An Event-Based Platform-Independent Verification Method for OTT Content Usage History

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Abstract

In OTT (Over-The-Top) service environments, reliable recording and verification of content usage history are becoming increasingly important for copyright protection, royalty settlement, and dispute resolution. However, conventional platform-specific log management methods have limitations in interoperability, integrity assurance, and external verifiability. In addition, simple indicators such as the number of views or total playback time are insufficient to accurately reflect actual OTT viewing behavior, which often includes nonlinear interactions such as pause, seek, replay, and early stop.

This paper proposes a platform-independent event-based verification method for OTT content usage history. The proposed method defines usage history metadata consisting of content information, session information, playback event information, and usage result information, and derives valid usage intervals from playback events such as play, pause, seek, replay, and stop. In addition, hash-based verification information and linked recording

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structures are applied to the generated usage history to enhance integrity and traceability.

To examine the applicability of the proposed method, processing latency in the usage history aggregation stage was measured according to changes in the number of sessions and platforms. The experimental results show that the processing time increased in a stable manner as the session scale increased, indicating that the proposed method can be applied to large-scale OTT usage environments. This study is meaningful in that it presents a platform-independent and verifiable method for organizing OTT content usage history, and it can be further extended through future performance evaluation of blockchain recording and verification processes in diverse service environments.

Keywords: OTT, usage history, copyright protection, event-based verification, platform independence.

1 Introduction

With the rapid expansion of OTT (Over-The-Top) services, the production, distribution, and consumption of digital content have changed significantly, increasing the importance of systematically recording and verifying content usage history [4–6]. In OTT environments, the same content may be consumed across multiple platforms, devices, and user accounts, and such usage history can serve not only as an operational log but also as critical evidence for copyright protection, royalty settlement, contract compliance, and dispute resolution [3, 14–20]. In particular, in environments involving multiple stakeholders such as rights holders, platform operators, and content distributors, a reliable method is required to verify when, how, and to what extent content has been consumed.

However, existing OTT usage history management methods largely depend on platform-specific log structures and service-specific operational policies, resulting in limited interoperability and difficulty in independent verification by external organizations or third parties. Because platforms differ in logged fields, event definitions, timestamp handling, and usage calculation criteria, even the same content consumption behavior may be recorded and interpreted differently across services. These issues are closely related to the broader challenges of audience measurement in streaming and OTT environments, where traditional measurement methods are increasingly insufficient for accurately capturing fragmented and multi-platform viewing behavior [7, 8]. In addition, the diversification of subscription-based OTT models and competition among audiovisual media services further increase the complexity of measuring and comparing usage across platforms [9, 10]. Logs originally designed for service operation and internal analytics often do not sufficiently guarantee the integrity, traceability, and verifiability required for copyright protection and settlement purposes. These limitations reduce the reliability of usage history in multi-platform OTT distribution environments.

Moreover, simple summary indicators such as the number of views, play counts, or cumulative playback time are insufficient to accurately represent actual content consumption behavior. In OTT services, users often perform nonlinear playback actions such as pause, seek, replay, and early stop, rather than consuming content in a strictly continuous manner. For example, a user may repeatedly watch only a specific segment, skip part of the content, or stop playback after a short viewing period. Such behaviors cannot be fully explained by simple cumulative time or play-count metrics alone. Prior studies on multimedia quality monitoring and online video Quality of Experience also indicate that video consumption should be interpreted through more detailed playback-related events and user experience factors rather than relying only on aggregate indicators [12, 13]. In addition, recent studies on automatic content recognition in smart TVs show that content consumption can be tracked across device-level environments, further highlighting the need for transparent and verifiable usage records [11]. Therefore, a more precise interpretation of content usage requires analysis that reflects the sequence and relationship of individual playback events.

From this perspective, OTT content usage history should be defined in a way that is not dependent on the internal log format of a specific platform while still being capable of representing actual playback behavior. This requires a common metadata structure encompassing content information, user and session information, playback event information, and usage result information, along with a method for deriving actual usage intervals from playback event sequences such as play, pause, seek, replay, and stop. Rights expression models such as ODRL provide a useful basis for representing rights, permissions, prohibitions, and obligations in a structured form, which can be connected to usage history for copyright protection and contract compliance purposes [3]. By jointly considering the order of events and changes in playback position, it becomes possible to reconstruct meaningful usage flows rather than merely listing raw events. Such an approach is useful for interpreting OTT usage history more accurately and for structuring it in a form that can support settlement and dispute resolution.

Meanwhile, for usage history to be utilized as evidence for copyright protection and post hoc verification, it must support not only data collection and storage but also verification of record integrity and traceability after generation. To this end, hash-based verification information and linked recording structures can be applied to generated usage records so that the relationships among records are preserved and tampering can be detected. The concept of hash-linked records was popularized through Bitcoin [1], and permissioned blockchain technologies such as Hyperledger Fabric have been widely discussed as suitable infrastructure for multi-stakeholder environments requiring controlled participation and verifiable transaction records [2]. Similar approaches have also been applied to digital rights management, code copyright management, video copyright transaction traceability, and digital media copyright confirmation [14–19]. In the OTT domain, studies have examined copyright management using ODRL and Hyperledger Fabric, suggesting the applicability of verifiable rights and usage management to OTT content distribution environments [20]. This approach is meaningful because it extends usage history management beyond internal service administration toward a form that can support external review and subsequent verification.

In this paper, we propose a platform-independent event-based verification method for OTT content usage history. The proposed method defines a common usage history metadata structure applicable across diverse OTT service environments, derives valid usage intervals from playback event sequences, and applies a verifiable recording structure to generated usage records in order to enhance integrity and traceability. To examine the applicability of the proposed method, we analyze the processing latency of the usage history aggregation stage under varying numbers of sessions and platforms.

The remainder of this paper is organized as follows. Section 2 reviews related studies on OTT usage history management, copyright protection, and verifiable recording methods. Section 3 presents the proposed platform-independent event-based verification method for OTT content usage history, including the metadata structure and the procedure for deriving valid usage intervals. Section 4 describes the experimental setup and evaluation results. Finally, Section 5 concludes the paper and discusses future research directions.

2 Related Work

2.1 OTT Content Usage History Management

OTT services provide digital content through diverse platforms and devices, enabling users to consume various types of media such as movies, dramas, and sports in multiple viewing environments [2–7]. In this process, usage history is generated through playback events such as play, pause, seek, replay, and stop, and such records can serve as important information not only for service operation but also for copyright protection, settlement, and dispute resolution [6–8]. OTT content usage history consists of content information, user or session information, playback event information, and derived usage result information, as shown in Figure 1.

In OTT environments, actual usage cannot be sufficiently explained by simple indicators such as play count or total viewing time alone [6–8]. Users may skip specific segments, replay certain parts, or stop playback after watching only a portion of the content [7, 11]. Therefore, event-level records and their interpretation are necessary to more accurately represent actual content usage. However, in practice, such records are usually managed within platform-specific internal systems, which limits interoperability and consistent verification across heterogeneous OTT platforms [6–8].

2.2 Blockchain-Based Copyright Protection and Verification

Blockchain has attracted attention as a distributed ledger technology capable of providing tamper resistance and traceability of recorded data, making it suitable for digital content protection [1, 2, 14–20]. In conventional centralized systems, the generation and management of records are concentrated on a single platform or operator, whereas blockchain-based structures can ensure record integrity through consensus among distributed nodes [1, 2]. The conceptual difference between these two structures is illustrated in Figure 2.

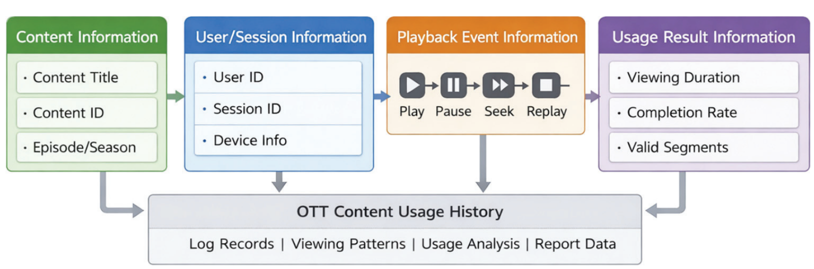

Figure 1 Conceptual structure of OTT content usage history.

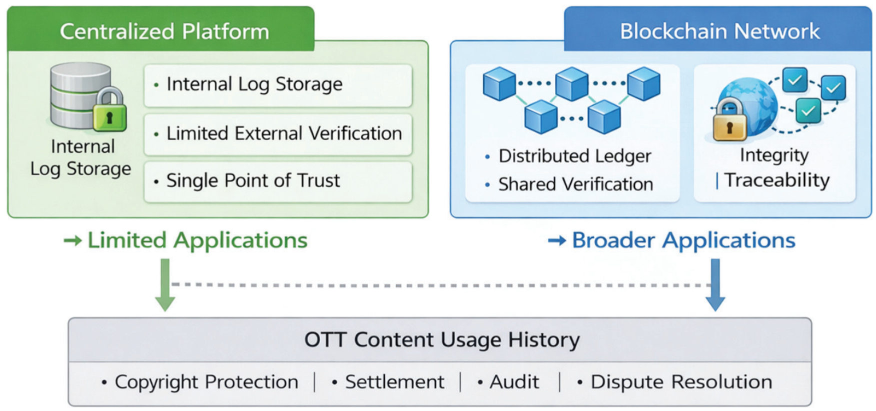

Figure 2 Comparison between centralized logging and blockchain-based verification.

From the perspective of copyright protection, the trustworthiness of records is highly important [15–20]. If content usage records are altered or omitted, the accuracy of royalty settlement may be degraded, and such records may not function as objective evidence in the case of disputes [14–20]. In contrast, blockchain-based record structures make arbitrary modification difficult and preserve relationships among records, thereby improving traceability and verifiability [1, 2, 16–20]. For this reason, blockchain can serve as an effective technical foundation for using OTT content usage history in copyright protection and settlement support.

2.3 Requirements for Verifiable Usage History in OTT Environments

Although OTT platforms generate large volumes of operational logs, copyright-oriented usage history verification requires more than simple log collection [6–8]. Verifiable usage history should represent not only when and which content was accessed, but also how the content was actually consumed [6–8, 11]. For example, even when the total playback time is identical, the meaning of actual usage may differ depending on whether pause, seek, or replay events occurred during playback [7, 11]. The key requirements for usage history verification in OTT environments are shown in Figure 3.

A verifiable OTT usage history should satisfy several requirements [1–3, 15–20]. First, it should ensure integrity so that records remain protected against unauthorized modification [1, 2]. Second, it should provide traceability so that the sequence and context of usage events can be examined

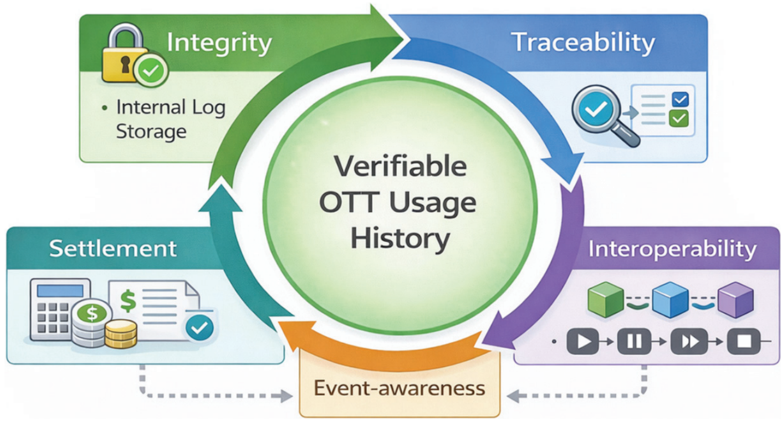

Figure 3 Core requirements for verifiable OTT usage history.

[1, 18, 19]. Third, it should support interoperability to allow heterogeneous records from different OTT platforms to be interpreted under a common framework [2, 3, 20]. Fourth, it should reflect event awareness so that playback semantics can be incorporated into usage interpretation [7, 11]. Finally, it should be practically applicable to copyright-related processes such as royalty settlement and dispute resolution [15–20]. These requirements support the need for a blockchain-based usage history verification method in OTT environments.

3 Blockchain-Based OTT Usage History Verification Method

3.1 Overview

In OTT service environments, content usage occurs across multiple platforms and devices, making it necessary to collect and verify usage records in a consistent manner. In this paper, information generated during content consumption is organized into usage history and then recorded on a blockchain to ensure integrity and traceability. The overall structure is shown in Figure 4.

3.2 OTT Usage History Metadata

To verify OTT content usage in a reliable manner, the generated usage history should be represented in a structured form. In this paper, usage history metadata are defined by combining essential information related to content, user or

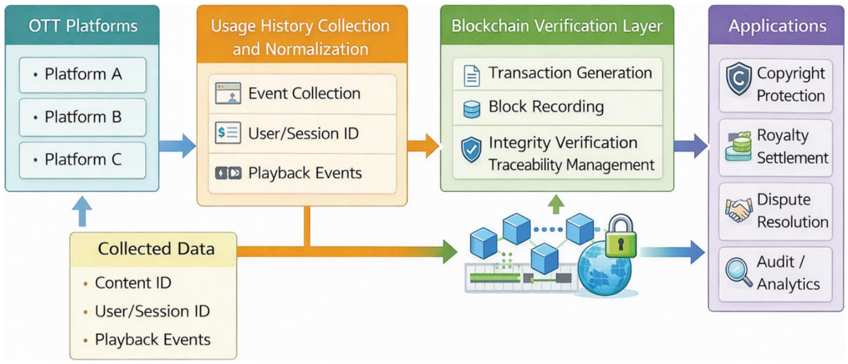

Figure 4 Overall flow of blockchain-based OTT usage history verification.

Table 1 Metadata fields for OTT content usage history

Category	Field	Description
Content Information	Content Title	Title of the content being consumed
	Content ID	Unique identifier for the content
	Episode/Season	Episode or season information
User/Session Information	User ID	Identifier for the user
	Session ID	Identifier for an individual usage session
	Device Info	Information on the device used for content consumption
Playback Event Information	Event Type	Type of playback event, such as play, pause, seek, replay, or stop
	Event Timestamp	Time at which each event occurred
	Playback Position	Playback position at the time of the event
Usage Result Information	Viewing Duration	Effective viewing time reflected in actual usage
	Completion Rate	Viewing completion ratio relative to the full content
	Valid Usage Interval	Valid usage intervals recognized as actual consumption

session, playback events, and derived usage results. The overall composition of the metadata is summarized in Table 1.

The content-related fields identify the digital asset being consumed. These fields include information such as content title, content identifier, and episode or season information, which allow the usage record to be associated with a specific content item. Since the same platform may provide multiple contents and the same content may be consumed in different sessions, explicit content identification is necessary for reliable usage verification.

The user or session-related fields describe the context in which the content is consumed. These fields include user identifier, session identifier, and device-related information. In particular, session-level information is important because actual usage patterns may differ even when the same content is consumed by the same user under different viewing conditions. By distinguishing sessions, the proposed method can represent usage history in a more precise manner.

The playback event-related fields record the sequence of user actions generated during content consumption. These include events such as play, pause, seek, replay, and stop, along with their corresponding timestamps. Since OTT content consumption is event-driven rather than strictly linear, these event records provide the basis for interpreting how the content was actually consumed.

Finally, derived usage result fields are included to represent summarized information obtained from playback event analysis. These fields may include viewing duration, completion rate, and valid usage intervals. Such information is not directly collected as a raw event, but is derived from the sequence of recorded playback actions and is useful for copyright-oriented verification and settlement support.

3.3 Usage History Generation and Verification Procedure

Based on the metadata defined in the previous section, the proposed method generates OTT content usage history from playback-related events and records it on a blockchain for verification. The significance of this procedure lies not in simply storing logs, but in interpreting individual events as part of the actual content consumption flow and transforming them into trustworthy records. The overall procedure consists of data collection, usage history generation, blockchain recording, and verification, as shown in Figure 5.

Raw logs generated in OTT environments are not directly suitable for copyright verification because they may differ across platforms, be fragmented into event-level records, and reflect nonlinear viewing behaviors such as seeking, pausing, replaying, and partial viewing. Therefore, instead of directly using raw events, the proposed method reconstructs them into structured usage history units according to a normalized metadata scheme. The generated usage history is then recorded on a blockchain, after which integrity and traceability can be used for verification.

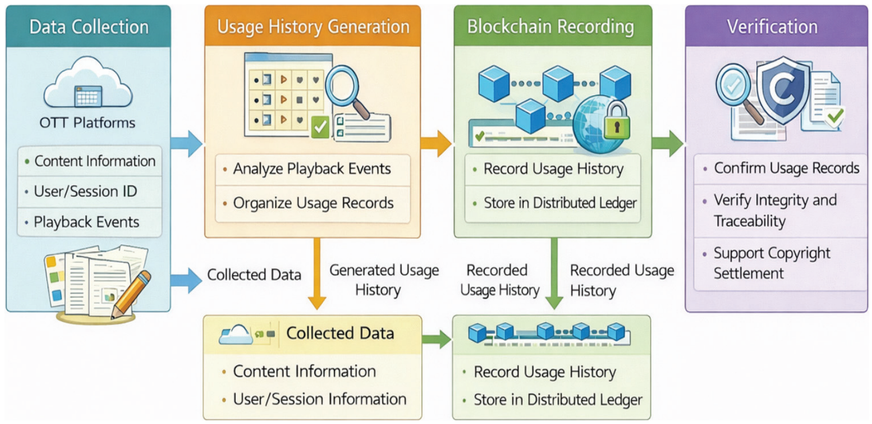

Figure 5 Content usage history collection, generation, blockchain recording, and verification framework.

Table 2 Metadata fields for OTT content usage history

Category	Collected Field	Description
Content Information	Content ID, Title, Episode/Season	Identification of the target content
Session Information	User ID, Session ID, Device Info	Identification of the user and viewing context
Event Information	Event Type	Play, pause, seek, replay, and stop
	Event Timestamp	Time at which the event occurred
	Playback Position	Playback position at the time of the event

3.3.1 Data collection stage

In the data collection stage, key information generated during OTT content consumption is acquired. The collected data can be divided into three categories: content information, user or session information, and playback event information, as shown in Table 2.

Content information is used to identify which digital asset a usage record refers to, while user or session information is used to distinguish different viewing instances of the same content. Playback event information represents actual content consumption behavior and includes event types such as play, pause, seek, replay, and stop, along with the corresponding event timestamps.

The purpose of this stage is to acquire playback-related information in a common collection unit, even though the original data may be generated in different formats depending on the platform. For example, one platform may explicitly record seek events, whereas another platform may only record

Table 3 Metadata fields for OTT content usage history

Previous Event	Next Event	Interpretation
Play	Pause	End of one viewing interval
Play	Seek	Viewing up to the point before seeking
Pause	Play	Resume viewing
Seek	Play	Start viewing from a new position
Play	Stop	End of viewing within the session
Replay	Stop	End of a replayed viewing interval

changes in playback position. Therefore, regardless of the internal logging format of each platform, the proposed method treats content identification, session identification, event type, event timestamp, and playback position as the minimum extractable units.

3.3.2 Usage history generation stage

In the usage history generation stage, the collected events are sorted in chronological order and then used to reconstruct the actual content consumption flow. Since raw events are recorded as isolated actions, they are difficult to interpret directly as meaningful usage records. Therefore, the proposed method arranges all events occurring within the same session in temporal order and analyzes the relationships between adjacent events to generate usage history.

For example, if a pause event occurs after a play event, the corresponding segment may be interpreted as one viewing interval. If a seek event occurs, the segment before the seek event and the segment after the seek event may be recorded separately in order to better reflect the actual usage flow. Replay events indicate repeated consumption of the same segment and may therefore be represented as separate usage intervals. A stop event serves as the criterion for ending the generation of usage history within a session. Examples of event pair interpretation rules used in this stage are summarized in Table 3.

Let the set of collected events for a session s be defined as:

$$E_s = \{e_1,\ e_2, e_3, \ldots, e_n\} \tag{1}$$

where e_i denotes the i-th event occurring in session s. Each event can be represented by its event type, timestamp, and playback position:

$$e_i = (t_i, \tau_i, p_i) \tag{2}$$

Once the events are sorted chronologically, each adjacent event pair (e_i, e_{i+1}) can be analyzed to construct a candidate valid viewing interval. For example, when $t_i = \text{play}$ and $t_{i+1} \in \{\text{pause}, \text{seek}, \text{stop}\}$, the corresponding segment may be interpreted as one usage interval. In this way, the generated usage history is no longer a simple list of raw events, but a structured record that reflects actual content consumption.

3.3.3 Valid usage interval derivation stage

A key issue in OTT content usage history verification is not merely counting events or summing playback time, but deriving valid usage intervals that can be recognized as actual viewing. Even within the same session, long pauses, frequent seeking, repeated playback, or partial viewing may alter the meaning of actual content consumption. Therefore, the proposed method extracts valid usage intervals based on the event sequence.

Let the set of m valid usage intervals generated in session s be denoted by $I_s = \{I_1, I_2, \ldots, I_m\}$. Each interval I_k is expressed by its start position a_k and end position b_k:

$$I_k = [a_k, b_k] \tag{3}$$

Based on these intervals, the total valid viewing time V_s of session s is defined as:

$$V_s = \sum_{k=1}^{m} (b_k - a_k) \tag{4}$$

where $b_k - a_k$ denotes the length of the k-th valid usage interval. If the total content length is denoted by L_c, the completion rate C_s for the session can be calculated as:

$$C_s = \frac{V_s}{L_c} \tag{5}$$

The above expression represents the basic form. In practical applications, a correction policy may be introduced depending on whether replayed segments are counted separately or whether overlapping intervals should be merged. For example, if repeated viewing of the same segment is not counted as additional effective usage, the total valid viewing time excluding duplicated segments can be expressed as:

$$V_s^* = \left| \bigcup_{k=1}^{m} I_k \right| \tag{6}$$

where V_s^* denotes the effective viewing time after removing duplicated intervals. This approach has the advantage of representing actual content consumption more precisely than a simple total-playback-time calculation.

3.4 Blockchain Recording Stage

The generated usage history is then transformed into transaction units and stored in a blockchain ledger. The objective of this stage is to preserve usage history in a form that is resistant to later modification while maintaining the sequence and relationships among records. A recorded usage history unit may include content identification, session identification, summarized event information, valid usage intervals, generation time, and reference information to previous records.

A usage history record R_i can be represented as:

$$R_i = (CID_i, SID_i, E_i, V_i, TS_i, H_{i-1}) \tag{7}$$

where CID_i is the content identifier, SID_i is the session identifier, E_i is the summarized event information, V_i is the valid usage interval or valid viewing time, TS_i is the recording timestamp, and H_{i-1} is the reference value to the previous record.

Each usage history record can thus maintain continuity with previous records, allowing the usage flow of a specific session or content item to be traced. In addition, the recorded record becomes the target of integrity verification through a hash-based identifier. The hash value $h_i$of the usage history record is defined as:

$$h_i = \mathrm{Hash}(R_i) \tag{8}$$

If the content of the record is modified after recording, the hash value changes accordingly, making it possible to detect integrity violations.

3.5 Verification Stage

In the verification stage, the usage history recorded on the blockchain is examined to determine whether it has been altered, whether the event flow is valid, and whether it reflects actual content consumption. The purpose of this stage is not merely to confirm storage, but to ensure that the recorded usage history can serve as trustworthy evidence for copyright protection and settlement support. The main verification items considered in the proposed method are summarized in Table 4.

First, integrity verification checks whether recorded data have been changed by comparing the stored hash values. Second, traceability verification examines the sequence and linkage of usage history records corresponding to a specific session or content item. Third, usage verification determines

Table 4 Verification items for usage history

Verification Type	Verification Content	Purpose
Integrity Verification	Comparison of hash values and detection of record modification	Prevention of data tampering
Traceability Verification	Examination of record order and linkage	Tracking of usage flow
Usage Verification	Checking valid intervals, completion rate, and event sequence	Determination of actual content usage
Applicability Verification	Examination of usability for settlement and dispute response	Assurance of service applicability

whether the recorded data appropriately reflect actual consumption based on valid usage intervals, completion rates, and event sequences. Finally, applicability verification examines whether the verified usage history can be effectively used for practical copyright-related processes such as royalty settlement and dispute resolution. Through these verification procedures, the proposed method enables OTT content usage history to be utilized not merely as operational logs, but as verifiable records for copyright protection, royalty settlement, and dispute resolution.

4 Experiments and Results

4.1 Experimental Environment

To evaluate the performance of the proposed OTT usage history processing method, experiments were conducted under varying session scales and numbers of platforms. The experiment focused on the aggregation stage, in which usage history records collected from multiple OTT platforms are integrated, and the processing latency was measured according to the number of sessions and platforms. The experimental environment and main settings are summarized in Table 5.

In the experiment, the number of sessions was set to 1000, 10,000, 50,000, and 100,000, while the number of platforms was configured as 2, 4, and 8, considering practical OTT service environments. For each experimental condition, the aggregation latency was measured five times, and the median value was used as the representative result in order to reduce the influence of outliers. In addition, the aggregation process was designed to include not only the total aggregation time but also processing across each metadata dimension.

Table 5 Experimental environment and settings

Category	Setting
Experiment Target	Aggregation processing of OTT usage history
Number of Sessions	1000, 10,000, 50,000, 100,000
Number of Platforms	2, 4, 8
Measurement Item	Aggregation latency (ms)
Number of Repetitions	Five runs for each condition
Representative Value	Median
Aggregation Scope	Total aggregation and per-metadata-dimension processing
Experiment Objective	Analysis of aggregation performance according to session and platform scales

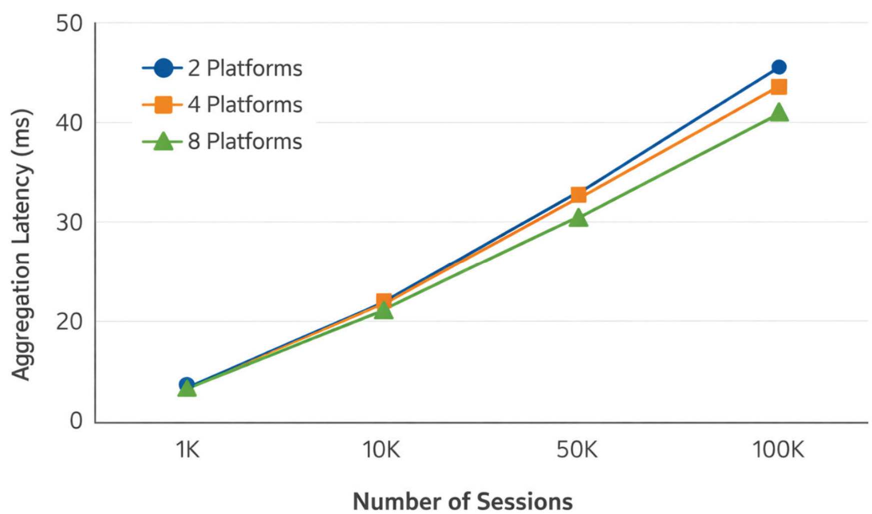

Figure 6 Aggregation latency according to the number of sessions.

4.2 Aggregation Latency Results

The change in aggregation latency according to the increase in the number of sessions is shown in Figure 6.

As the number of sessions increased from 1000 to 100,000, the aggregation latency also showed an overall increasing trend. In particular, the latency exhibited an almost linear increase as the number of sessions grew, indicating that the proposed aggregation process has predictable processing characteristics with respect to session-scale variation. The detailed measured values are summarized in Table 6.

Table 6 Median aggregation latency (ms): sessions × platforms

Sessions	2 platforms	4 platforms	8 platforms
1000	0.37	0.37	0.36
10,000	3.72	3.90	3.65
50,000	19.96	20.83	20.63
100,000	45.79	43.26	43.71

More specifically, under the 1000-session condition, the aggregation latency was below 1 ms for all platform settings, indicating that the processing overhead was very small in small-scale session environments. At 10,000 sessions, the latency increased to approximately 3.6–3.9 ms, and at 50,000 sessions, it reached around 20 ms. Even under the 100,000-session condition, the latency ranged from 43.71 ms to 45.79 ms. For example, in the 2-platform setting, the latency increased from 0.37 ms at 1000 sessions to 45.79 ms at 100,000 sessions.

Even when the number of platforms increased from 2 to 8 under the same session condition, the difference in latency remained small. This indicates that the overall aggregation latency is affected more by the number of sessions than by the number of platforms. In other words, the aggregation performance of the proposed method is more sensitive to increases in session volume than to increases in platform multiplicity.

These results demonstrate that the proposed method can maintain stable aggregation performance even for large-scale OTT usage history data. In particular, the fact that the processing latency remained within tens of milliseconds even at the 100,000-session level suggests that the proposed method has sufficient efficiency for practical usage history analysis and verification tasks in real OTT environments.

5 Conclusion

This paper proposed a blockchain-based usage history verification method for OTT content copyright protection. The proposed method organizes playback-related information generated in OTT environments into structured usage history metadata and records it on a blockchain so that the resulting records can be managed with integrity and traceability. In addition, by reconstructing playback events into interpretable usage history and deriving valid usage intervals, the proposed method enables OTT content consumption to be represented in a more reliable and verifiable manner than simple log-based approaches.

To evaluate the effectiveness of the proposed method, experiments were conducted under varying session scales and platform conditions. The results showed that aggregation latency increased as the number of sessions grew, while the effect of the number of platforms remained relatively limited. Even at the 100,000-session level, the processing latency remained within tens of milliseconds, indicating that the proposed method can maintain stable aggregation performance in large-scale OTT usage history processing environments.

These results suggest that the proposed method can provide a trustworthy basis for copyright protection, royalty settlement, and dispute resolution in OTT service environments. By combining structured usage history generation with blockchain-based recording and verification, the method extends OTT usage records beyond simple operational logs and enables them to function as verifiable evidence for copyright-related processes.

Future work includes refining the derivation of valid usage intervals for more diverse playback patterns, extending the method to more complex OTT service scenarios, and improving the practical applicability of blockchain-based verification in real-world multi-stakeholder environments.

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References

[1] S. Nakamoto, “Bitcoin: A Peer-to-Peer Electronic Cash System,” 2008..

[2] E. Androulaki et al., “Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains,” in *Proceedings of the Thirteenth EuroSys Conference*, 2018.

[3] R. Iannella and S. Villata, *ODRL Information Model 2.2*, W3C Recommendation, 2018.

[4] Sandvine, *Global Internet Phenomena Report 2024*. Sandvine Inc., 2024.

[5] Nielsen, "Time Spent Streaming Surges to Over 40% in June 2024," *The Gauge*, 2024.
[6] Nielsen, "What's the Difference between OTT, CTV and Streaming?," *Nielsen Insights*, 2024.
[7] A. González-Neira and C. Quintas-Froufe, "Television Audience Measurement: the Challenge Posed by the Rise of Streaming and OTT Platforms," *Comunicación y Sociedad*, vol. 17, e7284, 2020.
[8] J. P. Kelly, "Television by the Numbers: The Challenges of Audience Measurement in the Age of Big Data," *Convergence*, vol. 25, no. 1, pp. 113–132, 2019.
[9] A. Papathanasopoulos and A. Stavrianea, "The Evolution of Subscription Services in Greece: From Satellite TV to Over-The-Top (OTT) Streaming Models," in *Strategic Innovative Marketing and Tourism*, Springer Proceedings in Business and Economics, pp. 739–747, 2024.
[10] O. Budzinski, S. Gaenssle, and N. Lindstädt-Dreusicke, "The Battle of YouTube, TV and Netflix: an Empirical Analysis of Competition in Audiovisual Media Markets," *SN Business & Economics*, vol. 1, no. 9, art. 116, 2021.
[11] G. Anselmi, Y. Vekaria, A. D'Souza, P. Callejo, A. M. Mandalari, and Z. Shafiq, "Watching TV with the Second-Party: A First Look at Automatic Content Recognition Tracking in Smart TVs," in *Proceedings of the ACM Internet Measurement Conference (IMC)*, 2024.
[12] W. Robitza, A. Ahmad, P. A. Kara, L. Atzori, M. G. Martini, A. Raake, and L. Sun, "Challenges of Future Multimedia QoE Monitoring for Internet Service Providers," *Multimedia Tools and Applications*, vol. 76, pp. 22243–22266, 2017.
[13] U. Bulkan and A. Dagiuklas, "Predicting Quality of Experience for Online Video Service Provisioning," *Multimedia Tools and Applications*, vol. 78, pp. 18787–18811, 2019.
[14] N. Jing, Q. Liu, and Z. Yong, "A Blockchain-Based Code Copyright Management System," *Information Processing & Management*, vol. 58, no. 3, 102518, 2021.
[15] R. F. Ciriello, A. C. G. Torbensen, M. R. P. Hansen, and C. Müller-Bloch, "Blockchain-Based Digital Rights Management Systems: Design Principles for the Music Industry," *Electronic Markets*, vol. 33, art. 5, 2023.
[16] Z. Ma, W. Huang, and H. Gao, "A New Blockchain-Based Trusted DRM Scheme for Built-In Content Protection," *EURASIP Journal on Image and Video Processing*, vol. 2018, art. 91, 2018.

[17] W. Tan, X. Zhang, and X. Cai, "Digital Rights Management Platform Based on Blockchain Technology," in *Human Centered Computing: 6th International Conference (HCC 2020), Revised Selected Papers*, pp. 173–183, 2021.

[18] Y. Yang, D. Yu, R. Zhang, and Y. Yan, "A Video Copyright Transaction Traceability Method Based on the Parent-Child Chain," in *Proceedings of the 2020 3rd International Conference on Blockchain Technology and Applications (ICBTA)*, pp. 1–6, 2020.

[19] H. Guan, Y. Huang, J. Liu, and W. S. Zhang, "Digital Media Copyright Confirmation Service System Based on Block-Chain Registration and Identifier Tracking," in *Proceedings of the 9th International Conference on Communication and Information Processing (ICCIP 2023)*, pp. 273–278, 2024.

[20] W. Son, S. Kwon, S. Oh, and J.-H. Lee, "OTT Service Copyright Management Framework Using ODRL Based on Hyperledger Fabric," in *Proceedings of ICEA 2023*, pp. 84–89, 2024.

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