A Usage History Information Generation and Inquiry Method for Theme, Background and Signal Music Based on Hyperledger Fabric

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Received 27 April 2021; Accepted 06 January 2022;
Publication 05 July 2022

Abstract

Theme, background and signal music is the music inserted into broadcasting contents of a broadcaster, and is recognized as a created content like normal music. Since there are lyricists and composers who have the rights of music, the copyright fee is distributed. However, there often occur problems with inaccurate monitoring results for theme, background and signal music usage due to the omission of usage details and non-transparent settlement method. In this paper, we propose a method of generating music usage monitoring information based on a blockchain, on which the usage information of music source is recorded by the usage monitoring tool based on the feature-based filtering technology of monitoring organizations. The framework proposed in this paper includes a blockchain network structure, a series of transaction procedures in which the theme, background and signal music usage history is stored and the recorded data format in the blockchain ledger. In the proposed framework, accurate music usage details can be created, details are stored in

Journal of Mobile Multimedia, Vol. 18_6, 1811–1828.
doi: 10.13052/jmm1550-4646.18615

blocks without changes or omissions, and eventually transparent settlement and distribution are possible by processing smart contract, instead of previous non-transparent settlement practice.

Keywords: Hyperledger fabric, broadcasting music, [theme, background, and signal music], usage history, transaction.

1 Introduction

Currently, interest in the music industry is increasing in themes, backgrounds, and signal (hereinafter, TBS) music. TBS music is the music inserted into broadcasting contents such as dramas, entertainment, current affairs, news, etc. of a broadcaster, and is a term used by music trust management organizations [1]. TBS music has rights holders such as lyricists and composers who have the right to music as creators, like ordinary music, and all rights holders must receive fair shares as much as the music is used [2]. However, unlike ordinary music, transparent settlement and distribution of TBS music is currently impossible due to the absence of an accurate monitoring and distribution system for music use [3]. Currently for ordinary music, there are multiple systems that can generate statistical data in trust organizations and music streaming service [4] as much as users use in real time, such as, but TBS music does not have such a system that can accurately generate usage statistics. In addition, settlement and distribution are being performed even without a system based on accurate verification. Music rights holders exercise their rights alone and they usually entrust their music rights to a trust management organization because it is expensive and time-consuming. Consequently, the trust management organization exercises the right of music instead rights holders [5]. Therefore, for the transparent settlement and distribution of TBS music, a usage history aggregation system that satisfies all TBS music users (mainly broadcasters), trust management organizations, and music rights holders is needed.

In this paper, we propose a method of generating and searching TBS music usage history information based on Hyperledger Fabric [6, 7] that generates music usage history information through an accurate monitoring tool. To this end, we propose a blockchain network structure, and a series of procedures in which a monitoring organization generates information by monitoring TBS music usage history, and stores TBS music usage history in a transaction on a blockchain ledger. We also propose a procedure for storing data and the data format to be prepared for each step. According to the

proposed procedure and data format, the data written in the ledger is disclosed in the blockchain, and the stored data is secured based on integrity.

The structure of this paper is as follows. As a related research in Section 2, we describe Hyperledger Fabric, which is frequently used as a blockchain framework, and music usage monitoring technology and rights management information for music. In Section 3, we propose a TBS music usage monitoring system and a monitoring information generation method using Hyperledger Fabric. Section 4 verifies the attack on block generation to validate the information generation method in this paper, and the conclusion is given in Section 5.

2 Related Research

2.1 Hyperledger Fabric

Hyperledger Fabric takes the form of a permissioned private blockchain. Unlike the public blockchain where anyone can participate freely, Hyperledger Fabric allows only users authorized by the authentication management system to participate in the blockchain network as shown in Figure 1.

Accordingly, all nodes participating in the blockchain network are authorized nodes and can be viewed as trusted nodes, so there is no need for complex consensus algorithms to verify malicious nodes. You simply need to verify the authorized user, authority, and transaction configuration to access

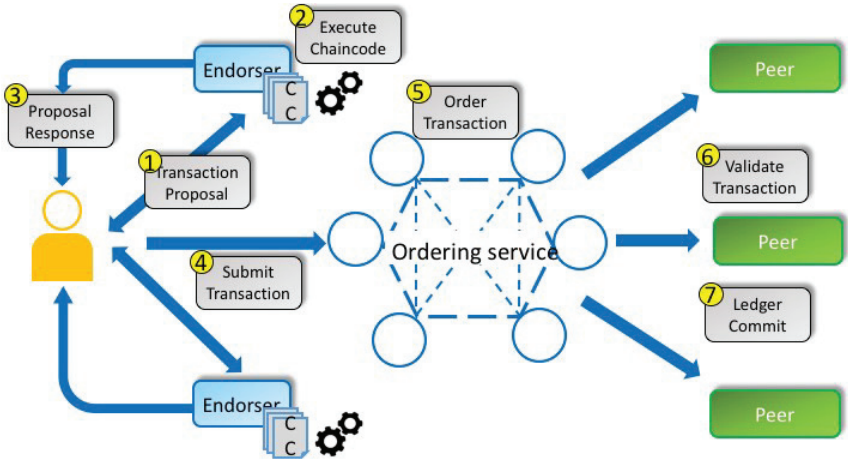

Figure 1 Hyperledger fabric overview.

the ledger, and you can select and use a consensus algorithm as needed. In Hyperledger Fabric, all nodes can share the same ledger to all nodes, and it is possible to create and share separate ledgers only to nodes that they want to share for each business. It is designed to be easy for companies to use by providing a channel to create a separate ledger suitable for the purpose within the network [8].

2.2 Current Music Monitoring Technology

The copyright holder and the neighboring copyright holder have the right to claim compensation for the use of music used in broadcasting, such as TV, Radio, and CableTV, and a systematic monitoring system is required for accurate rights processing. The existing TBS music monitoring system is a system in which a person or software recognizes it in real time or after recording that is used in broadcasting contents, and creates a usage history by matching the recognized music with an integrated DB storing music information [4]. Recently, music used in broadcasting is recognized using a content-based and feature-based recognition technology. It shows the procedure for extracting the DNA of the sound source from the program transmitted from the broadcast and performing a search for it. When a broadcast is transmitted from a broadcaster, the broadcast recording system records a broadcast program for each channel and detects a non-music section in the recorded broadcast program. After excluding the region in which the non-musical section is detected, DNA is extracted for the music region, and the DNA is matched to search for what kind of music it is. After that, it consists of the process of detecting the music section, as shown in Figure 2.

2.3 Rights Management Information

Rights management information is defined in Article 2, No. 29 of the Copyright Act of Korea, as "the information for identifying works, the information for identifying copyrights or other rights holders protected under this Act, the information on methods and conditions for using works, the numbers or symbols indicating those information, the information attached to the original or copies of works, etc. protected by copyright or rights protected by this Act, or things accompanied by the performance or public transmission." Rights management information(RMI) for music expresses frequent rights fluctuations, difficulties in tracking rights, and complex licensing methods, and is finally used as standard information for distributing copyright fees for use of works to rights holders [9].

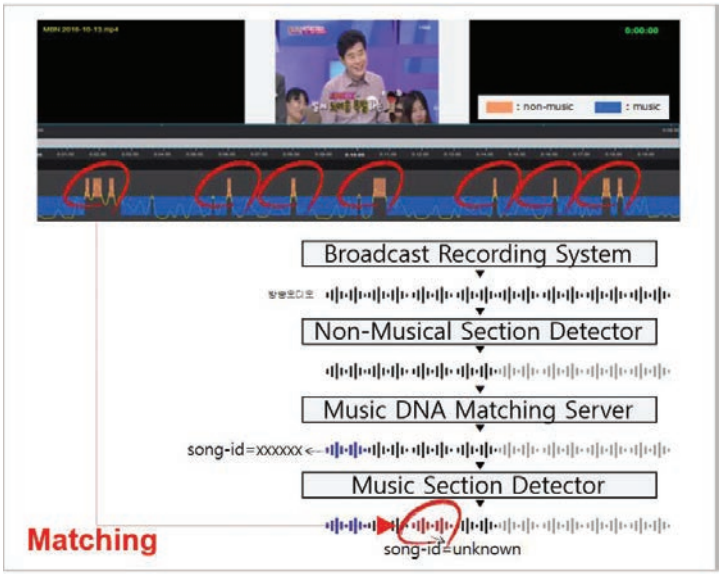

Figure 2 TBS music recognition method based on fingerprint.

Table 1 TBS music usage information data format

Item	Explanation
Company Code	Company Identifier Code
Company	Company Name
Content	Company's Content
Content Id	Music ID
Title	Music Title
Using Time	Time the Music was Used
Using Section	Section used in the content

3 Hyperledger Fabric-based TBS Music Usage History Monitoring System

3.1 Network Structure of Hyperledger Fabric TBS Music Usage History Monitoring System

The proposed TBS music usage monitoring information generation method is based on a network using Hyperledger Fabric. To create TBS music usage monitoring information, the network structure configured on Hyperledger Fabric consists of music users, monitoring companies to provide accurate copyright information on TBS music usage using the correct RMI and

Table 2 TBS music RMI data format elements

Category	Element	Subelement	Explanation
Music Info	Identifier	UCI Code	TBS music unique identifier provided by the Korea Copyright Commission
		ISRC	International standard record identifier
	Music Title	Title	Title representing TBS music
		Subtitle	TBS music subtitle
	Album	Album Code	Unique identifier to identify the album
		Album Title	Title representing the album
		Album Subtitle	Subtitle of the album
Rights Info	Copyright Holder	Copyright Holder Code	Unique identifier of the copyright holder/organization of TBS music
		Copyright Holder Name	People/organizations that own the copyright of TBS music
		Copyright Holder Role	Role that owns the copyright of TBS music
		Ownership Info	Share of TBS Music
	Contract Contents	License Range	In the case of a music license agreement, the scope of license in the agreement
		Rights Type	Classification of rights to works prescribed by law
Management Info	Biz Man	Biz Man Code	Unique identifier code for each music service provider
		Biz Man Name	Music service company name
	Settlement Code		Settlement code according to service type of music service company
	Music Code		Music service company's music management code
Usage Info	Biz Man	Biz Man Code	Music user identification code
		Biz Man Name	Name of the music operator
	Service	Content Name	Content name in which music is used
		Media Classification	Service media used by music users
	Music usage Info	UCI	TBS music unique identifier provided by the Korea Copyright Commission
		Title	Title representing TBS music
		Use Time	Time the music was used during main delivery in the content
		Usage Section	The section in which music is used in the entire length of the content

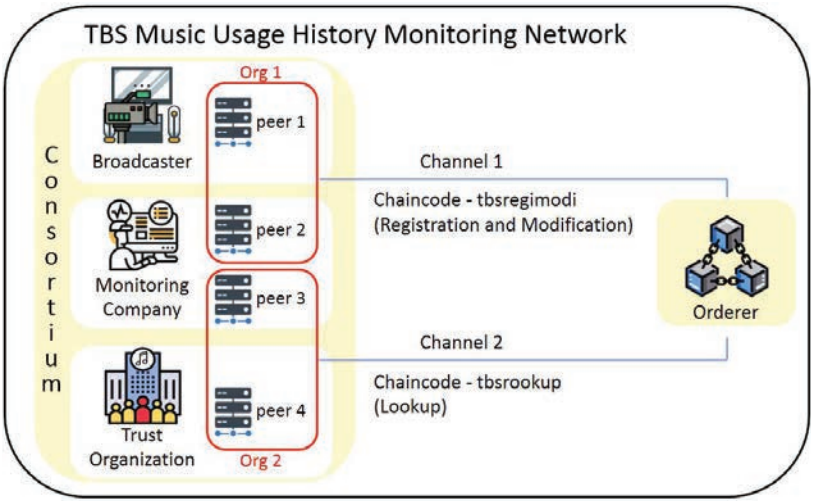

Figure 3 TBS music usage history monitoring network.

the trust management organizations. Hyperledger Fabric is the most appropriate blockchain framework for constructing a business network between these stakeholders, and the network structure proposed in this paper is shown in Figure 3.

It is classified into three Users Groups that use TBS music, that is, broadcasters and Trust Management Organization (T.O) Group, which provides TBS music, Monitoring Organization (M.O) Group, which monitors the use of sound sources during main delivery, and Orderer. The Orderer exercises the approval process for the consortium participating in the network, and manages all the operations of the network and the consortium participating in the network. It creates Channel 1 to transport the TBS music usage history between a broadcasting company using TBS music and a monitoring company, allowing peer communication between them. In addition, Channel 2 is created so that the trust management organization that has the right of TBS music can check the usage history of TBS music so that it can communicate with the monitoring company peer and the trust management organization peer.

3.2 Channel 1 Operation and Block Creation Process

Channel 1 is a communication process for communicating TBS music usage details between a broadcasting company to use TBS music and a monitoring

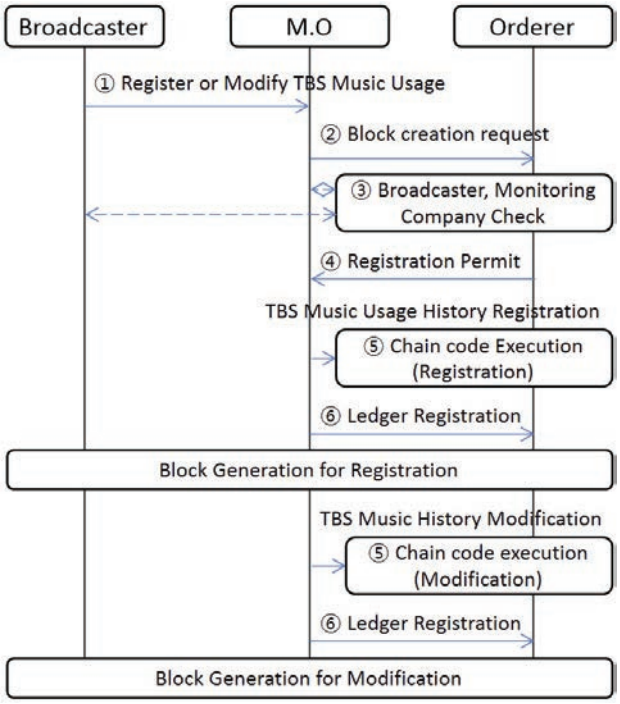

Figure 4 Channel 1 process.

company. It operates as a chain code registered when a broadcaster uses TBS music and a chain code when modifying TBS music usage details, as shown in Figure 4.

The monitoring company confirms the broadcaster's registration and modification of TBS music use. The monitoring company requests the Orderer to create a block based on the contents of registration and modification of TBS music use. The Orderer first checks the connection information of the broadcasting company and the monitoring company based on the information in Table 3. After confirmation, the Orderer permits registration, and allows TBS music usage history information to be registered on the ledger through chaincode (registration). Likewise, information on the chain code (modification) can be registered.

A block is created by recording the transaction of usage history to be written in the ledger for the TBS music usage history information in the monitoring company. The transactions written in the ledger are shown in Table 4.

Table 3 Broadcaster and M.O connection information

Item	Explanation
Company Code	Company Identifier Code
Company	Company Name
M.O Code	Monitoring Organization Code
M.O	Monitoring Organization Name

Table 4 TBS music usage information data format

Item	Explanation
Date	The date the content was played
Channel Code	Broadcaster channel code
Start Time(Pro)	Program start time
End Time(Pro)	Program end time
Program Title	Program title
Start Time(Music)	Music start time
End Time(Music)	Music end time
UCI	UCI code

Its main contents consist of program date, channel code on which the program is broadcast, program start time, end time, program name, start time(music), end time(music), and UCI (Universal Content Identifier) information with sound source information. In addition, information on the used sound source is required, and the necessary information for this is shown in Table 4 below. Here, UCI is the only and permanent Korean national standard identification system that is given to contents as identifiers currently provided by the Korean Copyright Commission. By assigning UCI to sound source contents, data information and distribution channels can be identified effectively.

3.3 Channel 2 Operation and Block Creation Process

Channel 2 is a communication process for verification of usage history between a trust management organization that has the right of TBS music and a monitoring company that provides TBS music usage history. It operates as a chain code when the trust management organization inquires about music usage, as shown in Figure 5.

The trust management organization requests the monitoring company to check the TBS music usage history that it has the right to use. At this time, the TBS music is one that is specifically designated or the trust management organization has the right to. The monitoring company makes a request to

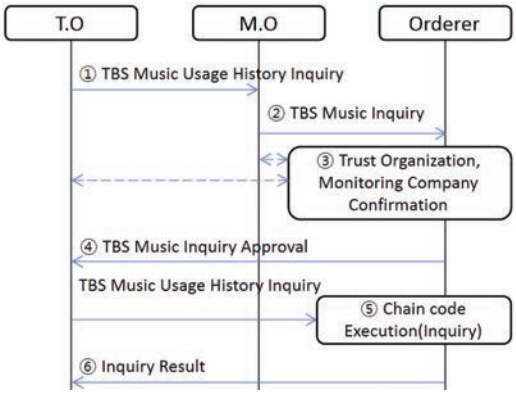

Figure 5 Channel 2 process.

the Orderer for the requested TBS music inquiry. The Orderer checks and approves the identities of trust management organization and the monitoring company before sending the requested TBS music usage inquiry results. Trust management organizations can search TBS music through chaincode. The information that can be checked is Tables 2 and 4. When inquiring TBS music, the monitoring company can secure reliability by simultaneously providing the contents recorded in the newsletter itself and the contents recorded in the network ledger.

4 Experimental Results

For the experiment on the method of generating and retrieving TBS music usage history information based on Hyperledger Fabric proposed in this paper, each channel was created to confirm that the transaction was recorded in the actual ledger, and the block was created and can be viewed. The environment for this experiment is shown in Table 5.

For the two Orgs composing each channel, two peer servers were configured. In each Org, TBS music can be registered, modified, and inquired through the chaincode, and each chaincode is named TBS Music Registration and Modification: ‘tbsregimodi’ and TBS Music Lookup: ‘tbslookup’ and the version of each chaincode is v1. Since Hyperledger Fabric communicates between servers through channels, each Org creates ‘tbschannel1’ and ‘tbschannel2’ to enable communication. ‘tbsschannel1’ is configured to have one peer server in the broadcaster and one peer server in the monitoring session so that TBS music usage details can be registered and modified.

Table 5 PC and platform specification

Category	Explanation
CPU	AMD RYZEN 5 5600X 4.0Ghz
RAM	32GB
SSD	250GB
OS	Ubuntu 18.04 LTS
Language	GO (1.10.4)
	Python (2.7.18)
	Node.js (8.17)
Platform	Hyperledger Fabric (1.4)
	Docker (18.09.05)
	Fabric SDK (1.4)

```
Channels:
    tbschannel1:
        orderers:
            -   orderer.tbsmusic.com

        peers:
            peer1.org1.tbsmusic.com
                endors ingPeer: true
                chaincodeQuery: true

            peer2.org1.tbsmusic.com
                endors ingPeer: false
                chaincodeQuery: true

            peer1.org1.tbsmusic.com
                endors ingPeer: true
                chaincodeQuery: false

            peer2.org1.tbsmusic.com
                endors ingPeer: false
                chaincodeQuery: true

            chaincode:
                - tbsregister: v1
                - tbsmodify : v1
```

```
Channels:
    tbschannel2:
        orderers:
            -   orderer.tbsmusic.com

        peers:
            peer3.org2.tbsmusic.com
                endors ingPeer: true
                chaincodeQuery: true

            peer4.org2.tbsmusic.com
                endors ingPeer: false
                chaincodeQuery: true

            peer3.org2.tbsmusic.com
                endors ingPeer: true
                chaincodeQuery: false

            peer4.org2.tbsmusic.com
                endors ingPeer: false
                chaincodeQuery: true

            chaincode:
                - tbslookup: v1
```

Figure 6 Server setting for each channel.

In addition, 'tbschannel2' has one peer server for the monitoring company and one peer server for the trust management organization so that the trust management organization can view TBS music. There are two experiments, the first is the chaincode operation process for registration and modification in the communication process for Channel1, and the second, the chaincode operation process for querying usage details in the communication process for Channel2. Among the settings for organizing each channel, the main parts are shown in Figure 6.

```
Func (t *Chaincode) tbsregimodi(args []string) {
    // Resigter
    if (tbsregimodi == true) {
        tbsData := monitering.getTbsdata(tbsregimodi)
        blockchain.Resigter(tbsData)
    } else {
        fmt.Println("An unusual approach")
    }
}
```

Figure 7 'tbsregimodi' chaincode.

Table 6 Generated music usage information data by TBS music monitoring system

Date	C.C	S.T(P)	E.T(P)	Pro	S.T(M)	E.T(M)	UCI
				Register			
2020-01-02	RC002	08:05:00	08:55:00	A	08:09:30	08:10:21	I500-1000006882805.100053732528-1
2020-01-02	RC002	09:00:00	09:55:00	B	09:12:20	09:14:01	I500-1000006882805.100053732528-1
2020-01-02	RC002	10:00:00	10:55:00	C	10:04:31	10:05:12	I500-1000006882805.100053732528-1
				Modifiy			
2020-01-02	RC003	08:05:00	08:55:00	A	08:10:12	08:11:13	I500-1000006882805.100053732528-1
2020-01-02	RC003	09:00:00	09:55:00	B	09:13:21	09:14:11	I500-1000006882805.100053732528-1
2020-01-02	RC003	10:00:00	10:55:00	C	10:14:31	10:15:12	I500-1000006882805.100053732528-1

※ C.C: Category Code, S.T: Start Time, E.T: End Time.

```
{ { Key: 'A001',
  Record:
  { authenticityresult: -'
  musichash: 'eIDjdgie39shnDJF9d8fhyDE93jg33DdfDQ3s=',
  musicid : 'A001',
  date: 2020-01-02,
  channelcode: 'RC002',
  starttimepro: '08:05:00',
  endtimepro: '08:55:00',
  programtitle: 'A',
  starttimemusic: '08:09:30,
  endtimemusic: '08:10:21',
  uci: I500-100006882805.1000053732528-1' } },
```

(A)

```
{ { Key: 'A002',
  Record:
  { authenticityresult: -'
  musichash: '3dfEGdfe456cCVe4tD34DB0deg2nkR67hVhj=',
  musicid : 'A002',
  date: 2020-01-02,
  channelcode: 'RC002',
  starttimepro: '08:05:00',
  endtimepro: '08:55:00',
  programtitle: 'A',
  starttimemusic: '08:10:12,
  endtimemusic: '08:11:13',
  uci: I500-100006882805.1000053732528-1' } },
```

(B)

Figure 8 Transaction of TBS music usage information (a) registration (b) modification.

First, the chain code for registering and modifying the TBS music usage history in Channel1 is shown in Figure 7.

As for the data generated by the monitoring system according to such a chaincode, when the information in Table 6 is entered according to the metadata items in Table 4, transaction information as shown in Figure 8 is entered into the ledger.

In such a transaction registered or modified in the ledger, the hash value of the data is included to ensure the integrity of the monitoring contents of music usage when creating blocks. If the transaction is successfully included in the block, the integrity of the data can be verified by comparing the record received by the user with the hash value included in the block when the

```
Func (t *chaincode) tbslookup(args []string) {
    //tbslookup
    if (tbslookup == true) {
        tbsdata := trust.getTbsdata(tbslookup)
        blockchain.lookup(tbsdata)
    } else {
        fmt.Println("An unusual approach")
    }
}
```

Figure 9 'tbslookup' chaincode.

```
uci: 'I500-100006882805.1000053732528-1'
ISRC:
musicTitle: 'ABC'
musicSubtitle:
albumCode: '123abc'
albumTitle: 'ABCA'
albumSubtitle:
copyrightHoldercode: '123abc'
copyrightHoldername: 'Trust A'
copyrightHolderrole: 'no1'
ownershipInfo: 'share'
licenseRange: 'License1'
rightsType:
bizmanCode: '1234abc
bizmanName: 'B Company'
settlementCode: 'abcd1234'
musicCode: 'B-ABC'
usagebizmanCode: 'CBA321'
usagebizmanName: 'C Brodcaster'
usageContnetname: 'A'
usageMedia: 'news'
usageUci: 'I500-100006882805.1000053732528-1'
usageTitel: 'ABC'
usageTime: '49'
usageSection: '08:09:30-08:10:21'
```

Figure 10 TBS music rights management information.

trust management organization or requester receives a record of music usage. Hyperledger Fabric basically uses SHA256 to generate a hash value.

Secondly, the chain code for inquiring TBS music usage history in Channel2 is shown in Figure 9.

When the trust management organization requests the monitoring company to view the TBS music usage history, you can search the transaction contents written in the ledger as shown in Figure 7, and you can check the rights management information of the TBS sound source linked by the UCI code. Based on the contents, the rights management information linked to UCI recorded in the musicid 'A001' in Figure 8(A) is shown in Figure 10.

Music information, RMI, and information on the rights holder can be checked, and it can be used as raw data for transparent settlement and distribution of copyright fees. Therefore, when pretending to perform an attack on the record of the blockchain for the verification of the integrity of the experiment, the competition between the chain of honest nodes and the chain of the attacker can be specified as a Binomial Random Walk.

If an honest chain successfully creates one block, it is assumed to be $+1$, and if the attacker's chain fails to create a block, it is assumed to be -1. The probability of success of such an attack is similar to the Gambler's Ruin problem [11]. Suppose a gambler with unlimited credit starts in a deficit, tries almost unlimited games and reaches break-even point. The probability that he will reach the break-even point, that is, the probability that the attacker can catch up with the honest chain can be calculated as in (1) [12].

$$q_z = \begin{cases} 1 & \text{if } p \leq q \\ (q/p)^z & \text{if } p > q \end{cases} \tag{1}$$

where

$p =$ Probability of an honest node finding the next block
$q =$ The probability that the attacker's node finds the next block
$q_z =$ probability of finding z next blocks quickly

Given the assumption that p $>$ q, the probability that the attacker can catch up with the block increase decreases exponentially with the number of blocks and can be calculated as in (2). If the attacker rushes first and luckily does not succeed, then the odds get thinner as he goes back.

$$f(z) = (q/p)^z \tag{2}$$

The graph for this is shown in Figure 11.

In addition, when using the RMI of TBS music linked by the UCI code, the block size can be reduced. For example, if the size of music information is usually 4K and the block size using UCI is 1K, the amount of 3K reduction can be achieved. The sum of the sizes of each block according to the block size is shown in (3), and the result is shown in Figure 11.

$$f(x) = \sum_{\mathrm{i}=0}^{\mathrm{n}} Mx_i \tag{3}$$

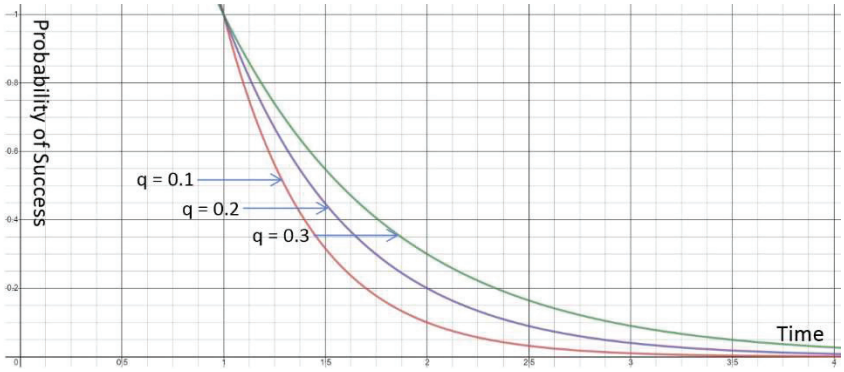

Figure 11 Change in probability of success according to 'q' value.

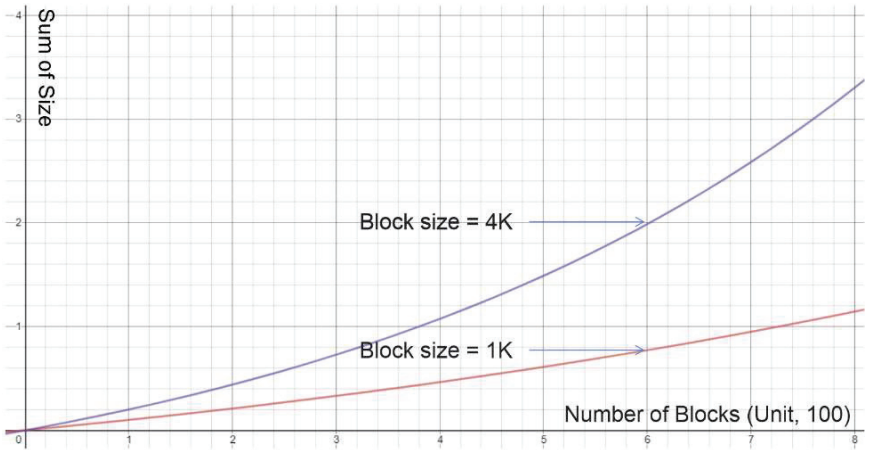

Figure 12 Sum of block sizes according to block size.

5 Conclusion

In order to solve the problem of inaccurate monitoring results for TBS music usage, omission of usage history and non-transparent settlement method, this paper proposes TBS music usage history generation method based on Hyperledger Fabric. Data formats and procedures have also been proposed so that TBS music monitoring information recorded in the ledger can be registered, modified, and inquired for each channel. By using the usage history information generation method proposed in this paper, it is possible to generate information on accurate TBS music usage history, and the history stored in the ledger can be saved without any changes or omissions, and raw data

can be generated for transparent settlement and distribution. Through the proposed method in the future, It is expected that the proposed method in this paper can be used in the transparent settlement and distribution for TBS music as well as in the monitoring field of other genres, but the transaction number assignment condition for block creation time and the data search performance for TBS music usage history inquiry may need improvement.

Acknowledgement

This research project supported by Ministry of Culture, Sport and Tourism (MCST) and Korea Copyright Commission in 2021 (2020-MC-9400).

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Biographies

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