertising growth. 99% of all mobile smartphones and app ecosystems are either Android (Google) or iOS (Apple). It is clear that FAANG dominate our digital lives on the Internet which means the power of the Internet is centralized in the hands of these five dominant players, whose combined market capitalization is over US$3.01 trillion or 27% of the total market capitalization of all companies listed on NASDAQ. We believe that blockchain has the potential to truly decentralize the Internet and online video, and these DApps or decentralized platforms would benefit from the normalized and enhanced video metadata generated by the CRWORK platform.



2. Our Solution

2.1 Overview

Our solution known as CRWORK is a decentralized, open-source blockchain protocol and ecosystem being built on a consensus network of Artificial Intelligence (AI) computing resources and a community of human experts, working together to generate normalized and enhanced metadata for video content. This enhanced metadata will be the basis for the CRWORK protocol's first decentralized application - an open search engine for video, one that is decentralized, indexed and maintained by our community.

CRWORK believes that Internet and services on the Internet must be decentralized or else there is too much power in too few powerful hands. CRWORK focuses on decentralizing and democratizing online video, giving power back to Internet users. The problem of having the power of the Internet in just a few hands is that there is little or no transparency and even if these few companies mean well, they are now so big that there are many ways to destabilize them. In 2017, both Google and Facebook faced major scandals of bad actors taking advantage of loopholes in the system. Google's YouTube was compromised multiple times with users posting content that was malevolent creating brand and content safety controversies. Facebook faced both a fake news problem and a data breach by Cambridge Analytica. This is why CRWORK is applying blockchain to content and the underlying metadata that powers content cataloging, indexing, search, discovery, trade and monetization and CRWORK believes that this will be the backbone of a decentralized video open network and search engine that could act as a check and balance on FAANG.

Artificial Intelligence

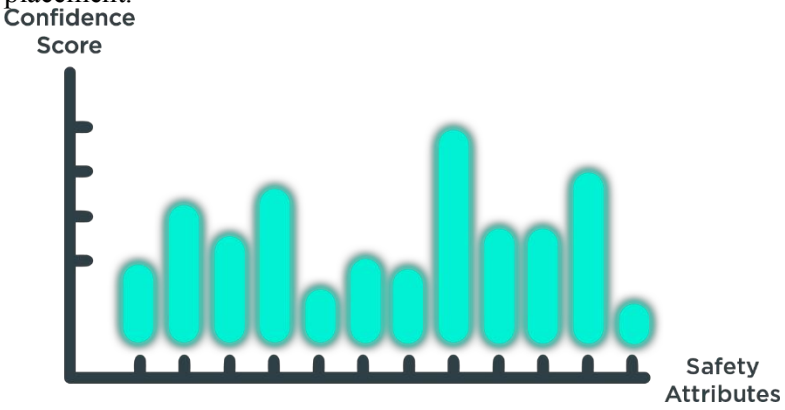
Specialized AI algorithms will be deployed on AI nodes, of which the CPU and GPU resources can be used to scan media files, generate the enhanced metadata including time-coded tags, classification, categories, transcripts and translations, and an index of the video objects. Anyone with a reasonably powerful computer can establish an AI node and join the CRWORK network. Load will be decentralized and distributed across the CRWORK network, similar to how SETI@home and other distributed crowdsourced computing projects timeshare computing resources.

Each video object, such as a complete program or extracted clip, will be assigned a unique identifier using the Entertainment Identifier Registry (EIDR). The EIDR provides global unique identifiers for the entire range of audiovisual object types that are relevant to entertainment commerce.

CRWORK nodes will record their metadata in JSON format anchored to the Ethereum blockchain. Most o f the metadata will not be stored directly in the blockchain, but linked to it using the EIDR identifier. Thi s is because the size of the data can be quite large, especially when you include transcripts and translations.

A key feature of this project is the generation of a trademark content safety index known as a ContentGraph. The CRWORK platform will use AI to define a confidence score for each of several content safety attributes , such as: nudity, adult, offensive language, hate speech, violence, guns, alcohol, illegal drugs, religio n etc. These confidence scores (each from 0-9) will be combined into an array of numbers. This short stri ng of numbers, called a ContentGraph, will enable programmatic matching of content and context, for opti

placement.



A ContentGraph can be visualized as a bar graph where content attributes are plotted along the horizontal axis and confidence scores plotted on the vertical axis. There will be attributes where the confidence is zero and the feature is not detected. The left-to-right ordering is reserved based on the schema, so that two or more ContentGraph patterns can be compared. Accessing attributes involves a single subscript which represents an array index (e.g. graph [6] returns the value of the 6th element - guns). The number of positions corresponding to specific attributes being recorded can increase over time, without affecting other uses of the graph.

Is AI any good at detecting scenes involving nudity, violence or guns? To some degree yes. it has been shown that AI algorithms can reliably (95% accurately) detect objects such as guns within video content - even grainy CCTV footage. Nudity detection is a bit more challenging, but it has been reported to be reliable on still images. According to one widely referenced paper on the subject: “the algorithm is indeed able to provide good recognition rates for nudity even at the frame level, achieving, in the best case, a value of 93.2% of correct classification. The results also indicate that the proposed voting scheme significantly enhances the recognition rates for video segments, solving some ambiguities and frames misclassifications”. This shows that nudity detection involving a temporal component is even more accurate.

Decentralized Applications (DApp) and traditional applications can use ContentGraph to automate the determinations of content suitability and brand safety. We believe that ContentGraph will not only solve many problems for the content industry, such as search and discovery, but it can also become an industry standard much like MPAA Rating. It will also help solve the problem of contextual relevance for video advertising by adopting the IAB Content Taxonomy standard set of categories, which are already widely accepted in the publisher and advertising industry and applying numerical confidence indexes which are determined by AI algorithms.

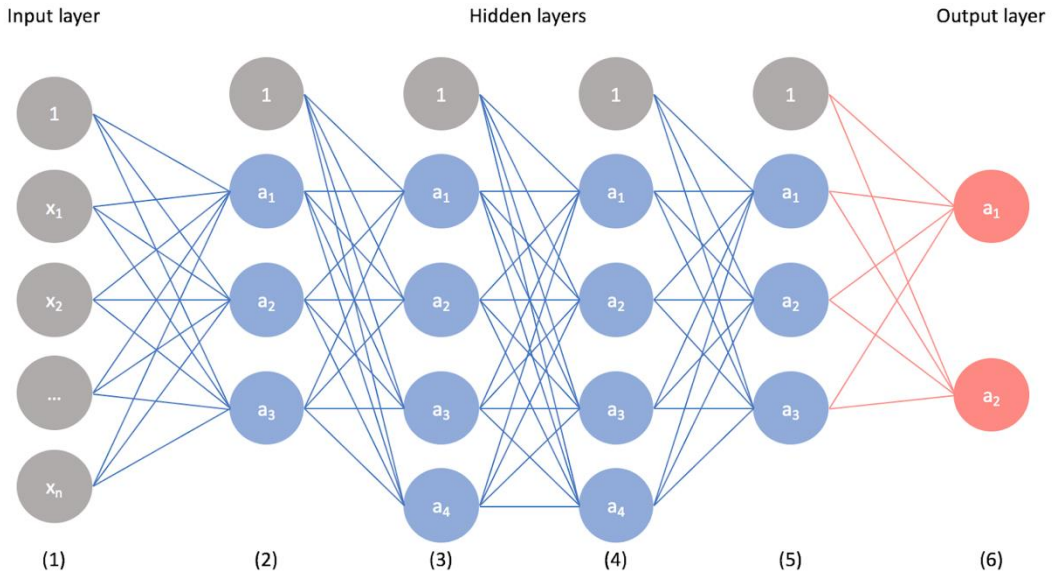
ContentGraph has many interesting features, such as extensibility to add new content safety attributes, addressing the need to stay relevant as social norms change over time. If the AI can be trained to recognize new safety attribute in video content, the attribute can be added to ContentGraph by adding a single digit, without affecting the other attributes or earlier uses of the graph.

Another feature of ContentGraph is the ability to derive other indexes by applying filters. For example, one might be specifically interested in just 3 attributes: nudity, offensive language and violence. So, the numeric values of these attributes could be added (eg- graph [1] + graph [3] + graph [5]) to create a single digit 'Disney Rank' or similar derivative index.

AI Node

Until recently, it was very difficult for a computer to tell apart a cat and a tiger or recognize a human's face, whereas a human can perform these tasks almost effortlessly. Fortunately, the field of Artificial Intelligence (AI) and Machine Learning (ML) has made tremendous progress in the last few years to become better at understanding images. In particular, a model known as deep Convolutional Neural Network (CNN) has proven to be adept at achieving excellent performance on visual recognition tasks.

A Neural Network is a set of algorithms with interconnecting nodes, modeled loosely after the human brain, that is designed to recognize patterns. Similar to how a child learn by mimicking the behavior of familiar persons (like parents) and applying the learning outcomes to modify its own behavior, a Neural Network "learns" to perform task by optimizing using large labeled training data sets to "minimize" the error between the output and the desired outcome.



Example of a Convolutional Neural Network with 4 hidden layers

Unfortunately, there is no "one size fits all" generalized AI algorithm or Neural Network that can perform all the tasks required. For example, the CNN optimized and trained to identify objects will be different from the CNN configured for identifying faces. Hence, we'll need to combine various best of breed AI techniques to develop a package of Neural Network based AI software with the specific trained models to perform the following tasks:

- Visual recognition of faces, object scenes at frame level
- Visual recognition of ContentGraph attributes at frame level
- Auto speech-to-text transcription
- Auto text-to-text translation

Instead of re-inventing the wheel, CRWORK will also leverage some of the state-of-art open source machine learning frameworks such as Tensorflow, Caffe, Torch and Darknet, combined with our existing data sets. This approach will ensure that CRWORK AI software will be continuously upgraded with the latest technique and technologies especially given that the field is advancing by leap and bound.

The pictures below are visual illustrations of what our AI software will detect visually in terms of celebrities and objects and their associated time-code.

Using an example of an episode from Big Bang Theory, one set of AI algorithm will identify the celebrity faces in the frame, in this case Kaley Cuoco and Johnny Galecki, while another AI algorithm will pick up the objects in the frame, in this case bed and laptop.

Example of face tags and associated time-code

Because the AI analyzes the video at frame level, it will produce a rich set of metadata with very precise time-code which will be extremely useful when it comes to searching by scene. However, analyzing every frame in a video is computationally intensive and, in most cases, unnecessary, hence the default will be to take 1 frame from 1 second of video for analysis. For fast moving videos, we can increase to 3-5 frames a second for better accuracy.

Metadata Extraction

Aside from assigning a content safety index, AI algorithms will be used to capture various types of metadata. The 3 most common types of metadata used for search optimization are: source, derived, and added metadata or tagging.

Source metadata is whatever information is implicit in the file. This would include file type, file size, duration, encoding method, resolution, aspect ratio, data rate, number of audio tracks, closed captions, timecodes, etc. Uploader may supply data such as titles, descriptions and locale that can provide a lot of information for indexing purposes.

Derived metadata is data obtained by interpretation, such as the use of speech recognition to extract a transcript, optical character recognition to read movie credits and image processing algorithms to recognize faces and temporal action. These tools work in concert.

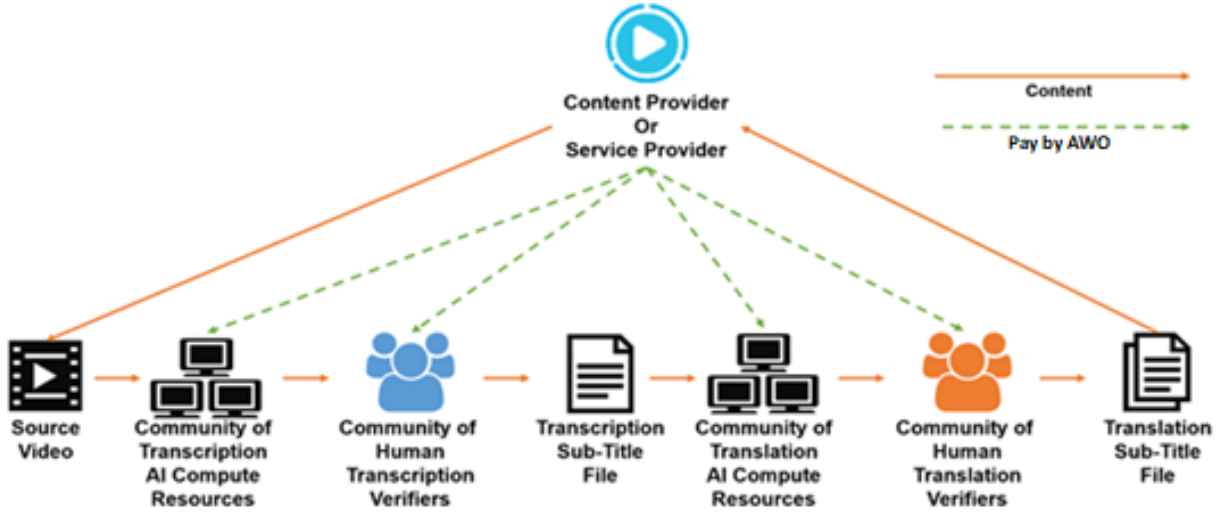
Added metadata or tagging can be done by AI, but is usually augmented by human experts. This is where temporal sequences or spatial regions of the video are marked as being of interest and keywords are added

to describe the video. For example, in a sports video, the AI may recognize goal posts as spatial regions of interest and use that information to note sequences in which points are scored. This could be combined with recognition of play-by-play by sportscasters on the audio track to increase the accuracy of such tags.

Human Experts Network

Despite rapid advancement in the field, AI is not perfect; humans continue to play two important roles in the process. First, they help label the data that will be fed to the algorithms. Then, they correct any wrong predictions made by the AI machines to improve the accuracy of future results.

We will use a multi-disciplinary, crowdsourced network of freelancers with skills in logging, tagging, metadata management, moderating, transcribing and translation. CRWORK will empower its community with tools which enable individuals to create added metadata. Of crucial importance is the performance of content categorization by supplying accurate descriptions and assignment of appropriate tags based on the most widely accepted lexicons and taxonomies. This is where expertise and powerful tools are required. There are certainly very different lexicons for medical conference recordings, sporting events and headline news stories. Individuals will have the opportunity to participate in specific subject areas, according to their expertise.

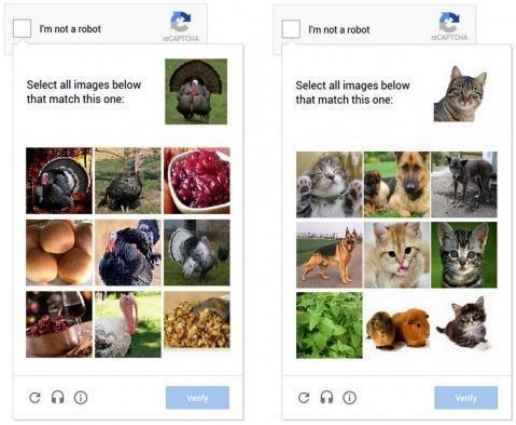


Workflow for transcription and translation using AI and human experts

The community will also be involved in moderation, review and verification of derived metadata, including categorizations assigned by AI, as well as correcting the transcriptions and translations. How hard is it for humans to correct transcripts produced by AI? We have seen recent studies which show that machine translation is accurate to 95% for broadcast recording, but recognizing speech from "an iPhone on a table in a cavernous conference room with five people talking could be 70% or less". Humans will certainly prefer correcting transcriptions generated by AI, rather than writing them from scratch.

CRWORK will reward these crowdsourced human experts with tokens based on their accuracy and productivity. This approach not only provides a larger pool of human experts to choose from, the diversity of decision making process and the use of a consensus network can eventually lead to better results in AI accuracy.

Each face, object or scene identified, or sentences transcribed or translated comes with a confidence score. For confidence score below a certain threshold (which may vary over time and for different attributes) or if the AI node is unable to detect any meaningful context, the validator can send these segments to the Human Expert network for further verification or correction.

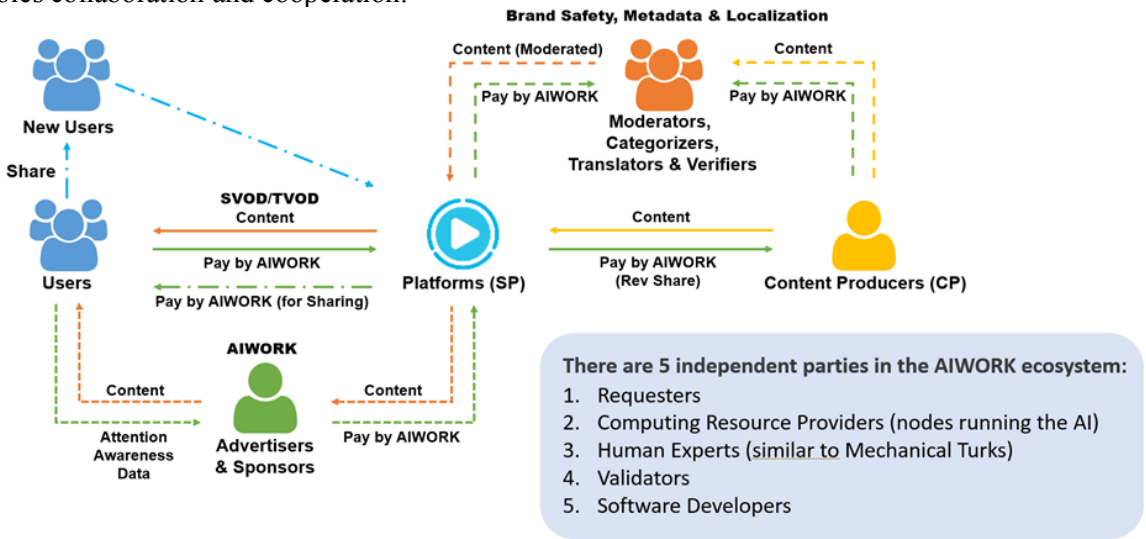


Examples of Google reCaptcha Image selection

For simpler verification tasks, CRWORK will pose to its human expert questions that are similar to image recognition reCaptcha, meaning a human expert can be offered a random number of celebrity images and be asked to select the ones that belong to George Clooney, for example. As a proof of work, the human expert can be asked to complete a similar reCaptcha image selection of which the results have been pre-determined by the parent validator node. The validator node could also send the same tasks to a group of randomly selected human experts (odd number), the same answers provide by majority of the human experts would be deemed the correct one.

Pulling It All Together

CRWORK will be part of a larger content ecosystem consisting of content producers, advertisers and streaming media service providers. In the illustration below, we can see how our CRWORK platform enables collaboration and cooperation.



The CRWORK community will provide an open, distributed and crowd-sourced community for transcription and translation. Content owners and distributors in need of transcription and translation of their content will come into the open marketplace to transcribe and translate their content through CRWORK 's AI machine transcription and translation with distributed crowd-sourced computing resource s combined with a crowd-sourced open community of transcribers and translators, all incentivized using th e AWO (CRWORK Token).

2.2 Architecture

CRWORK is built on a standard Ethereum blockchain as well as Plasma Network. All the video metadata will be anchored to Ethereum blockchain and Decentralized Applications (DApps) can easily access the data and either spend or earn AWO.

Attributes of AWO:

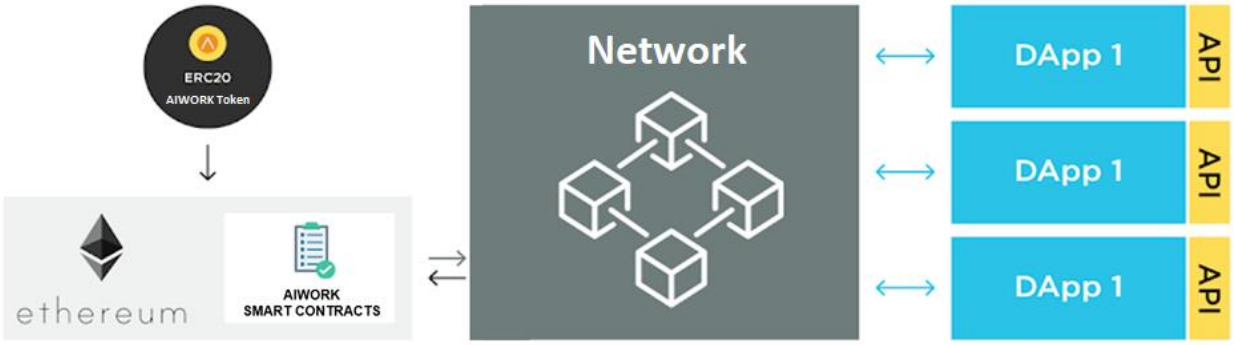
- blockchain protocols: Ethereum (ETH) Mainnet & CRWORK Plasma Chain
- Token standard: ERC20
- Total supply: capped at 10 billion
- Token issuance at genesis: 60% of total supply

AWO is implemented as an ERC20 token on Ethereum mainnet while CRWORK is implemented on a Plasma Network. Plasma is a blockchain scaling solution designed by Joseph Poon and Vitalik Buterin which enables the creation of "child" block chains anchored to the "main" Ethereum blockchain. As only periodic merkleized commitments (e.g. computations committed into merkle proofs) are broadcast to the Ethereum root blockchain, this design can allow for extremely scalable and low-cost transaction state updates. See diagram below.

We chose the Ethereum chain because of its robustness, great ecosystem of DApps, security and strong immutability features. This approach marries the performance and power of Plasma with the public verifiability of Ethereum blockchain. The disk storage is for off-chain metadata, including transcriptions and translations.

Smart contracts on Ethereum mainnet acts as a trustless medium to bring AWO into CRWORK Plasma network from Ethereum mainnet and vice versa. Transactions involving AWO that take place in CRWOR K Plasma chain are signed by validators based on a consensus algorithm. Participants are free to join and e xit the Plasma chain as and when desired in a trustless manner, able to claim the tokens previously locked in the smart contracts net of any transactions, either gains or spends, that have taken place in the Plasma ch ain prior to the exit.

There will be independent nodes and blockchain in CRWORK Plasma network, independent of Ethereum. Validator nodes will provide proof-of-stake and perform the block minting. Applications such as a search engine or an ad network are instantiated as DApps and participate in the CRWORK network, providing their own respective APIs for real-world consumptions.



CRWORK Protocol and Decentralized App Open API Architecture using Ethereum and Plasma

2.3 CRWORK Ecosystem

There are 5 independent parties in the CRWORK ecosystem:

1. Requesters
2. Computing Resource Providers (nodes running the AI)
3. Human Experts (similar to Mechanical Turks)
4. Validators
5. Software developers

Requesters

1. Requesters submit videos to CRWORK to obtain a normalized metadata of videos.
2. Requesters pay for the job in the native token of CRWORK .

Computing Resource Providers (CRP)

1. Providers run CRWORK decentralized open source AI software that runs inside isolated Docker container and is based on popular Deep Learning frameworks like Caffe and TensorFlow; Convolutional Neural Network will be used as it is the current state-of-the-art model architecture for image classification tasks.
2. Providers share its computer's computing resource (CPU/GPU) to run CRWORK AI software to generate the enhanced metadata including ContentGraph.
3. Providers gain token in exchange for the provided computing resource and tasks performed.

Human Experts (HE)

1. Human Experts perform simple micro tasks to verify that the output from AI.
2. Human Experts also provide additional metadata that cannot be easily generated by AI
3. Relevant results can be fed into the AI network to teach and improve it.
4. Human Experts gain token in exchange for well performed tasks.

Validators

Validators stake a significant amount of AWO and gain the rights to perform the following tasks in accordance with consensus:

1. Picking up the chunks of video jobs and distributing them to providers and workers.
2. Validation of the results submitted from providers and workers
   Analyzing and combining of the results to produce a single coherent ContentGraph for each video.

2. Validators mint new block on CRWORK plasma, gain token for the job and assign rewards to participating CSPs and HEs.
   Validator may lose a portion of the staked tokens if it is not performing the tasks in accordance to consensus.
   Validator decides the next validator via psuedo-random algorithm that is independently provable and bias-free.

Software Developers

1. Developers play a role in the ecosystem by developing applications that interact with CRWORK or utilize Content Graph
2. CRWORK will be developing at least the following 2 applications:
   1. Open Source Search engine and relevant API
   2. Advertisement matching service and relevant API

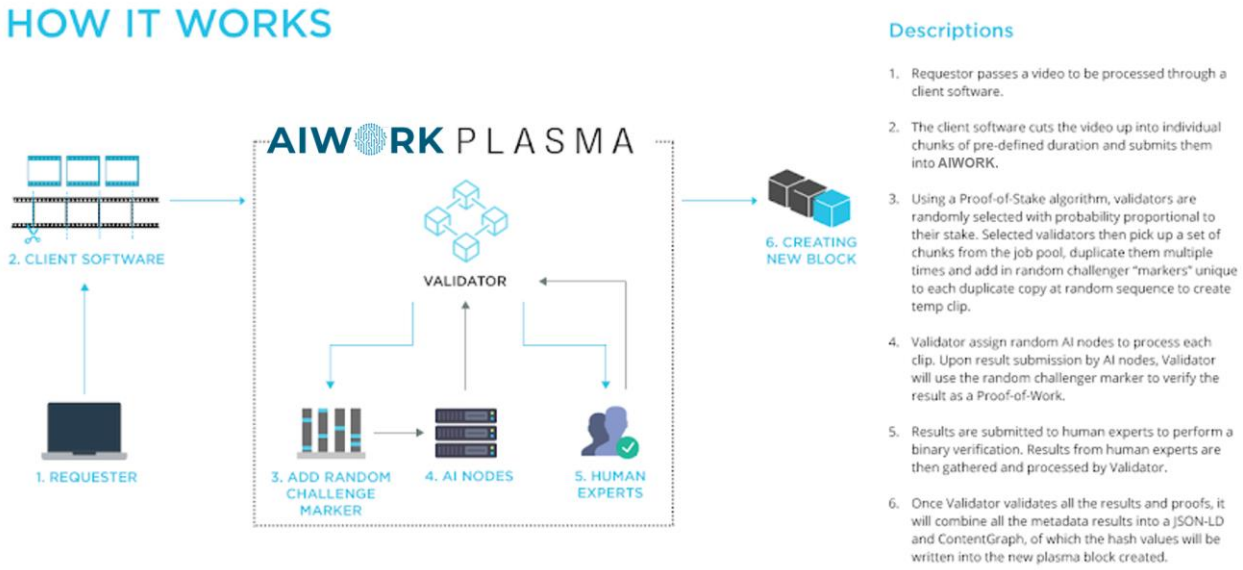
3. Developers would be able to utilize CRWORK to create new applications which they could charge using our tokens
4. Developers gain access to list of non-private videos processed by CRWORK , with their corresponding ContentGraph

2.4 Deployment

All CRWORK software will be shipped and distributed in dockerized containers. The Docker virtual machines, called Docker images or containers, will contain the whole environment required by the software to run, including all the required libraries, dependencies and configurations. This makes it easy for anyone to set-up a validator, AI or human expert node which can run on cloud servers, PCs and even android devices.

2.5 How It Works

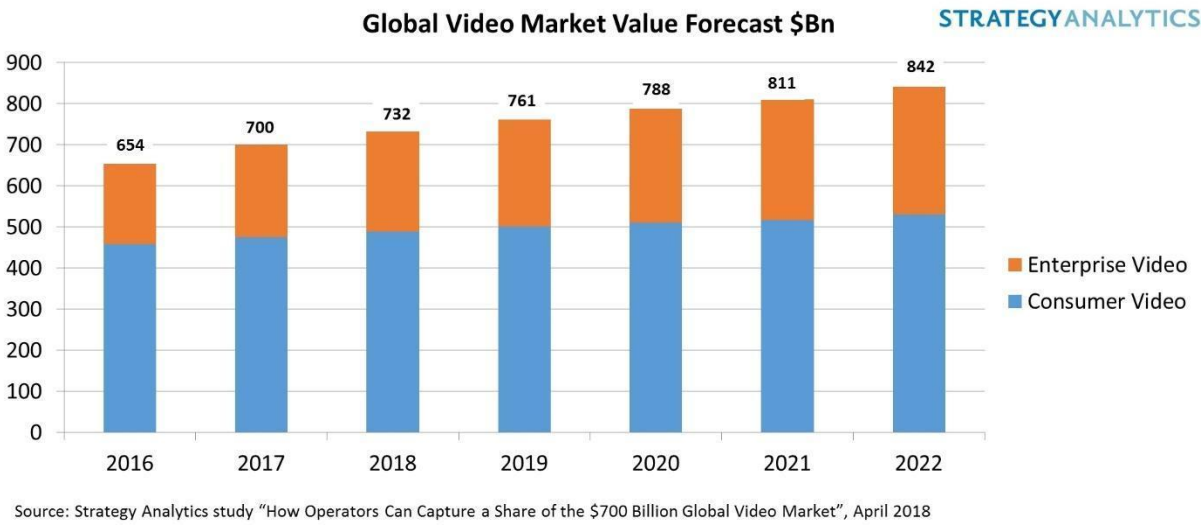
The diagram below illustrates the submission, mining and verification process.



1. Requester passes a video to be processed through a client software.
   The client software cuts the video up into individual chunks of pre-defined duration and submit them into CRWORK
   Using a Proof-of-Stake algorithm, validators are randomly selected with probability proportional to their stake. Selected validators then pick up a set of chunks from the job pool, duplicate them multiple times, and add in random challenger “markers” unique to each duplicate copy at random sequence to create temp clip.
   Validator assign random AI nodes to process each clip. Upon result submission by AI nodes, Validator will use the random challenger marker to verify the result as a Proof-of-Work.
5. Results are submitted to human experts to perform a binary verification.
6. Results from human experts are gathered and processed by Validator.
   Requester monitors the network, once all tasks for chunks that make up a complete video are completed, Requester would be able to make a claim by providing the order of the chunks and publish an aggregated score of the original video, also known as ContentGraph.
   Claim by Requester will be evaluated based on consensus. If it passes, Validator will publish the result as ContentGraph onto a new block on CRWORK Plasma Chain.

2.6 Market

Addressable Market



Source: Strategy Analytics study "How Operators Can Capture a Share of the $700 Billion Global Video Market", April 2018

The global video market value was US$700 billion in 2017, growing to US$842 billion by 2022. Today, over 400 hours of videos are uploaded and 4.3 million videos are viewed every minute on YouTube. On Google and Facebook, over 1.1 billion hours of video are watched per day.

2.7 Roadmap

Development Roadmap

Following is our development roadmap.

Versions	Estimated Date	Milestone
	Oct 2020	Design of CRWORK architecture
0.5	Jul 2021	Alpha testing of CRWORK AI client
0.6	Sep 2021	Alpha testing of CRWORK Marketplace
0.7	Oct 2021	Alpha testing of the validator and AI nodes, and task allocation
0.8	Feb 2022	Alpha testing of marketplace for job submission and review
	Jun 2022	Release of Minimum Viable Product (MVP)
0.9	Sep 2022	Alpha testing of workflow support for human experts to verify and validate
1.0	Dec 2022	Release of V1.0 of System with validator and AI nodes
	Mar 2023	Incorporate support of Polygon's L2 layer to reduce latency and transaction cost

	Jun 2023	Commence development of Generative AI services (details to be announced later)
	Sep 2023	Launch of AWO marketplace. Users can earn reward by helping with AI data annotation and verification.
	Dec 2023	Beta testing of AWO staking mechanism
	Jun 2024	Launch of AWO staking and reward programme to the public

3. Applications

3.1 Real World Examples and Applications

The following examples are included to illustrate how the CRWORK platform can be utilized in real worl d situations to solve real world needs.

Better Content Metadata for Better Search and Discoverability

Currently, metadata are supplied by users and in some cases very inconsistent, incomplete and subjective. For example, when two people are uploading the same dog competition video, one might put tags such as "dog, show" and the other might tag it with more details, such as: "dog, terrier, best in show, 2018, Westminster Dog Show." Neither is wrong but the latter metadata is much more descriptive and detailed. Therefore, normalized and standardized metadata will help individuals query better matching results.

OTT (Over The Top Video) Platforms can benefit with consistent, completed, normalized and standardized metadata. This will allow their content to be easily discoverable and searchable by subscribers. OTT Platform providers could use CRWORK in multiple ways to add or enhance their metadata. They would receive detailed scene-accurate metadata and tags for each item, paying CRWORK in tokens for the A I computation and human work.

Scene Level Metadata

Metadata today is done at the file level, meaning the information that is used to describe, classify and index content is only descriptive of an entire program or clip. But, there is so much underlying information at the scene-level that currently is not tagged. And it is impossible to perform scene level tagging using human because it is simply too costly and not scalable.

Once scene level metadata is extracted, it will also improve recommendation engines by inferring what you like based on underlying metadata of scenes you've watched in the past. Through enhanced and improved recommendation engine content will become discoverable and searchable if tagged to such that granularity of scene and frame. Viewers could search down to the second or jump right to a particular scene based simply on the content. Lastly, from the engine information, video editors could easily find b-roll footage to assemble and create videos instead of scrubbing through videos to find footage.

AI Match Verification and Correction

AI is not perfect, and since faces and objects can look similar, there will always be misidentifications or "false positives." Humans, while limited by speed and dataset, are still better at comparing and identifying

faces and objects. Therefore, a hybrid approach of combining AI with human verification and correction is the most optimal way of achieving AI computer vision at scale and accuracy.

CRWORK will provide AI match verification and correction through the CRWORK open community. Requesters such as AI technology providers and content owners, can use CRWORK to request AI matc h verification and correction on their AI generated datasets. They would then pay the CRWORK op en community for this match verification and correction using AWO.

AI Decentralized Distributed Computing Cloud

Although the power of AI is efficient and scalable, it still requires lots of computing power to process, recognition, match and tag content. One growing pain of AI is the lack of computing resources a company can have and utilize without jeopardizing cost, efficiency and scalability. In addition, the compute demand may fluctuate based on the "spikes and valleys" of videos uploaded. A decentralized and distributed AI computing cloud using crowd-sourced computing cycles is a good solution to handle the fluctuations in demand while maintaining optimal costs.

Content Safety

The consumption of video content has increased dramatically over the last few years due to new platforms like YouTube, Facebook, and Twitch. However, it is difficult for these platforms to manage, review and validate all the videos uploaded therefore, leading to underlying issues of content safety. For instance, recently, there were fake videos using famous cartoons and characters such as Peppa Pig, Nickelodeon's PAW Patrol and Disney's Mickey and Minnie Mouse, but with violent, demonic and/or gory scenes and storylines uploaded to YouTube. Bad actors were taking advantage of YouTube searches of famous cartoon and characters to show negative images to kids and they were able to do so by taking advantage of the way YouTube catalogs and indexes video using user titles, descriptions, tags and metadata.

YouTube Content Safety: Fake Mickey Mouse shown lying in a pool of blood

Through CRWORK , videos like above can be easily detected and flagged as inappropriate by the power o f AI and human experts. CRWORK 's ContentGraph score would label rejected and with a low score of safe ty. The scene level detection and metadata, will clearly define the inappropriate scenes for childr en. \Meanwhile, Service Provider could use CRWORK and ContentGraph to offer content safety filters w hich viewers could use to search for safe and appropriate content. Contributors to the CRWORK platform, those who are providing computing resources or expertise, would be rewarded with tokens.

Brand Safety for Advertisers

In 2017, YouTube had a lot of trouble with brand safety. In February 2017, there was a problem with advertisements inadvertently showing up alongside hate messages and ISIS terrorist videos. Brand safety is a big issue for advertisers because they can't see what content their ads are played against. Ads from brands such as Adidas, Procter & Gamble and Unilever were found to be displayed next to ISIS terrorist videos and hate speech videos on YouTube.

CRWORK can ensure brand safety for advertisers with the ContentGraph scoring that is applied to each video. This ContentGraph is based on a score as determined by CRWORK 's decentralized AI compute network and verified by CRWORK 's crowdsourced open community, which would be compensated with tokens.

Globalization and Localization of Content

Globalization enabled the availability of many more sources of content, and the dissemination of cultural information, over the Internet. But for content to be globalized, videos need to be transcribed and translated for local needs prior to consumption. Through human experts, transcription and translation is time consuming and costly. It can take up to 20 times the duration of the video to properly transcribe and translate a video. For instance, if a video is 5 minutes, it could take up to 100 minutes to transcribe and translate that video. Therefore, AI can transcribe and translate a video in 2-3 times real-time instead of 20 times real-time. However, current machine transcription (speech-to-text) and translation (language-to-language) is not accurate enough with accuracy being around 50-60% at best.

To obtain accuracy in transcription and translation, CRWORK empowers the ability of both human experts and AI. If a human round of verification and correction are added behind the machine transcription and then again after machine translation, accuracy can be much higher. Community participants will be rewarded with tokens. Nonetheless, videos can be more cost-effectively transcribed and translated and this, in turn, will broaden appeal, accessibility and consumption of content by more international audiences, enabling a true globalization of video.

3.2 New and Innovative Advertising Opportunities

Digital Product Placement

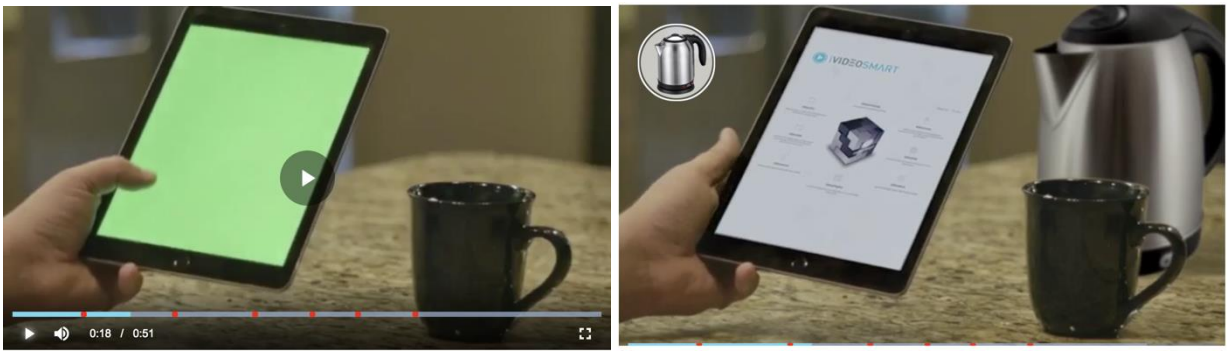
Through CRWORK 's scene detection by AI, it empowers new native ad technologies like Digital Product Placement Technology, DPP, to accelerate and enhance the experience of the audience while increasing monetization for Content producers. From scene detection by CRWORK , Content Producers are provided with quality information on time-coded placement opportunities for advertisers to insert videos, products, and banners like a can of soda or even a car. The technology is capable of placing or replacing moving objects and even replacing products being handled by actors. Also, the technology enables objects to be inserted post-production after the video has been filmed and produced. When advertisers are integrated they are placed in such a way so it is clear to the audience that they were always there and are part of the scene.

As video content consumption has become global, some content producers will produce different versions of the content to accommodate the market and audience. With AI enhanced DPP, product placement can be adapted to the market of broadcasting. For instance, in one scene viewed in the U.S., the actor is drinking a can of Coca-Cola, meanwhile the same scene viewed in Hong Kong, the actor can be drinking Vitasoy tea,

a local Hong Kong beverage brand. This allows the content producer to generate revenue from both advertisers.

Ad Overlay

Advertisers are seeking advertising opportunities beyond standard video ad formats such as pre-roll, mid- , and post-roll type ads. The "ad overlay" is when videos contain a small, semi-transparent overlay across the bottom of the screen. The ads show up for a period of time in the videos. Viewers are less likely to be annoyed and become more accepting of advertising if the ads are more appealing and contextually relevant to what they are watching.



Picture on left shows scene prior to any DPP or HotSpots. Picture on right is after DPP and Interactive Hotspots dynamically inserted into scene.

With CRWORK 's normalized and standardized time-coded scene level metadata, advertisers are able t o better advertise and target viewers based on the context of the video and not just simply targeting blindl y. For example, when the user is viewing a car video review of a BMW 3-series, an ad overlay can appear to display advertising from local BMW dealerships or from BMW. With such relevancy between video conte xt and the ad, the viewer is more likely to engage with the ad.

Interactive Touch Hotspots

"Interactive Touch Hotspots" is a new native video advertising concept that allow viewers to interact and engage with. For instance, when a mobile phone is identified, with hotspot technology, the mobile device can become interactive for the user to click on. Content producers can leverage hotspots to increase monetization as interactivity and purchase influence is at a greater level which can demand higher ad dollars. When the viewer hovers over the product, additional information will appear to the viewer where they can either click, read, save for later or make a purchase of the product.

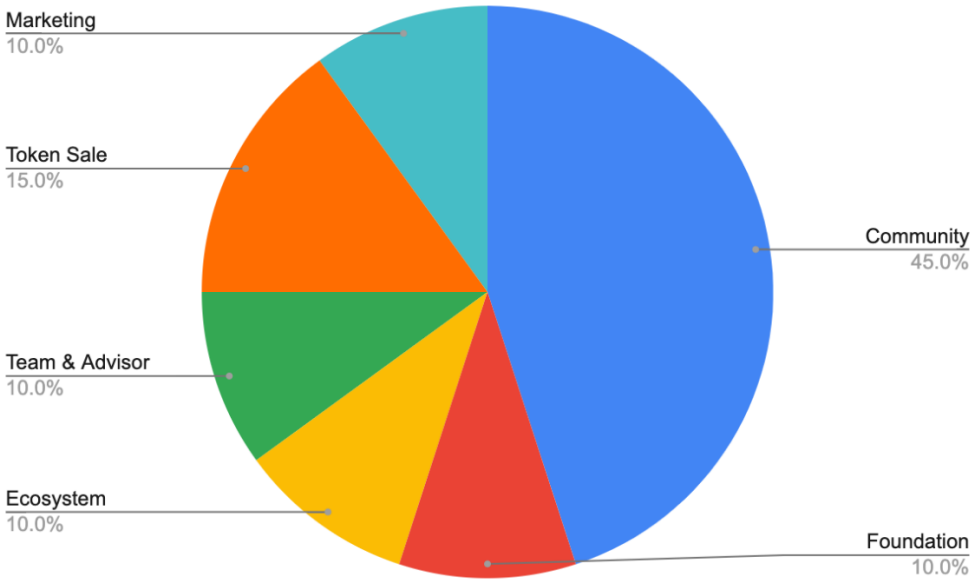
Picture on left shows interactive hotspot added on top left of the player. Picture on right shows info card and ad information after interacting with hotspot.

4. Token Model and Distribution

4.1 Token Issuance

The AWO is the native token of the CRWORK platform and developed using the Ethereum ERC20 token standard. The total supply of AWO is 10 billion, and there will be no additional issuance of AWO in the future.

The majority of AWO will be provided to the community as incentives to platform participants and act as fuel for platform growth. Upon launch, users will all be able to offer their computing resources for AI processing or human expertise to tagging, verification, transcription and translation. Gradual unlocking of AWO in the other categories will be used for the Research & Development, Licensing, Operations, Marketing, Legal and other associated aspects of the business.



Allocation	Percentage	Details
Community	45%	Used for platform activity incentive; The incentive ratio for the different activities will be different and depending on the voting of the Governance; Release schedule will be determined after full product launch
Foundation	10%	1-year lock-up since listing, then unlock 10% every month
Ecosystem (External Collaborators)	10%	1-year lock-up since listing, then unlock 10% every month
Team & Advisor	10%	1-year lock-up since listing, then unlock 10% every month
Private Token Sale	15%	Unlock 15% of the token on the listing day, then unlock 3% every month
Marketing	10%	Used for global marketing and airdrop; unlock based on needs

AWO shall not and cannot be considered as shares or securities in any jurisdiction as they do not give any rights to dividends, interests, profits or to participate in the general meeting of the company. It will not be listed on any regulated stock exchange. The offering of AWO on any trading platform is done in order to allow the use of AWO on the platform and are not for speculative purposes. The offering of AWO on any trading platform does not change the legal nature of the AWO, which remain as a simple means for the use of the platform and not security.

4.2 Tokenomy

AWO serves three main purposes: utility, staking, and governance.

Utility

For the platform to succeed and grow, the vibrant community and interactions/transactions on the platform is key. We foresee increased demand for AWO as participants and transaction volume increases. As an utility token, AWO serves the following main functions:

- As a micro-accounting tool and payment solution
- A medium of exchange within the platform
- As a rewards and incentive token for platform contributors

There are many possible downstream business or utility use cases of AWO

Actors	Examples of AWO Use Cases
End Users End users watching video	● Earn AWO by participating in the ***Human Expert network*** or ***AI node network*** to provide verification or editorial services. ● Reward with AWO by the publishers or Advertisers for viewing or interacting with Ads ● Earn more AWO by opting-in to provide more user data ● Donate or gift AWO to support their favorite Content Producers or Publishers ● Use AWO to exchange for other digital goods or services such as top up airtime offered by the local partnership.
Content Producer Media companies, independent studios, Youtubers	● Use AWO to pay for CRWORK services to enable better content discovery and placement by advertisers. ● Use AWO to pay CRWORK to generate the ContentGraph and CRWORK Advertising exchange DApp to command higher Ad rate. ● Use AWO to crowdfund to produce better quality video content or allow users to guide/sponsor the content like a Patreon page. ● Advertisers could commission Content Producers via our Advertising Exchange to create sponsored content and paid using AWO or fiat. Content Producers will be incentivized to be paid in AWO by earning bonus in AWO. ● AWO can be used by long tail Content Producers as an incentive for Publishers to distribute their content.
Publishers Online media companies, mobile operators or video apps	● Use AWO to pay Content Marketplace DApp to discover and access relevant content. ● Use AWO to pay for digital goods, services offered by the Publishers or vouchers for physical goods. ● Use AWO as an incentive for popular short tail Content Producers to grant Publishers the distribution rights. ● AWO can be used as an incentive for users to opt in or share more information.
Advertisers Brands, Agencies, SMEs & government	● Use AWO to pay for access to the CRWORK Advertising exchange to search and buy placement on appropriate content. ● Use AWO to pay for access to the CRWORK Marketplace to search discover appropriate Content Producers to create sponsored content.

The key advantage is we have a very global network of partners that have very localized influence, for instance the publishers could be local media companies or mobile operators with existing relationships to local merchants. This would help create more value-added services that could be offered in exchange for our AWO.

Staking

Staking is an important part of the healthy growth of the platform as it incentivizes AWO holders to behave in honest ways. Good actors are rewarded by this mechanism whilst bad actors will lose their stake in the network.

1. All participants must put down a small deposit (Staking) in AWO to gain the right to participate. New participants can automatically designate their registration rewards as the deposit for further participation.

2. Validator or AI/HE nodes must put down a deposit in AWO to have the chance to be selected.

3. Staking is required to vote and act as the governance of the CRWORK platform.

Depending on the staking amount, duration and history, the participants will be divided into different levels. For validators and nodes, higher levels will have priority access to higher paid jobs as they are more incentivized to provide higher quality services. For service purchasers or marketers, higher level will have access to higher quality end-users or nodes at similar payment rate.

Governance

After the initial stabilization period, the governance of the CRWORK platform will be fully transferred to the AWO holders. The community will vote on the key issues within the platform, such as incentives, processes, and act as judges for fraudulent activities. The community will also decide on the direction of the CRWORK platform if significant changes of the business model are necessary in the future.

6. Conclusion

Video is everywhere on the internet and plays an increasingly important role in monetization. Yet video search and discovery are especially difficult due to several factors: (a) video is opaque and subject to indexing biases, (b) video is usually not indexed scene-by-scene, (c) brand safe placement requires categorical conventions, and (d) most video content is not internationalized.

These problems are all related to the quality of metadata - the information that describes and defines a piece of content, including its title, description and tags, but also myriad other data such as closed captions and schema markups. Yet, aside from an understanding that metadata supplied by users is often incomplete and unreliable, the value of investing in metadata is not fully appreciated by those outside the industry.

Even with the best intentions, there is a lack of agreement on standard terms for categorization. Inaccurate and inconsistent metadata results in content that is hard to find, search for and/or discover, no matter how well-produced the content is. On the other hand, accurate tags and metadata information are crucial to the distribution and placement of videos in their proper context, and aid in search and discovery of content.

The challenge for CRWORK is to decentralize operation of the AI and freelancer community on top up of a consensus protocol, so that all sorts of DApps - both free or commercial - can reap the benefits of an Open Video Search Engine with much better metadata and our trademarked content safety index - ContentGraph .

The blockchain implementation will achieve this with three components:

Smart contracts between the network operator, content publishers, advertisers, distributors and service providers (i.e. hosting provider or freelancer), which will maximize utilization by enabling dispatch of jobs to the most productive service providers and grant incentives to promote better quality.

A mechanism for service providers to transact and be compensated using flexible pricing, while providing predictable rewards for the network operator.

An immutable record of the metadata and annotations for each classified item, which can be accessed by item code and which includes a ContentGraph.

CRWORK will open this blockchain platform for use by third-parties, including content distributors, publishers and AD exchanges. This will help CRWORK achieves broad adoption and network effect s benefiting all participants. The CRWORK Open Video Search Engine represents the first decentralize d, open and unbiased video search engine which, unlike YouTube, is created, curated and maintained by t he community.

Disclaimer

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This White Paper does not constitute an investment, legal, tax, regulatory, financial, accounting or other advice, and this White Paper is not intended to provide the sole basis for any evaluation of a transaction on acquiring of the AWO. Prior to acquiring the AWO, a prospective purchaser should consult with his/her own legal, investment, tax, accounting and other advisors to determine the potential benefits, burdens and other consequences of such transaction.

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The AWO is not a digital currency, security, commodity or any other kind of financial instrument and has not been registered under the Securities Act of 1933, the securities laws of any state of the United States of America or the securities laws of any other country, including the securities laws of any jurisdiction in which a potential token holder is a resident.

The AWO is not being offered or distributed to, as well as cannot be resold or otherwise alienated by their holders to, citizens of, natural and legal persons, having their habitual residence, location or their seat of incorporation in the country or territory where transactions relating to digital tokens are prohibited or in any manner or restricted by applicable laws or regulations. If such restricted person or party were to purchase the AWO, then such restricted person or party has done so on an unlawful, unauthorized and fraudulent basis and in this regard, shall bear adverse civil and or criminal consequences.

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