International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Digital Rights Management: Addressing Copyright Protection in the Digital Era

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Abstract

The simplicity of material reproduction and distribution has made protecting intellectual property rights more and more difficult in the digital age. By means of access and use control, Digital Rights Management (DRM) systems have become increasingly important in protecting copyrighted material. Studies indicate that DRM especially in the music and publishing sectors discourages illegal use and supports monetisation strategies for digital media. DRM, on the other hand, sometimes creates compromises that can lower user happiness and even promote piracy as a kind of resistance by restricting consumer rights and interoperability problems. New studies underlined the need of a balanced DRM strategy combining legal, technical, and economic elements while honouring fair use and user autonomy. Advances in blockchain and smart contracts are also being investigated as decentralised substitutes for conventional DRM systems, promising possible enhancements in rights enforcement and openness. The ease with which material may be reproduced and disseminated in the digital age has made intellectual property rights protection more difficult. Systems for digital rights management, or DRM, have become essential for protecting intellectual material by limiting access and use. DRM successfully discourages unauthorised usage and promotes digital media monetisation models, according to research, especially in the publishing and music sectors. DRM frequently brings trade-offs, though, such restricted consumer rights and interoperability problems, which can lower user pleasure and occasionally incite piracy as a form of resistance. A balanced DRM strategy that incorporates legal, technological, and economic tactics while upholding fair usage and user liberty is crucial, according to recent study. As decentralised alternatives to conventional DRM systems, developments in blockchain technology and smart contracts are also being investigated since they may enhance rights enforcement and transparency.

Keywords: Digital, Monetisation, Blockchain, media, Intellectual, Property

Introduction

In the digital era, the protection of creative works faces unprecedented challenges. The rapid proliferation of digital technologies has dramatically increased the ease with which content can be duplicated, distributed, and accessed, often without authorization. As a response, Digital Rights Management (DRM) systems have emerged as crucial tools for safeguarding intellectual property online. DRM refers to a set of technologies and strategies designed to control the use, modification, and distribution of copyrighted digital content.

DRM plays a pivotal role in mitigating unauthorized use and piracy by restricting access and copying of digital materials such as music, videos, software, and e-books. Legal frameworks have evolved to incorporate DRM into copyright laws, emphasizing its necessity in balancing creators' rights and public access.[1] However, this technological approach has not been without criticism questions about consumer rights, fair use, and freedom of expression continue to spark debate among legal scholars and the public.[2] As content distribution shifts further into decentralized and online platforms, the role of DRM is likely to grow. Innovations such as blockchain-integrated DRM systems are being explored to enhance transparency, security, and user control over digital assets. In this evolving landscape, understanding the mechanisms, benefits, and limitations of DRM is essential to crafting effective copyright protection strategies in the digital age.

Copyright plays a crucial role in the digital economy by protecting creators' rights, incentivizing innovation, and supporting economic growth. As digital technologies make content creation and distribution easier, effective copyright systems are essential to balance the interests of creators, users, and platforms.

The rapid advancement of digital technologies has fundamentally transformed the landscape of copyright protection, presenting both new opportunities and significant challenges. In the digital era, the ease of copying, distributing, and accessing creative works has intensified concerns over piracy, unauthorized use, and the enforcement of copyright laws across global networks.[3] Copyright protection has become a core issue for creative industries, serving as a key value generator and a critical factor for maintaining competitive advantage in increasingly digital markets.[4]

Legal frameworks and enforcement mechanisms are under constant pressure to adapt, as traditional approaches often struggle to address the complexities of cyberspace and digital content distribution.[5] Innovative solutions, such as digital watermarking and new licensing models like Creative Commons, have emerged to help balance the interests of copyright holders and the public, while also addressing the persistent problem of illegal content distribution.[6]

Ultimately, effective copyright protection in the digital era requires a multifaceted approach that considers legal, technological, economic, and social factors. Only by integrating these perspectives can policymakers and stakeholders develop strategies that safeguard intellectual property while fostering innovation and access in the digital age.

Copyright-intensive sectors account for millions of jobs and significant economic activity, especially in regions like the EU where over 7 million jobs are directly linked to these industries.[7] Copyright ensures

[1] Ismail, O. 2025. Born-Digital Memes as Archival Discourse: A Linked-Data Analysis of Cultural Sentiment and Polarization. *Journalism and Media*. https://doi.org/10.3390/journalmedia6010028.

[2] Litoama, F., & , P. 2023. The Legal Certainty of Legitimate Ownership in Copyright Works of Songs or Music, as well as Associated Rights in Non-Declarative Recording in accordance with the Royalty Management System under Government Regulation No. 56 of 2021 (Case Study on Copyright. *Sinergi International Journal of Law*. https://doi.org/10.61194/law.v2i1.102.

[3] Nasir, R., Ponnusamy, V., & Lee, K. 2007. Copyright Protection In The Digital Era: A Malaysian Perspective.

[4] Mogol, N., & Crudu, R., 2023. CHALLENGES AND STRATEGIES FOR COPYRIGHT PROTECTION IN THE DIGITAL ERA. *Journal of Social Sciences*. https://doi.org/10.52326/jss.utm.2022.5(4).01.

[5] Tang, G., 2010. Is administrative enforcement the answer? Copyright protection in the digital era. *Comput. Law Secur. Rev.*, 26, pp. 406-417. https://doi.org/10.1016/J.CLSR.2010.05.006.

[6] Kim, M., 2007. The Creative Commons and Copyright Protection in the Digital Era: Uses of Creative Commons Licenses. *J. Comput. Mediat. Commun.*, 13, pp. 187-209. https://doi.org/10.1111/j.1083-6101.2007.00392.x.

[7] 2022. Copyright. *2022 30th Southern African Universities Power Engineering Conference (SAUPEC)*. https://doi.org/10.1109/saupec55179.2022.9730753.

creators receive recognition and payment, encouraging continued investment and innovation in the creative sector.[8] The digital environment has led to new forms of content, distribution, and licensing, requiring copyright to adapt and support emerging business models.[9]

The objectives and scope focus on understanding how copyright systems can adapt to the challenges and opportunities presented by digital technologies. The study aims to address the effectiveness of current legal, technological, and policy frameworks in safeguarding intellectual property in a rapidly evolving digital environment.

Objectives of the Study

- Examine the unique challenges to copyright protection posed by digital technologies, such as increased piracy, unauthorized distribution, and enforcement difficulties.[10]
- Assess the adequacy and effectiveness of existing copyright laws and enforcement mechanisms, including administrative, civil, and criminal approaches, in different jurisdictions.[11]
- Investigate the role of technological measures like digital watermarking and digital rights management in preventing infringement and supporting copyright enforcement.[12]
- Study the impact of copyright protection on creative industries, economic growth, and public access to information, considering perspectives from law, technology, economics, and public policy.[13]
- Propose strategies and policy recommendations for improving copyright protection and balancing the interests of creators, users, and the public in the digital era.[14]

Scope of the Study

- The study covers legal, technological, economic, and social dimensions of copyright protection.
- It may include comparative analysis of copyright regimes in different countries or regions, such as China, Malaysia, Nigeria, and the EU.[15]
- The scope includes various forms of digital content, such as music, images, and online publications, and examines both traditional and emerging business models.
- The study considers the views of creators, copyright owners, users, policymakers, and technology providers.[16]

[8] Peukert, C., & Windisch, M., 2024. The Economics of Copyright in the Digital Age. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4608809.

[9] Wunsch-Vincent, S., 2016. The economics of copyright and the Internet. , pp. 229-246. https://doi.org/10.4337/9780857939852.00019.

[10] Nasir, R., Ponnusamy, V., & Lee, K., 2007. Copyright Protection In The Digital Era: A Malaysian Perspective.

[11] Ufuoma, O., & Alloh, B., 2024. The Prospects/Shortcomings of the Nigerian Copyright Act 2022 With Regards to Criminal Liability for Copyright Infringement. *Global Journal of Politics and Law Research*. https://doi.org/10.37745/gjplr.2013/vol12n62043.

[12] Shen, W., Rong, J., Liu, Y., & Zhao, Y., 2022. IrisMarkNet: Iris feature watermarking embedding and extraction network for image copyright protection. *Applied Intelligence*, 53, pp. 9992 - 10008. https://doi.org/10.1007/s10489-022-04047-5.

[13] Kim, M., 2007. The Creative Commons and Copyright Protection in the Digital Era: Uses of Creative Commons Licenses. *J. Comput. Mediat. Commun.*, 13, pp. 187-209. https://doi.org/10.1111/j.1083-6101.2007.00392.x.

[14] Tian, Y., 2008. Re-thinking Intellectual Property: The Political Economy of Copyright Protection in the Digital Era. . https://doi.org/10.4324/9780203889794.

[15] Tanghe, Y. 2016. Copyright Protection in the Digital Era: Hyperlinking and the Right of Communication to the Public. The GS Media Case.

[16] Kim, M. 2007. The Creative Commons and Copyright Protection in the Digital Era: Uses of Creative Commons Licenses. J. Comput. Mediat. Commun., 13, 187-209. https://doi.org/10.1111/j.1083-6101.2007.00392.x.

Research Questions

1. What are the legal and ethical implications of DRM on consumer rights and fair use? How do consumers perceive DRM-protected content compared to non-DRM content?
2. How do international copyright laws affect the implementation and enforcement of DRM systems across borders?
3. To what extent do current copyright laws support or hinder innovation in DRM technologies?
4. How do different jurisdictions balance DRM enforcement with the public's right to access and use digital information?

Review of Literature

- **Garnett, (2001)-** Policy Evolution in effective DRM should incorporate copyright exceptions, balance enforcement with access, and evolve alongside digital trends.
- **Makhdumi & Khan (2008)-** Libraries and Education helps DRM poses specific challenges to libraries and educational institutions that rely on fair use provisions for teaching and research.
- **Maji & Das, (2009)-** Need for Managerial Oversight beyond technical implementation, DRM needs thoughtful management to align with institutional goals, especially in digital libraries.
- **Nagpal, (2017)-** Balancing Rights and Access in a recurring concern is the tension between DRM-enforced protection and user rights like fair use. Strict DRM can undermine the public's right to access knowledge and information.
- **Tan et al., (2020)-** Integration with Blockchain aims in some researchers to propose blockchain-based DRM systems for immutable, transparent rights enforcement, offering an innovative solution to problems like attribution and transaction tracking.
- **Mogol & Crudu, (2023)-** It distinguished between Public Interest vs. Private Rights. The increasing use of DRM risks skewing copyright law in favour of corporate interests, reducing the public domain and cultural accessibility.
- **Atanasova (2024)-** Safeguarding Digital Content in DRM provides mechanisms to prevent unauthorized reproduction and distribution of digital works, including text, music, and video.
- **Peukert & Windisch (2024)-** Economic and Innovation Impacts Copyright enforcement strategies, including DRM, must consider their broader impact on innovation, fair competition, and creativity
- **Alsamara et al., (2025)-** Traditional copyright laws struggle to keep pace with digital technologies that enable mass copying and sharing, prompting calls for more robust and adaptive DRM solutions.

Copyright Law – Fundamentals and Evolution

Copyright law is a foundational element of intellectual property, designed to protect the rights of creators and promote the advancement of knowledge and culture. Its principles and frameworks have evolved over centuries, adapting to technological changes from the analog era to the digital age. International agreements have played a crucial role in harmonizing copyright protection across borders.

A. Concept and rationale of Copyright

Copyright is a set of legal rules that protect the rights of creators over their original works in literature, art, science, and other fields. It grants both personal (moral) and economic rights, arising automatically upon creation and fixation of a work.[17]

The main rationale is to incentivize creativity by granting creators exclusive rights, while also ensuring

public access to knowledge and culture. Copyright aims to balance the interests of rights holders and the public, promoting both innovation and the dissemination of information.[17]

B. Rights under Copyright law

- **Exclusive Rights:** Copyright holders are granted exclusive rights such as reproduction, distribution, public performance, adaptation, and making works available to the public.[18]
- **Moral and Economic Rights:** These include the right of attribution (paternity), the right to the integrity of the work, and the right to exploit the work economically.[19]
- **Limitations and Exceptions:** Doctrines like fair use and statutory licenses allow certain uses without permission, balancing protection with public interest.[20]
- **Infringement and Remedies:** Copyright law provides remedies for infringement, including monetary damages, injunctions, and criminal sanctions.[21]

C. Historical development from Analog to digital

Copyright law has roots in the Statute of Anne (1710) and earlier regulations, evolving through major legal milestones such as the Copyright Act of 1976 and subsequent reforms.[22] The rise of the internet and digital technologies has complicated enforcement, increased piracy, and required new legal and technological responses to protect rights in a global, digital environment.[23]

The Rise of Digital Content and New Challenges

The digital revolution has led to an unprecedented surge in the creation, distribution, and consumption of digital content. While this has expanded access and opportunities for creators and consumers, it has also introduced significant challenges related to copyright protection, piracy, and enforcement.

A. Digital revolution and Content proliferation

The widespread adoption of digital technologies has made it easy to produce and share vast amounts of content, including music, films, software, and books, without the need for physical media.[24] Online streaming platforms and peer-to-peer networks have revolutionized content delivery, offering instant access to a global audience.[25]

- **Nature of Digital works**
- Digital works can be copied perfectly and distributed globally at virtually no cost, making unauthorized sharing and privacy much easier compared to analog formats.[26]

[17] Sujatmiko, A., Haq, H., Romadhona, M., & Antons, C., 2024. Pierre Cardin and the Legal Battle for Well-Known Marks: Insights from Indonesia and the Netherlands. *Hasanuddin Law Review*. https://doi.org/10.20956/halrev.v10i3.5583.
[18] Landy, G., & Mastrobattista, A., 2008. Digital Copyright Basics. . https://doi.org/10.1016/B978-1-59749-256-0.00002-3.
[19] Goldstein, P., 2001. International Copyright: Principles, Law, and Practice.
[20] Adu, T., & Walt, T., 2021. Effects of awareness of user rights on compliance with copyright laws and policies in academic libraries. The Journal of Academic Librarianship. https://doi.org/10.1016/J.ACALIB.2021.102359.
[21] Choudhary, S., 2024. Copyright Infringement: Bridging the Gap Between Legislation and Enforcement. International Journal For Multidisciplinary Research. https://doi.org/10.36948/ijfmr.2024.v06i03.19965.
[22] Kantorowicz, J., Kantorowicz-Reznichenko, E., & Nahmias, Y., 2025. The price of creativity: a conjoint experiment in copyrights. Journal of Public Policy. https://doi.org/10.1017/s0143814x25000042.
[23]Alsamara, T., Iriqat, M., & Zamouna, A., 2025. Legal Protection of Copyright in the Digital Era. Journal of Ecohumanism. https://doi.org/10.62754/joe.v4i1.6008.
[24] Shah, R., Cemiloglu, D., Yucel, C., Ali, R., & Katos, V., 2024. Is cyber hygiene a remedy to IPTV infringement? A study of online streaming behaviours and cyber security practices. *Int. J. Inf. Sec.*, 23, pp. 1913-1926. https://doi.org/10.1007/s10207-024-00824-0.
[25] Rahman, Z., 2023. Enforcing Copyright on Online Streaming Platforms: Challenges Faced by Rights Holders in the Digital Era. International Journal For Multidisciplinary Research. https://doi.org/10.36948/ijfmr.2023.v05i05.8075.

- Peer-to-peer and torrent technologies facilitate the rapid spread of pirated content, challenging traditional business models.

B. Piracy and unauthorized access

Digital piracy, defined as the unauthorized copying and distribution of digital goods, is a global issue that undermines revenue and creative incentives for rights holders.[26] The availability of affordable, legal content has been shown to reduce piracy rates, suggesting that market solutions can be more effective than enforcement alone.[27]

C. Challenges in the digital environment

Digital technologies make unauthorized copying and distribution of works much easier, increasing the risk of copyright violations and threatening creators' financial interests.[28] The roles of copyright owners, users, and platforms are increasingly blurred, creating tensions between free information flow and exclusive rights.[29] Rapid technological change often outpaces legal frameworks, leading to inconsistencies and the need for updated laws and international cooperation.[30]

D. Balancing interests and access

Effective copyright systems must balance protection for creators with public interests, such as education, research, and cultural development, by allowing certain exceptions and limitations.[31] Aligning the interests of businesses, creators, and users is key to developing sustainable copyright-sharing models in the digital economy.[32]

Digital Rights Management and Legal Frameworks supporting DRM

Digital Rights Management (DRM) is a set of technologies and systems designed to control the use, distribution, and access to digital content. Its primary goal is to protect the rights of content creators and copyright holders in the digital environment, balancing the need for content protection with user accessibility.

DRM refers to technological measures that control user access to digital products, preventing unauthorized copying, sharing, or use of content such as music, films, books, and software.[33] The main objectives are to prevent piracy, ensure fair compensation for creators, manage licensing, and sometimes facilitate open access or restricted use depending on the rights holder's intent.[34]

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[26] Latif, M., Manap, N., & Althabhawi, N., 2025. MODERNISING SITE-BLOCKING MECHANISM IN PROTECTING COPYRIGHT OWNERS CONTENT AGAINST DIGITAL PIRACY IN MALAYSIA. Malaysian Journal of Syariah and Law. https://doi.org/10.33102/mjsl.vol13no1.763.

[27] Quintais, J., & Poort, J., 2019. The Decline of Online Piracy: How Markets – Not Enforcement – Drive Down Copyright Infringement. American University of International Law Review, 34, pp. 807-876.

[28] Wen, S., 2024. How Can Institutional and Technical Improvements Enhance Copyright Protection in the Digital Economy?. *Modern Economics & Management Forum*. https://doi.org/10.32629/memf.v5i5.2848.

[29] Lee, J., 2019. Tripartite Perspective on the Copyright-Sharing Economy in China. *Legal Anthropology: Laws & Constitutions eJournal*. https://doi.org/10.1016/j.clsr.2019.05.00.

[30] Alsamara, T., Iriqat, M., & Zamouna, A., 2025. Legal Protection of Copyright in the Digital Era. *Journal of Ecohumanism*. https://doi.org/10.62754/joe.v4i1.6008.

[31] Ennan, R., 2025. Enforcement and protection of copyright in the digital environment (on the Internet). *Uzhhorod National University Herald. Series: Law*. https://doi.org/10.24144/2307-3322.2024.86.2.16.

[32] Causi, M., 2019. Digital challenge for copyright and regulation. , pp. 165-172. https://doi.org/10.1446/94082.

[33] Smith, K., Burger, B., Gay, J., Eschenfelder, K., & Kasprowski, R., 2009. DRM: Digital rights management or digital restrictions management?. , pp. 1-3. https://doi.org/10.1002/MEET.2008.1450450114.

[34] Fitzgerald, B., & Reid, J., 2005. Digital Rights Management (DRM): Managing Digital Rights for Open Access. , pp. 268. https://doi.org/10.4337/9781845426842.00031.

A. Technical components

- **Encryption:** Protects content by making it accessible only to authorized users with the correct decryption keys.[35]
- **Authentication:** Verifies the identity of users or devices before granting access to protected content.[36]
- **Access Control:** Sets rules for what users can do with the content (e.g., view, copy, print, share), often encoded directly into the product or hardware.[37]

B. Types of DRM systems

1. **Hardware-based**- DRM controls embedded in physical devices (e.g., e-readers, gaming consoles)
2. **Software-based-** DRM implemented through software applications or operating systems.
3. **Watermarking**- Embeds invisible information in content to trace unauthorized distribution.
4. **Blockchain-based**- Uses distributed ledgers for transparent rights management and royalty enforcement.

Music and Film are widely used to control copying, streaming, and sharing of digital media. Publishing e-books and academic content often use DRM to restrict printing, copying, and sharing. Software is used for licensing and activation systems prevent unauthorized installation and use. Education plays a crucial role in specialized DRM systems manage access and rights for digital educational materials.

C. Legal Frameworks

Legal frameworks supporting Digital Rights Management (DRM) are built on a combination of statutory recognition, anti-circumvention laws, judicial interpretations, and the use of licensing and contracts. These frameworks aim to protect digital content but also raise concerns about user rights and fair use.

Legal recognition of DRM technologies

DRM technologies are explicitly recognized and protected by law in many jurisdictions, notably in the U.S. and the European Union, where legislation has been crafted to address the unique challenges of digital content protection.[38] The legal framework for DRM is not limited to technology alone but also includes contracts, licenses, and traditional copyright law, creating a multi-layered system of protection.[39]

Anti-Circumvention Laws

1. **U.S.:** The Digital Millennium Copyright Act (DMCA) Section 1201 prohibits the circumvention of technological protection measures (TPMs) and the trafficking of circumvention tools, regardless of whether actual copyright infringement occurs.[40]

[35] , Z., Jiang, M., Gao, H., & Wang, Z., 2018. Blockchain for digital rights management. Future Gener. Comput. Syst., 89, pp. 746-764. https://doi.org/10.1016/j.future.2018.07.029.

[36] Özmen, A., Sansli, A., & Sahin, V., 2018. EDU-DRM: A Digital Rights Management (DRM) system for K-12 education. Scientia Iranica, 26, pp. 103-113. https://doi.org/10.24200/SCI.2018.5345.1219.

[37] Jamkhedkar, P., & Heileman, G., 2009. Digital rights management architectures. Comput. Electr. Eng., 35, pp. 376-394. https://doi.org/10.1016/j.compeleceng.2008.06.012.

[38] Bechtold, S., 2004. Digital Rights Management in the United States and Europe. American Journal of Comparative Law, 52, pp. 323-382. https://doi.org/10.2307/4144454.

[39] Bechtold, S., 2006. The Present and Future of Digital Rights Management. *2006 Second International Conference on Automated Production of Cross Media Content for Multi-Channel Distribution (AXMEDIS'06)*, pp. 6-7. https://doi.org/10.1109/AXMEDIS.2006.52.

[40] Ashtar, R., 2011. Licensing as Digital Rights Management, from the Advent of the Web to the iPad. *Yale Journal of Law and Technology*, 13, pp. 141.

2. **EU:** The EU Copyright Directive (EUCD) Article 6 similarly bans circumvention of DRM and the distribution of circumvention devices.[41]
3. **International:** The WIPO Copyright Treaty (WCT) requires member states to provide legal protection for DRM and anti-circumvention measures.[42]
4. These laws can sometimes extend beyond traditional copyright, potentially restricting legitimate uses such as fair use or exceptions for research and education.

Role of Licensing and contractual terms

Licensing agreements and contracts are central to DRM, often defining the scope of user rights and restrictions beyond what copyright law provides.[43] The combination of DRM technology and restrictive licensing can further limit user rights, sometimes overriding statutory copyright exceptions.[44] This intertwining of legal and technical controls can create a new form of property right, raising concerns about over-protection and the erosion of public interest safeguards.

Legal And Ethical Balance Between DRM vs. User Rights and The Future of DRM

The increasing use of Digital Rights Management (DRM) technologies has sparked significant debate about the balance between protecting copyright holders and preserving user rights. Legal and ethical concerns focus on fair use, consumer access, and the broader impact on knowledge sharing and accessibility.

A. Fair use and user exceptions under copyright law

Fair use allows users to engage with copyrighted works for purposes such as criticism, research, and education. However, most DRM systems do not accommodate fair use exceptions, and circumventing DRM even for legitimate fair use can violate laws like the DMCA.[45] The inflexibility of DRM contrasts with the flexible, case-by-case nature of fair use, leading to conflicts where users are prevented from making lawful uses of content.[46]

B. Criticism of DRM

- **Overreach and Consumer Rights:** DRM is often criticized for restricting not only piracy but also legitimate consumer activities, such as making backup copies or shifting content between devices.[47]
- **Access to Knowledge:** Strict DRM can limit the dissemination and reuse of information, potentially stifling creativity and innovation. Critics argue that DRM can extend copyright protection beyond its intended scope, undermining public interest and access to knowledge.[48]

[41] Deveci, H., 2012. Can hyperlinks and digital rights management secure affordable access to information?. *Comput. Law Secur. Rev.*, 28, pp. 651-661. https://doi.org/10.1016/J.CLSR.2012.09.002.
[42] Samuelson, P., 2003. Digital Rights Management {and, or, vs.} the Law. *Communications of The ACM*, 46.
[43] Kubesch, A., & Wicker, S., 2015. Digital rights management: The cost to consumers. *Proc. IEEE*, 103, pp. 726-733. https://doi.org/10.1109/JPROC.2015.2418457.
[44] Bechtold, S., 2001. From Copyright to Information Law - Implications of Digital Rights Management. , pp. 213-232. https://doi.org/10.1007/3-540-47870-1_14.
[45] Bober-Kotarbińska, A., 2024. The Justification for Establishing Exceptions and Limitations to Copyright for Programs based on Artificial Intelligence. *Gdańskie Studia Prawnicze*. https://doi.org/10.26881/gsp.2024.4.02.
[46] Hazarika, S., 2012. Digital Rights Management: A Restrictive Rather than a Defensive Mechanism and the Survival of the 'Fair Use' Doctrine. . https://doi.org/10.2139/SSRN.2180305.
[47] Smith, K., Burger, B., Gay, J., Eschenfelder, K., & Kasprowski, R., 2009. DRM: Digital rights management or digital restrictions management?. , pp. 1-3. https://doi.org/10.1002/MEET.2008.1450450114.
[48] Moscon, V., 2011. Rights Expression Languages: DRM vs. Creative Commons. *Legal Perspectives in Information Systems eJournal*. https://doi.org/10.4403/JLIS.IT-4593.

- **Market Impact:** Overly restrictive DRM may reduce consumer demand and does not always benefit copyright owners, as some studies suggest piracy can decrease when DRM restrictions are relaxed.[49]

A. DRM and accessibility issues

DRM can hinder access for people with disabilities by preventing the use of assistive technologies or limiting the ability to adapt content for accessibility needs.[50] There is ongoing dialogue about the need for DRM systems to consider ease of access and legitimate use for all users, including those with disabilities. Creative Commons (CC) licenses use technology similar to DRM but aim to facilitate sharing, reuse, and open access to content. They provide a flexible, decentralized approach that empowers creators to specify permissions while promoting knowledge diffusion.[51] Open access and CC represent alternatives to restrictive DRM, focusing on maximizing the dissemination and collaborative development of knowledge. DRM technologies, while effective in protecting digital content, often conflict with user rights such as fair use, accessibility, and consumer freedoms. Alternative models like Creative Commons and open access seek to restore balance by promoting sharing and flexibility, highlighting the need for ongoing legal and technological innovation to ensure both protection and access.

B. Technological Advancement

Technological advances are rapidly transforming Digital Rights Management (DRM), introducing new tools and strategies to address the challenges of protecting digital content in increasingly complex environments. Innovations in AI, blockchain, watermarking, and interoperability are shaping the future of DRM for streaming, cloud, and emerging platforms like the metaverse.

Blockchain is being used to create decentralized, transparent, and tamper-resistant DRM systems. Solutions like DRP Chain and Y-DWMS leverage blockchain for robust copyright management, efficient consensus protocols, and non-repudiation through smart contracts, making infringement more difficult and traceable.[52]

Artificial intelligence is enhancing DRM by improving fingerprinting and watermarking accuracy, automating content verification, and streamlining content administration. AI-driven approaches help detect counterfeiting and support decision-making in digital asset management. Blockchain, combined with AI-generated content (AIGC), is being explored for model watermarking and ownership verification, addressing the unique challenges of generative AI content.[53]

Interoperability and Standards Issues

As content delivery involves multiple distributors and platforms, new DRM architectures are being developed to ensure security and traceability across all parties. Joint watermarking schemes and blockchain-based protocols are designed to address interoperability and support complex distribution

[49] Foroughi, A., Albin, M., & Gillard, S., 2002. Digital rights management: a delicate balance between protection and accessibility. *Journal of Information Science*, 28, pp. 389 - 395. https://doi.org/10.1177/016555150202800504.

[50] Xie, H., 2007. Protecting fair use from digital rights management in china. , pp. 33-38. https://doi.org/10.1145/1314276.1314284.

[51] O'Dwyer, R., 2018. Limited edition: Producing artificial scarcity for digital art on the blockchain and its implications for the cultural industries. *Convergence: The International Journal of Research into New Media Technologies*, 26, pp. 874 - 894. https://doi.org/10.1177/1354856518795097.

[52] Yun, J., Liu, X., Lu, Y., Guan, J., & Liu, X., 2024. DRPChain: A new blockchain-based trusted DRM scheme for image content protection. *PLOS ONE*, 19. https://doi.org/10.1371/journal.pone.0309743.

[53] Chen, C., Li, Y., Wu, Z., Xu, M., Wang, R., & Zheng, Z., 2023. Towards Reliable Utilization of AIGC: Blockchain-Empowered Ownership Verification Mechanism. *IEEE Open Journal of the Computer Society*, 4, pp. 326-337. https://doi.org/10.1109/OJCS.2023.3315835.

chains.[54] Cloud-based DRM solutions, combined with blockchain, offer scalable and user-friendly protection, reducing reliance on trusted third parties and adapting to the needs of both content providers and end users.[55]

Digital Watermarking and Fingerprinting

Combining watermarking and fingerprinting, often enhanced by AI, provides robust copyright identification and ownership tracking for images and videos.[56] Storing watermark data on blockchain ensures authenticity, traceability, and efficient verification, even without access to the original content. These methods improve memory efficiency and resilience against attacks.[57] New schemes introduce user-side embedding for better efficiency and traceability in multi-owner media sharing.[58]

Future-Proofing DRM for Streaming, Cloud, and Metaverse Content

Advanced consensus algorithms and memory-efficient watermarking are being developed to handle the scale and complexity of streaming, cloud, and metaverse environments.[59] Emerging DRM systems focus on user-friendliness, transparency, and minimizing the need for intermediaries, supporting direct interaction between content owners and consumers.[60] Ongoing research aims to ensure DRM systems remain effective as new content formats and distribution models emerge, including AI-generated and immersive metaverse content.[61]

Challenges to enforcement in the digital domain

The global nature of the internet makes it difficult to enforce copyright laws across different countries and legal systems.[62] Pirates often use technical means to bypass site-blocking and other enforcement mechanisms, reducing their effectiveness. Enforcement policies can trigger both deterrence (reducing piracy) and defiance (increasing piracy), depending on users' emotional responses and social norms.[63]

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[54] Thomas, T., Emmanuel, S., Subramanyam, A., & Kankanhalli, M., 2009. Joint Watermarking Scheme for Multiparty Multilevel DRM Architecture. *IEEE Transactions on Information Forensics and Security*, 4, pp. 758-767. https://doi.org/10.1109/tifs.2009.2033229.

[55] Frattolillo, F., 2021. Blockchain and Cloud to Overcome the Problems of Buyer and Seller Watermarking Protocols. *Applied Sciences*. https://doi.org/10.3390/app112412028.

[56] Liu, X., Zhu, Y., Sun, Z., Diao, M., & Zhang, L., 2015. A novel robust video fingerprinting-watermarking hybrid scheme based on visual secret sharing. *Multimedia Tools and Applications*, 74, pp. 9157-9174. https://doi.org/10.1007/s11042-014-2073-4.

[57] Geethanjali, D., Priya, R., & Bhavani, R., 2020. Blockchain-Based Protected Digital Copyright Management with Digital Watermarking. . https://doi.org/10.3233/apc200113.

[58] Xiao, X., Zhang, Y., Zhu, Y., Hu, P., & Cao, X., 2023. FingerChain: Copyrighted Multi-Owner Media Sharing by Introducing Asymmetric Fingerprinting Into Blockchain. *IEEE Transactions on Network and Service Management*, 20, pp. 2869-2885. https://doi.org/10.1109/TNSM.2023.3237685.

[59] Darwish, S., Abu-Deif, M., & Elkaffas, S., 2024. Blockchain for video watermarking: An enhanced copyright protection approach for video forensics based on perceptual hash function. *PLOS ONE*, 19. https://doi.org/10.1371/journal.pone.0308451.

[60] Frattolillo, F., 2021. Blockchain and Cloud to Overcome the Problems of Buyer and Seller Watermarking Protocols. *Applied Sciences*. https://doi.org/10.3390/app112412028.

[61] Chen, C., Li, Y., Wu, Z., Xu, M., Wang, R., & Zheng, Z., 2023. Towards Reliable Utilization of AIGC: Blockchain-Empowered Ownership Verification Mechanism. *IEEE Open Journal of the Computer Society*, 4, pp. 326-337. https://doi.org/10.1109/OJCS.2023.3315835.

[62] Rahman, Z., 2023. Enforcing Copyright on Online Streaming Platforms: Challenges Faced by Rights Holders in the Digital Era. International Journal For Multidisciplinary Research. https://doi.org/10.36948/ijfmr.2023.v05i05.8075.

[63] Miocevic, D., 2022. Deterrence and defiance as responses to copyright enforcement policies of digital content: appraisal tendency perspective. *Inf. Technol. People*, 36, pp. 1252-1269. https://doi.org/10.1108/itp-12-2021-0937.

Digital Rights Management technologies have not fully succeeded in preventing infringement, highlighting the need for multi-faceted approaches.[64]

The future of DRM is being shaped by AI, blockchain, and advanced watermarking/fingerprinting, which together enhance security, traceability, and efficiency. Addressing interoperability and scalability is crucial for protecting content across streaming, cloud, and metaverse platforms, ensuring DRM remains robust and adaptable in a rapidly evolving digital landscape.

Comparative Legal and Policy Approaches

Comparative legal and policy approaches to Digital Rights Management (DRM) reveal significant differences across jurisdictions, ongoing challenges in international harmonization, and evolving best practices. These differences impact the effectiveness of DRM enforcement and the balance between copyright protection and user rights.

A. DRM Laws and Enforcement in Different Jurisdictions

- **United States:** The US enforces strong anti-circumvention provisions through the DMCA, giving copyright holders robust legal tools to protect digital content. Enforcement is supported by both legal action and technological measures, but challenges remain in addressing piracy and user rights.
- **European Union:** The EU Copyright Directive mandates protection for technological measures like DRM, with each member state implementing its own enforcement mechanisms. The EU also emphasizes user rights and exceptions, but practical enforcement varies.[65]
- **China:** China has enacted statutes regulating DRM circumvention, aligning with international treaties. However, enforcement is complicated by technological loopholes and the scale of digital content distribution.
- **India and Indonesia:** These countries have updated copyright laws to address digital content, but enforcement is often hampered by limited resources, jurisdictional issues, and the rapid spread of digital works. Indonesia, for example, faces challenges in law enforcement and public awareness, despite comprehensive copyright legislation.[66]
- **Global Trends:** Across jurisdictions, DRM is widely adopted by major content providers, but the effectiveness of enforcement is mixed, with ongoing issues of piracy and circumvention.[67]

B. International Cooperation and Harmonization Challenges

The global nature of digital content makes cross-border enforcement difficult, as legal standards and enforcement capabilities differ widely.[68] International agreements like the WIPO Internet Treaties aim to harmonize DRM protection, but practical implementation and cooperation remain inconsistent.[69] The rise

[64] Gill, S., & Dorsen, A., 2024. The Work of Art in the Age of Digital Commodification. TDR: The Drama Review, 68, pp. 19 - 50. https://doi.org/10.1017/S1054204323000618.

[65] Sun, Y., 2014. Rightholder as the Center: The DRM System in Copyright after so Many Years. . https://doi.org/10.2139/SSRN.2430424.

[66] Sanusi, R., Sasea, E., & Bonsapia, M., 2024. Copyright Protection in the Digital Age: Addressing Challenges and Finding Solutions in Indonesian Civil Law. *Sinergi International Journal of Law*. https://doi.org/10.61194/law.v2i3.170.

[67] Oliver, S., & Winarta, T., 2021. The Lack of Enforcement of the DRM Policy. , 7, pp. 15-25. https://doi.org/10.33555/EJAICT.V7I1.73.

[68] Rahman, Z., 2023. Enforcing Copyright on Online Streaming Platforms: Challenges Faced by Rights Holders in the Digital Era. *International Journal For Multidisciplinary Research*. https://doi.org/10.36948/ijfmr.2023.v05i05.8075.

[69] Kantaros, A., 2024. Intellectual Property Challenges in the Age of 3D Printing: Navigating the Digital Copycat Dilemma. *Applied Sciences*. https://doi.org/10.3390/app142311448.

of new digital asset classes increases the need for harmonized principles and best practices, but legal uncertainties persist.[70]

C. Best Practices and Policy Recommendations

Effective DRM enforcement requires a combination of legal, technological, and industry-led approaches, including improved detection technologies and streamlined reporting processes.[71] Increasing public awareness and simplifying copyright processes can reduce unintentional infringement and improve compliance.[72] Policymakers are encouraged to balance copyright protection with user rights, ensuring that DRM does not excessively restrict legitimate uses or access to knowledge.[73] Ongoing dialogue and cooperation between governments, industry, and international bodies are essential for addressing cross-border challenges and developing adaptable, future-proof DRM frameworks.

DRM laws and enforcement vary significantly across jurisdictions, with the US, EU, China, and others adopting distinct approaches. International harmonization remains challenging due to legal, technical, and practical differences. Best practices emphasize a balanced, multi-faceted approach that combines robust enforcement with user rights, transparency, and international cooperation.

Case Studies

1. **iTunes (Apple's FairPlay DRM)-** iTunes was one of the earliest and most successful DRM implementations, credited with creating a viable market for legal music downloads by balancing consumer usability and copyright protection.[74] Its centralized model created bandwidth bottlenecks and user frustration, prompting research into decentralized alternatives like P2PTunes.[75] iTunes' DRM was criticized for enabling infringement and complicating legal boundaries around personal copying and device compatibility.[76]
2. **Netflix, Disney+, Amazon (Cloud-based DRM)-** These platforms use advanced DRM systems like Apple FairPlay, Google Widevine, and Microsoft PlayReady to secure streaming content, offering seamless user experiences across devices. The systems are still vulnerable to microarchitectural side-channel attacks and lack post-quantum security measures.[77]
3. **Adobe and eBooks-** Adobe's DRM in PDF files and eBooks uses techniques like Hardware Fingerprint Encryption to enforce both access and usage control effectively. Users often find DRM-protected eBooks less usable, which negatively affects marketability. Consumers prefer unprotected

[70] De Las Heras Ballell, T., 2024. The Emergence of Principles and Best Practices on Digital Assets: Proprietary Rights, and Enforcement. *European Journal of Risk Regulation*. https://doi.org/10.1017/err.2024.55.
[71] Sanusi, R., Sasea, E., & Bonsapia, M., 2024. Copyright Protection in the Digital Age: Addressing Challenges and Finding Solutions in Indonesian Civil Law. *Sinergi International Journal of Law*. https://doi.org/10.61194/law.v2i3.170.
[72] Oliver, S., & Winarta, T., 2021. The Lack of Enforcement of the DRM Policy. , 7, pp. 15-25. https://doi.org/10.33555/EJAICT.V7I1.73.
[73] S, R., 2024. Securing the Digital Landscape: Present Concerns and Hurdles in Digital Rights Management. *International Journal of Science and Research (IJSR)*. https://doi.org/10.21275/sr24118193759.
[74] Guth, S., 2004. Interoperability of Digital Rights Management Systems via the Exchange of XML-based Rights Expressions.
[75] Bhatt, S., Sion, R., & Carbunar, B., 2009. A personal mobile DRM manager for smartphones. *Comput. Secur.*, 28, pp. 327-340. https://doi.org/10.1016/j.cose.2009.03.001.
[76] Yanisky-Ravid, S., & Martens, C., 2019. From the Myth of Babel to Google Translate: Confronting Malicious Use of Artificial Intelligence – Copyright and Algorithmic Biases in Online Translation Systems. *Intellectual Property: Copyright Law eJournal*. https://doi.org/10.2139/ssrn.3345716.
[77] Gudinavičius, A., & Grigas, V., 2021. Causes and consequences of unauthorized use of books: readers, authors, and publishers' perspective. *Online Inf. Rev.*, 46, pp. 886-903. https://doi.org/10.1108/oir-03-2021-0133.

formats due to better flexibility and access.[78] Restrictive DRM rights (e.g., no copy/print) decrease eBook prices and publisher revenue due to the increased risk of piracy perception and reduced customer satisfaction.[79]

Lessons Learned

- Effective DRM should protect rights without overly restricting legitimate use. Overly aggressive DRM often leads to backlash and circumvention.
- Moving from centralized systems (e.g., iTunes servers) to decentralized or hybrid P2P solutions (e.g., P2PTunes) can reduce bottlenecks.
- Current laws like DMCA Section 1201 often overprotect DRM, stifling innovation and consumer rights. Better legal clarity is needed on what constitutes fair circumvention.
- DRM implementations that reduce usability can directly hurt adoption, pricing power, and long-term sustainability in digital markets.

Conclusion

DRM systems like Apple's iTunes and Netflix have enabled content monetization by offering secure digital distribution channels. Consumers show resistance toward restrictive DRM, especially in the eBook market, where usability and access flexibility are critical. The DMCA's anti-circumvention rules (e.g., Section 1201) are often overly broad, leading to excessive protection that may hinder innovation and fair use. Even modern DRM systems are not immune to sophisticated attacks and lack future-proofing against threats like quantum computing.

Implications

- **For Copyright Holders:** DRM is a useful enforcement tool, but overly rigid systems can alienate customers and encourage piracy. Effective DRM should complement, not replace, competitive pricing, user-friendly access, and innovation in distribution.
- **For Consumers:** Current DRM models often compromise usability, interoperability, and fair use. There is a growing need for transparent DRM policies and user rights, including allowances for device compatibility and content backups.
- **For Lawmakers:** Overly protective laws can stifle innovation, restrict legitimate uses, and fail to align with evolving digital norms. Legislative frameworks must better distinguish between malicious piracy and legitimate circumvention (e.g., accessibility, device switching).

Recommendations for a balanced DRM approach

- DRM systems must prioritize usability by allowing reasonable uses such as content backup, offline access, and cross-device interoperability.
- Combine technical controls with dynamic licensing models to accommodate changing market expectations and user needs.

[78] Kasassbeh, F., 2021. The dilemma of information consumers' protection under the copyright law: the problem and possible reforms. *Information & Communications Technology Law*, 31, pp. 155 - 175. https://doi.org/10.1080/13600834.2021.1982192.
[79] Li, K., Zhang, L., Wang, D., & Pan, D., 2021. The Effects of Online Information on E-Book Pricing Strategies: A Text Analytics Approach. *Mathematical Problems in Engineering*. https://doi.org/10.1155/2021/2058960.

- Revise anti-circumvention laws to better distinguish between piracy and legitimate user rights. Introduce exemptions for educational use, accessibility, and innovation.
- Invest in DRM systems that are resistant to modern cyber threats, including side-channel attacks and quantum threats.
- Encourage cooperation among tech companies, rights holders, users, and regulators to build interoperable, transparent, and equitable DRM ecosystems.

Areas for Further Research and Reform

- Post-quantum secure DRM systems
- Impact of DRM on accessibility for disabled users
- Interoperability standards across devices and platforms
- Consumer awareness and perception of DRM transparency
- Market effects of DRM on subscription vs. ownership models

A successful DRM regime in the digital era must balance protection with access, security with usability, and enforcement with flexibility. Reforms in law, technology, and policy are necessary to support sustainable digital ecosystems that benefit creators and consumers alike.