

## Digital Rights Management (DRM) Metadata Elements and their Functionalities: A Comparative Study

Seyed Mahdi Taheri

Associate Professor, Department of Knowledge and Information Science, Allameh Tabataba'i University, Tehran, Iran  
Email: taherismster@gmail.com

Negin Shokrzadeh Hashtroudi

Ph.D. student, Department of Information Science, Alzahra University, Tehran, Iran.  
Email: negin.shokrzadeh94@gmail.com

Received: 2024-04-16

Accepted: 2024-06-17



### Abstract

The purpose of this study was to investigate the of metadata elements of Digital Rights Management (DRM) comparatively in different regions and the approach behind. This research was conducted using qualitative content analysis method. The data was gathered through documentary method and searching in databases to identify the best practices of DRM solutions. The results revealed that Different metadata elements are utilized in the DRM projects. These metadata elements are practical in different stages of content trading and greatly depends on the technology, law, and business models. As stated before, Digital Rights Management (DRM) is an important tool for digital contents. This tool is implemented in various countries and regions. The United States is known for its strong intellectual property laws. DRM in the United States is mostly based around the Digital Millennium Copyright Act (DMCA). Canada, takes a more balanced approach to DRM systems which reflects Canada's commitment to promoting access to information while protecting intellectual property rights. In contrast, the UK Copyright, Designs, and Patents Act of 1988 suggests that it differs significantly with regard to DRM and a more flexible approach is considered in digital rights management.

Journal of Research and Development in Comparative Law

Iranian Law and Legal Research Institute

Vol. 7 | No. 22 | Spring 2024  
(Original Article)  
[www.jcl.illrc.ac.ir](http://www.jcl.illrc.ac.ir)

DOI:  
[10.22034/LAW.2024.203251.0.1383](https://doi.org/10.22034/LAW.2024.203251.0.1383)

This law gives the owners of the rights of copying works control over them, yet it contains some exceptions like research, private study, and criticism. British government has also taken measures to promote the use of DRM technologies, for example, the Creative Content Online initiative that promotes legal distribution of digital content. In France the DRM projects are France comply with the French Intellectual Property Code (Code de la Propriété Intellectuelle) and consider Commission Nationale de l'Informatique et des Libertés – CNIL. The main components of DRM solutions in the France are data protection, privacy concerns, permissions, managing user data, usage rights, and etc. Germany has a similar approach to DRM as France. In Germany the implications of the German Data Protection Act (BDSG) is considered when managing user data through DRM solutions. The DRM solutions of this country implement strong access controls and techniques to protect content rights. based on legal frameworks, cultural norms, and infrastructures there is significant differences in approaches to the protection of digital content and this affect the selection of right metadata components in the DRM systems. When it comes to copyright, the US tends to be more pro-owner, while the UK prefers a balanced perspective that includes user activities. France and Germany have adopted strict measures in this respect, having legal provisions for sanctioning offenders. Switzerland has a more relaxed approach to DRM systems, while Australia, China, and Russia have a complex legal framework for legal protection, access controls, permissions of copyrighted content. Rights metadata have various functionalities such as Identifying and describing the content, to manage secure content distribution, access control, content protection, and usage tracking, monitoring changes, facilitate discoverability, within DRM systems the extent to which they protected content remains secure and accessible only to authorized users. In conclusion, it could be said that based on context-based approaches, cultural norms, and infrastructures there is significant differences in approaches to the protection of digital content and this affect the types and functionalities of right metadata elements in the DRM systems.

**Keywords:** *Digital Rights Management, DRM, Rights metadata, metadata functions.*

## Introduction

The rapid growth of technologies has led to the increase in the amount of digital content in information systems. These contents have generated, gathered, distributed and consumed (Subramanya and Li, 2006). Hence, digital content management is an effective solution to monitor and preserve this amount of data in information systems (Cote & Park, 2007). The main action that has been taken in this area is Digital Rights Management (DRM). Digital Rights Management (DRM) firstly initialed in 1900s and refers to the technologies and techniques developed to enable secure distribution and controlled access to digital contents. Some researchers like Rump (2003) calls it as the savior of the intellectual property. The main components of a DRM are presented in below:

- Secure containers: which make the content inaccessible to those users that are not authorized to access the content (Catuogno et al. 2020).
- Rights expressions: these statements are used to express to whom access to the digital content of the secure containers is permitted (Cote & Park, 2007).
- Content identification and description: this component is used to uniquely identify the content and assign the descriptive metadata to content (Rump, 2003).
- Identification of people and organizations: this component is intended to interact with the content (Oliveira, & Cunha, 2024).
- Algorithms to authenticate the persons and organizations that want to interact with any content (Rump, 2003).
- Reporting events related to content (Cote & Park, 2007).

DRM protects the rights of the content creators and distributors and covers the description, identification, codification. Trading, protection, distribution, monitoring and tracking all forms of the content usage both in tangible and intangible assets (Ceusters & Smith, 2007). Utilizing

Digital rights management has various benefits. One of the main benefits is its ability to control access intellectual property rights and defining required permissions (Arnab, & Hutchison, 2005; Chen et al. 2018). DRM provides content creators and distributors with the tools they need to protect their works from unauthorized usage to their personal data or business information (Seki, & Kameyama, 2003, Lin et al, 2010). Another major benefit of DRM is defining security controls and encryptions through digital rights policies like who has access to their content, how it is used, and for how long (Jonker et al, 2004). This help content owners ensure that only authorized users have access to digital content. Another advantage of DRM is enforcing licensing agreements and restrictions to develop specific terms and conditions to access data (Gaber et al. 2020). Likewise, by tracking and analyzing the log files and user data, content owners can gather valuable insights about their customers and providing more personalized services for them (Ciriello et al. 2023).

In recent years, considerable efforts have been made to develop a legal basis for digital content rights management between content providers and content users. Some of these actions are World Intellectual Property Organization (WIPO), U.S. Digital Millennium Copyright Act (DMCA), European Copyright Directive, and the German Copyright Law. However, as stated in previous literature (Gaber et al. 2020; Hussain et al. 2020; Garba et al. 2021; Freyberger, & Larsen, 2022) it is not clear how digital rights management systems or related legislation has any effect in the privacy of the content in practice.

The lack of transparency and a central database for gathering copyrighted objects cause serious problems in identifying the rights of the content owners and the content itself (Liu et al. 2021). Also, Rights holders cannot control the use of their digital content on the internet. Therefore, an awareness of the copyright protection is required in the digital environments (Liz, 2020). On the other hand, with the

emergence of new technologies such as blockchain and metaverse sufficient and comprehensive data about identities, key authentication, limitations and reliability is required in information systems to secure data and protect their privacy (Truong et al. 2023).

Metadata attempts to serve these purposes and address the property rights, licensing information, privacy and usage issues related to digital contents (Cote & Park, 2007). Therefore, metadata is a crucial component in DRM systems. Metadata is defined as “data about data”. Previously the metadata was considered as the second citizen of the information systems. But these days due to the rapid growth of data, the importance of the metadata have been increased from the primary data and the content itself. Various types of metadata such as descriptive, technical, administrative, and etc. are designed to describe different aspects of the entities. One of the most important types of metadata is rights metadata.

As stated in Mullins (2009) Using dynamic metadata-based information to achieve ‘active’ DRM for is the way of the future. Hence, it is necessary to study the effect of sufficient metadata elements and semantics in fully accommodate with the requirements of digital rights management on the web and a better representation of contents (García & Tummarello, 2006). DRM solutions have been implemented in different countries but the metadata components of them are not analyzed and a comprehensive approach to implementation of DRM systems is not considered in previous researches. Therefore, this research is aimed at addressing the below questions:

- What are the main metadata components of DRM solutions in different countries?
- What are the functionalities of rights metadata in digital rights management systems?

## Methodology

This research is applied research based on its purpose and conducted using a qualitative content analysis. The required data was gathered by identifying the best practices of this field. To identify them citation indexes and databases such as Web of Science, Scopus, Google scholar, Scencedirect, Taylor and Fransis were searched. The keywords of “Digital Rights Management”, “metadata elements”, “Rights metadata”, “best practices” were utilized to identify the related practices and projects. 93 researches Were identified in databases. By reviewing the abstracts and contents of the identified studies 21 papers were selected to analyze the best practices and metadata elements of DRM systems.

## Results

The results of the paper are presented in this section.

**Question 1:** What are the main metadata components of DRM?

The best practices of DRM in different regions and their metadata components are shown in the table 1.

**Table 1. DRM projects in different regions**

Country	Name of DRM solution	Rights Metadata elements
United states	Microsoft Rights Management Services (RMS)	User permissions
		Group permission
		document properties
		Usage rights
		Access control rules
		Tracking information
	Adobe Digital Rights Management (Adobe DRM)	Information about the content
		Information about the usage rights
		Viewing permissions
		Copyright permission

Country	Name of DRM solution	Rights Metadata elements
		Content sharing rights
		authentication details.
		Information about the transaction (purchase or rental history)
		payment details
		download history
	Verimatrix Video Content Authority System (VCAS)	content identification
		rights management
		user authentication
		transaction history
	Digify	Security metadata
		Passwords
		Download restrictions
		Print restrictions
		Metadata about document expiry
		Access controls
		Document tracking
		Copy controls
	Audible Magic CopySense	Watermark
		Unique identifier for the audio or video content being protected.
		Fingerprint ID
Detection timestamp		
Identifier for the source of the content (streaming platform, website, or social media channel).		
Metadata indicating the level of confidence in the match between the detected content and the reference database.		

Country	Name of DRM solution	Rights Metadata elements
		Copyright owner metadata
		Metadata specifying the action to be taken upon detection of unauthorized use (takedown, blocking, or reporting)
		Metadata capturing usage statistics and insights
		Metadata related to reporting and compliance with copyright enforcement laws and regulations.
	Seclore FileSecure	user identity
		permissions (for viewing, editing, printing, copying, sharing, and other actions)
		access rights
		information for security policies
		access controls
		usage restrictions
		expiration dates
		workflow rules.
		audit information to monitor and track document interactions.
		security measures
Canada	Vitrium	Device limits
		Expiry dates
		Restrictions
		Permissions
		User access controls
		Information about customized secure portal
		Tracking access
United Kingdom	Locklizard DRM	Information about the user accessing the protected content,

Country	Name of DRM solution	Rights Metadata elements
		user identity
		permissions
		access rights
		authentication details.
		License Metadata (expiration date, usage restrictions, and license terms)
		Information related to the security measures applied to the content
		encryption keys
		digital signatures
		watermarking
		access controls.
		logging information
		usage analytics
		License management
		Copyright status
Permissions		
Unauthorized use		
Access control		
Watermarks		
Usage control		
Austria	Sony DADC Media Security Services	user permissions
		access rights
		entitlements for accessing and using the protected digital media content.
		Information about the users interacting with the content
		Users' roles and permissions
		usage rights associated with the digital media
		Usage Tracking Metadata

Country	Name of DRM solution	Rights Metadata elements
		Security Metadata
South Africa	Custos Media Technologies	Unique identifier for the digital content being protected.
		Watermarking
		Usage tracking information
		Metadata related to the detection and reporting of unauthorized copies
		License information
		Blockchain transaction information
		verify the integrity of the content protection process
Australia	Bynder	Control access
		Usage rights
		Permissions
		Content protection metadata
		Asset tracking metadata
		Data sharing information
		Expiration dates
		Track sharing history
		enhanced searchability metadata
Germany	Fraunhofer Institute's Easy Rights	The title of the digital content
		The name of the creator or author of the content.
		A brief description of the content.
		Information about the rights and licenses associated with the content.
		The type of license that applies to the content.
		The date when the content was created or published.

Country	Name of DRM solution	Rights Metadata elements
		The format of the digital content (e.g., video, audio, text).
		A unique identifier for the content.
		The language in which the content is available.
		The source or origin of the content.
	Axinom DRM	Date and time when the rights to access the content expire.
		Access permissions
		Playback policy rules
		Metadata related to digital watermarking
		Encryption settings
		Authentication tracking information
France	Viaccess-Orca	Metadata Source
		Related Content
		Production Credits
		Licensing Information
		rights and permissions associated with the content
Switzerland	WISEKey	Asset ID
		Access permissions
		Watermarking information
		Metadata defining geographic restrictions for digital asset access.
		Usage tracking information
China	ChinaDRM	Content ID
		DRM type
		License information

Country	Name of DRM solution	Rights Metadata elements
		Metadata related to the digital rights licenses
		User authentication data
		Usage logs
		Encryption keys
		Digital signatures
Russia	Zschaler	Configuration data
		Metadata related to compliance requirements
		Information about security alerts, incidents, and vulnerabilities
		Metadata related to risk assessments Information about user actions and interactions with cloud resources.

As shown in table 1. Different metadata elements are utilized in the DRM projects. These metadata elements are practical in different stages of content trading and greatly depends on the technology, law, and business models. As stated before, Digital Rights Management (DRM) is an important tool for digital contents. This tool is implemented in various countries and regions.

The United States is known for its strong intellectual property laws. DRM in the United States is mostly based around the Digital Millennium Copyright Act (DMCA). This Act makes it illegal to get around any access-control technology or encryption used in protecting copyrighted material. It also has what is known as safe harbors for Internet service providers where they cannot be held accountable when their clients do something illegal. The DMCA, which restricts and limits consumer use of the copyrighted material not infringing on intellectual property laws, is overly restrictive and has been widely

criticized. Canada, on the other hand, takes a more balanced approach to DRM systems which reflects Canada's commitment to promoting access to information while protecting intellectual property rights.

In contrast, the UK Copyright, Designs, and Patents Act of 1988 suggests that it differs significantly with regard to DRM and a more flexible approach is considered in digital rights management. This law gives the owners of the rights of copying works control over them, yet it contains some exceptions like research, private study, and criticism. British government has also taken measures to promote the use of DRM technologies, for example, the Creative Content Online initiative that promotes legal distribution of digital content.

In France the DRM projects are France comply with the French Intellectual Property Code (Code de la Propriété Intellectuelle) and consider Commission Nationale de l'Informatique et des Libertés – CNIL. The main components of DRM solutions in the France are data protection, privacy concerns, permissions, managing user data, usage rights, and etc. Germany has a similar approach to DRM as France. In Germany the implications of the German Data Protection Act (BDSG) is considered when managing user data through DRM solutions. The DRM solutions of this country implement strong access controls and techniques to protect content rights.

The results of this study revealed that based on the laws, legal frameworks, cultural norms, and infrastructures there is significant differences in approaches to the protection of digital content. When it comes to copyright, the US tends to be more pro-owner, while the UK prefers a balanced perspective that includes user activities as it were. France and Germany have adopted strict measures in this respect, having legal provisions for sanctioning offenders. Switzerland has a more relaxed approach to DRM systems, while Australia, China, and Russia have a complex legal framework for DRM systems, the legal protection, access controls, permissions of copyrighted content.

Ultimately, the challenge for policymakers in all countries is to strike a balance between protecting the rights of copyright owners and ensuring that consumers have authorized access to the content. Since laws and legal frameworks vary in different countries, each region must design DRM according to its own structure. DRM has different elements in different laws, and each of these elements affects the functionalities of DRM.

**Question 2:** What are the functionalities of rights metadata in digital rights management systems?

The main component of all models and standards that specifies the functions of that standard is its metadata elements. Analyzing the metadata elements of DRM best practices reveals that DRM metadata have various functions. These functions are presented in the table 2.

**Table 2. Functions of DRM metadata elements**

Function	Related metadata elements	Description	Utilization in regions
<b>To identify</b>	Content ID	Identifying and describing the content and rights associated with it.	United States, South Africa, Germany, Switzerland, China
	Asset ID		
	Media ID		
	Fingerprint ID		
	Content type		
	Additional descriptive metadata		
	Copyright owner metadata		
	document properties		
<b>To access</b>	access rights	Providing information on how the resource can be used, shared, and accessed.	United states, Canada, United Kingdom, Austria, South Africa, Australia,
	access controls		
	Access permissions		
	document properties		
	DRM type		
	Encoder version		

Function	Related metadata elements	Description	Utilization in regions
	encryption keys		Germany, France, China, Russia
	Geolocation restrictions		
	Group permission		
	limitations or restrictions		
	Rights expiration date		
	Usage rights		
	access controls		
<b>To manage &amp; control</b>	authentication details	Managing and enforcing restrictions on usage, such as copyright protection or licensing terms and supporting digital rights management systems to control access and usage of digital content.	United states, Canada, United Kingdom, Austria, Australia, Germany, France, Switzerland, China, Russia
	download history		
	DRM type		
	Encoder version		
	encryption keys		
	Group permission		
	Geolocation restrictions		
	limitations or restrictions		
	digital watermarking		
	payment details		
	Playback policy rules		
	Rights expiration date		
	transaction history		
	usage restrictions		
Usage Tracking Metadata			
user authentication			
<b>To permit</b>	Content sharing rights	Facilitating rights clearance and permission processes.	United states, Canada, United Kingdom, Austria, Australia, Germany, France,
	access rights		
	digital signature		
	DRM type		
	Encoder version		
	encryption keys		
	Geolocation restrictions		

Function	Related metadata elements	Description	Utilization in regions
	Group permission		Switzerland, China
	Security policies		
	limitations or restrictions		
	Playback policy rules		
	Usage rights		
	user identity		
	User Key		
	User permissions		
<b>To track</b>	authentication details.	Monitoring and tracking usage of digital assets to ensure compliance with rights and permissions.	United states, Canada, United Kingdom, Austria, South Africa, Australia, Germany, France, Switzerland, China, Russia
	Blockchain transaction information		
	Configuration data		
	Document interactions		
	download history		
	source of content		
	logging information		
	Rights expiration date		
	transaction history		
	Usage Tracking Metadata		
	user authentication		
	user identity		
	User Key		
	User permissions		
<b>To monitor</b>	Document interactions	monitoring transparency and accountability in managing	United states, Canada, United Kingdom, South Africa, Australia,
	Usage rights		

Function	Related metadata elements	Description	Utilization in regions
	Permissions	rights-related issues.	Germany, France, Switzerland, China, Russia
	Logging information		
<b>To discover</b>	document properties	Enhancing and supporting discoverability of digital resources by enabling better search and retrieval based on rights information.	USA, Germany, Australia, China
	DRM type		
	Group permission		
	Content sharing rights		
	source of content		
	Additional descriptive metadata		

The table 2 shows the functionalities of rights metadata in digital rights management. Since the functionality of standards and management systems are determined based on their metadata elements, these components are analyzed to identify the functionalities of DRM systems. Based on the results the functions of rights metadata in DRM systems are: to identify, to access, to manage, to permit, to control, to track, to support, to monitor, to discover, and to facilitate. Some metadata elements are supporting various functions. For example, limitations or restrictions support access, manage, permit, and control functions. All these functions are related to rights of the content and implemented in different digital content management stages.

Likewise, the results revealed that in different regions, rights metadata support different functions. In the United States various DRM solutions are developed to support required functions these DRMs support all functions of rights metadata. In UK, Canada and France the access,

manage, track, permit, track, and monitor functions are considered in its DRMs. In South Africa access, manage, track, permit, and track functions have received more attention. Similar to America, Germany and China also support all functions due to the use of various DRMs. Switzerland paid more attention to the digital rights management in Australia supports access, manage, permit, track, monitor, and discover functions. In Russia, the access, manage, track and monitor functions have been more considered in the design of DRMs.

### **Discussion and conclusion**

Digital Rights Management (DRM) systems are utilized by content owners and has the ability to protect the rights of the assets and intellectual properties and prevent unauthorized access to the content. DRM systems are widely implemented around the world from United States to China. Although the main aim of the DRM systems is to manage and control the rights related to digital contents, there is a significance differences between DRM systems. One of the key differences in the implementation of DRM in is the legal framework. In the United States, for example, the Digital Millennium Copyright Act (DMCA) provides legal protection for DRM systems.

Another key difference in the implementation of DRM in different countries is the level of consumer protection. In countries like Germany, there are laws that require companies to disclose the use of DRM on their products.

Additionally, the level of enforcement of DRM also varies from country to country. Consequently, enterprises are stricter in implementing DRM protections and suing individuals who attempt to break them in places like the UK and the USA where there are tough laws on copyright enforcement. In contrast, in countries with weaker copyright enforcement laws, such as Russia, companies are less likely to take

legal action against individuals who bypass DRM protections, leading to a higher rate of piracy and unauthorized distribution of copyrighted content.

Obviously, Metadata is an essential component in developing DRM systems. The rights metadata utilized to manage and control the use of digital objects. These metadata components work together to enable secure content distribution, access control, content protection, and usage tracking within DRM systems that protected content remains secure and accessible only to authorized users. such as Identifying and describing the content, to manage secure content distribution, access control, content protection, and usage tracking, monitoring changes, facilitate discoverability, within DRM systems the extent to which they protected content remains secure and accessible only to authorized users

It should be noted that, each country must have its unique and local DRM. We cannot merge DRM from different regions. It seems that cultural context is affective in developing DRM. Each region-based context has unique metadata elements that suit its own structure. Understanding the differences in DRM systems around the world can provide valuable insights into global trends in intellectual property protection. By comparing the various approaches to DRM, we can gain a better understanding of the challenges and opportunities in safeguarding digital content in the digital age.

## References

- Arnab, Alapan and Hutchison, Andrew (2005). Requirement Analysis of Enterprise DRM systems , Proceedings of Information Security South Africa, 29 June 2005 - 01 July 2005, Hotel Balalaika, Sandton, Johannesburg.
- Catuogno, L., Galdi, C., & Riccio, D. (2020). An enterprise rights management system for on-the-field maintenance facilities. *IEEE Access*, 8, 95987-95996.
- Ceusters, W., & Smith, B. (2007). Referent tracking for digital rights management. *International Journal of Metadata, Semantics and Ontologies*, 2(1), 45-53.
- Chen, H. B., Lee, W. B., & Chen, T. H. (2018). A novel DRM scheme for accommodating expectations of personal use. *Multimedia Tools and Applications*, 77, 23099-23114.
- Ciriello, R. F., Torbensen, A. C. G., Hansen, M. R. P., & Müller-Bloch, C. (2023). Blockchain-based digital rights management systems: Design principles for the music industry. *Electronic Markets*, 33(1), 5.
- Cote, J. A., & Park, E. G. (2007). Digital Rights Management Metadata and Standards. In *Encyclopedia of Information Ethics and Security* (pp. 136-142). IGI Global.
- Freyberger, J., & Larsen, B. J. (2022). Identification in ascending auctions, with an application to digital rights management. *Quantitative Economics*, 13(2), 505-543.
- Gaber, T., Ahmed, A., & Mostafa, A. (2020, April). Privdrm: A privacy-preserving secure digital right management system. In *Proceedings of the 24th International Conference on Evaluation and Assessment in Software Engineering* (pp. 481-486).
- Garba, A., Dwivedi, A. D., Kamal, M., Srivastava, G., Tariq, M., Hasan, M. A., & Chen, Z. (2021). A digital rights management system based on a scalable blockchain. *Peer-to-Peer Networking and Applications*, 14, 2665-2680.
- Hussain, A., Kiah, M. L. M., Anuar, N. B., Md Noor, R., & Ahmad, M. (2020). Performance and security challenges digital rights management

- (DRM) approaches using fog computing for data provenance: a survey. *Journal of Medical Imaging and Health Informatics*, 10(10), 2404-2420.
- Jonker, H. L., Mauw, S., Verschuren, J. H. S., & Schoonen, A. T. S. C. (2004, June). Security aspects of DRM systems. In *25th Symposium on information theory in the Benelux* (pp. 169-176).
- Lin, W., Zhang, N., & Liu, S. (2010, May). A metadata-based interoperable digital rights management system architecture. In *2010 Third International Joint Conference on Computational Science and Optimization* (Vol. 2, pp. 432-434). IEEE.
- Liu, Y., Zhang, J., Wu, S., & Pathan, M. S. (2021). Research on digital copyright protection based on the hyperledger fabric blockchain network technology. *PeerJ Computer Science*, 7, e709.
- LIZ. (2020). The dilemma and outlet of my country's digital copyright protection in the era of big data. *Journal of Hainan Tropical Ocean University*, 27(03):91-94.
- Oliveira, A. F. D., & Cunha, M. B. D. (2024). COLLECTION DEVELOPMENT IN DIGITAL COLLECTIONS. *RDBCI: Revista Digital de Biblioteconomia e Ciência da Informação*, 17, e019025.
- Seki, A., & Kameyama, W. (2003, December). A proposal on open DRM system coping with both benefits of rights-holders and users. In *GLOBECOM'03. IEEE Global Telecommunications Conference (IEEE Cat. No. 03CH37489)* (Vol. 7, pp. 4111-4115). IEEE.
- Subramanya, S. R., & Yi, B. K. (2006). Digital rights management. *IEEE potentials*, 25(2), 31-34.
- Truong, V. T., Le, L., & Niyato, D. (2023). Blockchain meets metaverse and digital asset management: A comprehensive survey. *Ieee Access*, 11, 26258-26288.