Standard Essential Patents and FRAND Licensing in AI, IoT and Automotive Innovation

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Abstract: Standard Essential Patents (SEPs) and Fair, Reasonable, and Non-Discriminatory (FRAND) licensing underpin interoperability in Artificial Intelligence (AI), Internet of Things (IoT), and automotive technologies. The problem lies in the persistent inconsistency of FRAND interpretation and enforcement across jurisdictions, which generates uncertainty in global rate-setting, limits access for SMEs, and creates tension over injunctions and aggregate royalty transparency. This research therefore asks: How should FRAND principles be applied and adapted across leading jurisdictions to balance innovation incentives for SEP holders with fair, predictable access for implementers in emerging technology markets? A comparative doctrinal analysis is conducted across the European Union, United Kingdom, United States, China and India discussing the landmark cases such as Huawei v. ZTE, Nokia v. Daimler, Sisvel v. Haier (EU/Germany), Unwired Planet v. Huawei (UK), FTC v. Qualcomm (US), and Ericsson v. Xiaomi (India/China). The paper also looks at standards policies (ETSI, IEEE, and ISO) and collective licensing systems like Avanci, while we also examine that how the EU Commission's 2023 SEP Regulation (COM/2023/232) affected the consistency of European policy. The findings show that royalty stacking, over-declaration, and a lack of involvement by small and medium-sized businesses are still problems. Finally, the study ends by suggesting specific changes, such as open royalty registers, FRAND paths that include small and medium-sized businesses, larger patent pools, and uniform means to settle disputes.

Keywords: Standard Essential Patents (SEPs), FRAND Licensing, Artificial Intelligence (AI), Internet of Things (IoT), Automotive Innovation

1. Introduction

Standard Essential Patents have traditionally been prominent in telecommunications, but their influence is now expanding into AI, IoT, automotive systems, and smart devices, particularly in the EU and its interaction between SEPs and competition law has become increasingly complex in the 5G, where regulatory and judicial precedents aim to balance innovation incentives with antitrust safeguards.[1]. The current literature emphasizes that the ETSI FRAND commitment does not categorically prohibit SEP holders from seeking injunctions, clarifying a widespread misconception in European and U.S. policy debates. Interoperability and modular architectures make standards and thus FRAND-encumbered SEPs central to innovation and market entry, as reflected in ETSI's Clause 6 FRAND undertaking and the broader international IP framework anchored in TRIPS[2]. Comparative research further suggests that competition law and licensing

[1] Metsola, Asko. "The interplay of standard essential patents (SEPs) and EU competition law in the 5G era." (2025). The study highlights how EU competition law frameworks in the 5G era must balance SEP enforcement with innovation and market fairness.
[2] Mossoff, Adam. "Patent Injunctions and FRAND Commitment: A Case Study in the ETSI Intellectual Property Rights Policy." Berkeley Tech. LJ 38 (2023): 487. The author argues that the ETSI FRAND commitment does not bar SEP holders from seeking injunctions, and that legal interpretation not economic assumptions should guide FRAND enforcement.

contracts can function as legal mechanisms to mitigate monopolistic effects of patent rights and preserve fair access to technology.[3]

In complex value chains like connected vehicles and IoT, disagreements persist over who should take the license and at what royalty base, underscored by recent scholarly work on automotive and IoT licensing models and connected car litigation, such as Nokia v. Daimler, emphasize that determining FRAND royalties in the IoT value chains requires moving beyond end-product pricing toward functional and component-level valuation models.[4] The EU's draft SEP Regulation sparked polarized reactions; recent analysis questions an EUIPO-led regime (register, essentiality checks, FRAND determinations) and contrasts it with China's SAMR guidelines[5] the same time, policymakers have identified persistent risks around fragmented FRAND interpretation, royalty stacking, and opacity in aggregate royalties concerns highlighted in the European Commission's 2023 impact assessment and sector-specific studies show how injunction exposure and licensing structure shape bargaining in the automotive space and it suggests market-based FRAND outcomes (bilateral deals and patent pools) have historically kept aggregate mobile SEP royalties $\lesssim$5% of handset revenues, challenging claims of pervasive royalty stacking.[6] This study therefore asks: How should SEP/FRAND frameworks be adapted and applied across leading jurisdictions to balance innovation incentives for SEP holders with fair, predictable access for implementers in emerging technology markets?

We use the comparative doctrinal methodology complemented by policy analysis, examining statutory frameworks, case law, and institutional instruments to identify convergence and divergence in FRAND enforcement. To explore this, our research undertakes a comparative doctrinal analysis of five jurisdictions such as the European Union, United Kingdom, United States, China, and India. We analyze landmark jurisprudence including Huawei v. ZTE CJEU, 2015[7] which sets out conditions for injunctive relief under competition law and the judgment of the CJEU remains the cornerstone of EU SEP jurisprudence establishing that injunctions by dominant SEP holders may constitute abuse of dominance under Article 102 TFEU if negotiation duties are not met; the German Federal Supreme Court's decision in FRAND-Einwand II BGH, 2020 further refined this framework, holding that injunctive relief is not abusive where the implementer fails to clearly and continuously express willingness to obtain a FRAND licenses and

[3] Harankaha, H. A. "Licensing Contracts and Competition Law as Mitigating Factors against Monopoly of Intellectual Property Rights: An Analysis." Issue 6 Int'l JL Mgmt. & Human. 7 (2024): 1224. The article explains how competition law and licensing contracts can mitigate monopolistic control of patent rights and promote balanced access to technology.

[4] Pourrahim, Maryam. "A New Approach to FRAND Royalty Determination in IoT Value Chains: Insights from Connected Cars." IIC-International Review of Intellectual Property and Competition Law 55, no. 7 (2024): 1097-1128. It proposes linking FRAND royalties in IoT and automotive markets to the technical value of connectivity rather than end-product prices.

[5] Singh, Manveen. "The European Commission's draft SEP regulation: A slippery slope or a renewed hope?." The Journal of World Intellectual Property (2025), It critically evaluates the EC draft SEP Regulation, including the EUIPO role, essentiality checks, and FRAND-rate procedure, with comparison to China's SAMR guidelines.

[6] Mallinson, Keith. "Discovering or Setting Aggregate Royalties and FRAND Rates for SEP Portfolios." JL Econ. & Pol'y 19 (2024): 1. It argues that long-run market practice in cellular standards and pools (e.g., H.264/AAC) yields modest aggregate royalty burdens ($\sim\lesssim$5% of handset revenues).

[7] Rato, Miguel, and Mark English. "An Assessment of Injunctions, Patents, and Standards Following the Court of Justice's Huawei/ZTE Ruling." Journal of European Competition Law & Practice 7, no. 2 (2016): 103-112. It provides the first detailed post-Huawei v. ZTE assessment of injunction standards and competition-law obligations for SEP holders and implementers in the EU.

both parties must negotiate in good faith without delay;[8] Unwired Planet v. Huawei UK, 2020[9], where English courts asserted authority to set global FRAND terms and the comparative analysis of the *Unwired Planet v. Huawei* judgment highlights how differing governing-law interpretations particularly the UK's reliance on English contract law over French ETSI principles that affect global FRAND uniformity[10]; FTC v. Qualcomm 9th Cir., 2020 [11], reflect the U.S. approach in prioritizing the contractual interpretation and patent rights over antitrust constraints on FRAND enforcement, although the U.S antitrust constraints on the SEP licensing that emphasize that contract remedies over the competition law enforcement.[12] In theTelefonaktiebolaget Ericsson v. Xiaomi Delhi HC, 2014/2016[13], that illustrates the Indian interim injunction and licensing practice and in other one of the recent Indian decisions such as Ericsson v. Lava Delhi HC, 2024,[14] which awarded damages in SEP litigation. We also place these within the policy and legal foundations the ETSI IPR Policy Clause 6 (commitment to license on FRAND terms)[15]; the TRIPS agreement particularly Articles 31 and 40, which provide flexibility for compulsory and anti-competitive licensing practices under the WTO framework, ensuring that intellectual property protection does not hinder competition or access to technology.[16] These TRIPS provisions, interpreted through WTO competition and abuse-of-dominance principles, reinforce that national approaches to FRAND and SEP regulation must remain adaptable across emerging technology sectors where market concentration and standardization risks are evolving.[17] Because national interpretations of FRAND diverge especially in newer technology sectors therefore, a comparative doctrinal approach is essential to discern coherent global trends and tensions.

[8] Treaty on the Functioning of the European Union, Art. 102 (2)(b) and (c) charles. heard@ ip. mpg. de. "“FRAND Defence II (FRAND-Einwand II)” Decision of the Federal Supreme Court of Germany (Bundesgerichtshof) 24 November 2020–Case No. KZR 35/17." (2021): 1465-1489. It confirms non-abuse absent clear implementer willingness; emphasizes bilateral good-faith duties and anti-holdout under Art. 102 TFEU.

[9] Binctin, Nicolas, and Jacques de Werra. "The governing law in global FRAND patent licencing disputes: a civil law perspective on the UK Supreme Court's Huawei v Unwired Planet judgment." Journal Of Intellectual Property Law and Practice 16, no. 11 (2021): 1220-1228. The authors examined the UK Supreme Court's Unwired Planet v. Huawei ruling from a civil law and French law perspective, stressing conflicts over applicable law in global FRAND licensing.

[10] Ibid, 1223-1224.

[11] Stanley, Pierce. "FTC v. Qualcomm Inc.-969 F. 3d 974 (9th Cir. 2020)." Intell. Prop. & Tech. LJ 25 (2020): 201. It summarizes that the Ninth Circuit's ruling rejecting antitrust liability for Qualcomm's "no license, no chips" policy and clarifying the boundaries of FRAND under U.S. law.

[12] Ibid., 992.

[13] Gandhi, Samir, and Shivanghi Sukumar. "Competition and Antitrust Enforcement Against Standard Essential Patents in India." The Antitrust Bulletin 62, no. 3 (2017): 447-452.

[14] Bansal, Amit. "Telefonktiebolaget Lm Ericsson (Publ) vs Lava International Ltd on 28 March, 2024." It argue that India's FRAND and SEP jurisprudence remains nascent but evolving, with the Competition Commission of India (CCI) and the Delhi High Court concurrently empowered to assess abuse-of-dominance and patent infringement claims involving Ericsson's SEPs.

[15] Mossoff, "Patent Injunctions and the FRAND Commitment," 492.

[16] Davies, Lowri. "Compulsory licensing: an effective tool for securing access to Covid-19 vaccines for developing states?." Legal Studies 43, no. 1 (2023): 86-103. The author points that TRIPS Articles 31 and 40 enable compulsory licensing as a flexibility to address anti-competitive conduct and ensure access to essential technologies**.**

[17] Schäfer, Quentin B. "Reconsidering the limits of EU competition law on the IP-Competition Interface." Journal of European Competition Law & Practice 15, no. 3 (2024): 188-196. The author argues that EU competition law, in harmony with WTO abuse-of-dominance principles, continues to shape how FRAND obligations and IP rights are balanced.

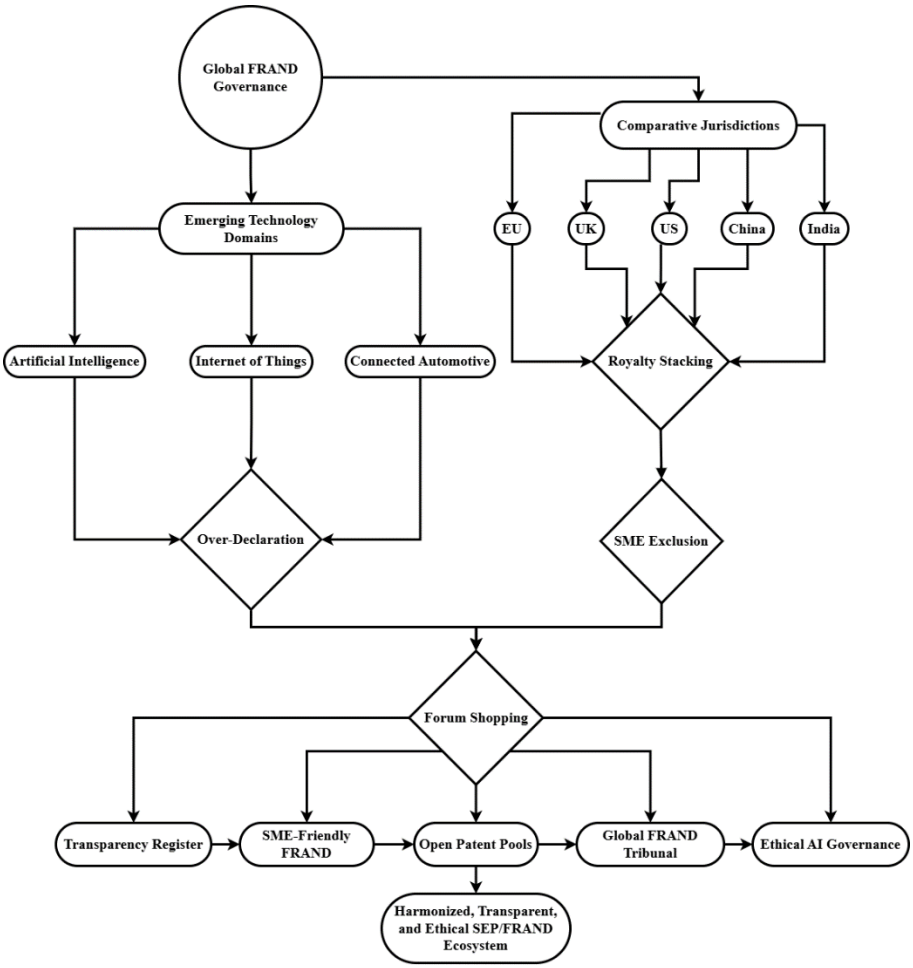

Figure 1: Conceptual framework of Global FRAND governance in emerging technologies

Figure 1 illustrates the core structure of the paper. The central theme of Global FRAND Governance connects with four dimensions and cross-jurisdictional analysis including (EU, UK, US, China, India) and the emerging technology domains such (AI, IoT, Automotive), systemic challenges (royalty stacking, over-declaration, SME exclusion, fragmentation), and proposed policy reforms (transparency registers, SME-inclusive licensing, patent pools, global arbitration, and ethical AI governance). Together, these form a roadmap toward a harmonized and ethically grounded international framework.

The novelty and contributions of this paper are as follows:

- We will discuss the scope of FRAND and SEP analysis beyond traditional telecommunications, exploring their growing impact on AI, IoT and automotive innovation where interoperability and standardization will create new legal challenges.
- We will conduct the comparative doctrinal analysis across the EU, UK, US, China, and India in order to illustrate that how divergent interpretations of FRAND obligations affect global consistency and enforcement.

- To integrate TRIPS Articles 31 and 40 with WTO competition principles, demonstrating how international trade law frameworks enhance flexibility in compulsory and anti-competitive licensing within the SEP domain.
- To critically examine the withdrawal of the EU Commission's 2023 SEP Regulation (COM/2023/232) and assess its implications for transparency, SME access, and essentiality checks.
- Finally, we propose a harmonized FRAND governance model, including transparent royalty registers, SME-inclusive pathways, and cross-border dispute-resolution mechanisms that balance innovation with equitable market access

The remainder of the paper is structured as follows. Section 2 lays out the doctrinal comparison framework such as negotiation conduct, injunction thresholds, rate transparency. Section 3 addresses case studies in AI, IoT, and automotive. Section 4 elaborates key challenges such as royalty stacking, SME access, essentiality disclosure. Section 5 proposes reforms such as transparent registers, pooling and finally in the section 6, we conclude the paper.

2. Comparative Doctrinal Framework

In this section, we analyze that how major jurisdictions interpret and enforce FRAND commitments under divergent legal traditions. Although all share the objective of balancing innovation incentives for SEP holders with equitable market access for implementers, the legal reasoning and enforcement mechanisms differ substantially across regions.

A. The understanding the Legal Framework for FRAND and SEP Disputes in the EU

The European Union has been at the forefront of shaping how SEPs and FRAND licensing obligations are enforced and these legal principles guarantee that patented technologies are essential to the industry standards such as 4G, 5G, AI and IoT connectivity standards which are made available to all companies on fair terms. In this regards, there is a landmark decision in this field is Huawei v. ZTE (Case C-170/13, 2015) which was delivered by the Court of Justice of the European Union (CJEU) [18] which established the legal framework for SEP holders to enforce their rights without abusing their dominant market position. It particularly addressed whether to seek an injunction (a court order to stop another company from selling products using the patented technology) could amount to an abuse of dominance under Article 102 of the Treaty on the Functioning of the European Union (TFEU)[19] and the CJEU ruled that SEP holders may request injunctions only after following a specific sequence of steps:

i. Notify the alleged infringer about the patent and explain the infringement claim.
ii. Make a concrete offer for a FRAND license.
iii. Allow the implementer a fair opportunity to respond and negotiate in good faith.

At the same time, the company accused of infringement must show a clear willingness to negotiate. Failure by either party to act in good faith may shift liability if the SEP holder rushes to court, it may be found to have abused its dominant position; if the implementer delays or avoids

[18] Huawei Technologies Co. Ltd. v. ZTE Corp., Case C-170/13, EU:C:2015:477 (CJEU, 16 July 2015).
[19] Treaty on the Functioning of the European Union (TFEU), art. 102.

negotiation, it risks being labeled as an unwilling licensee. After, the Huawei v. ZTE, the German courts further developed these principles through key judgments that further clarified what "good faith" and "willingness" mean in practical terms and the Federal Court of Justice (BGH) in Sisvel v. Haier (Case KZR 36/17, 2020) confirmed that an implementer must show unconditional willingness to take a license to avoid being seen as an unwilling. [20] Simply engaging in negotiations is not enough if it is used as a tactic to delay payment. The court also held that the SEP holder is not obliged to make a licensing offer first; it can wait until the implementer clearly declares its readiness to accept a FRAND license.

Similarly, in the Nokia Technologies Oy v. Daimler AG (Case 2 O 34/19, LG Mannheim, 2020), the Regional Court of Mannheim found that the Daimler liable for infringing the Nokia's 4G/LTE SEP and ordered an injunction against the sale of certain Mercedes-Benz cars in Germany.[21] So, the court rejected Daimler's FRAND defense because Daimler had not shown sufficient willingness to conclude a license agreement on fair terms. To implement that injunction, the Nokia was mandated to provide a substantial security deposit of €7 billion and that the matter was ultimately resolved in June 2021 via the global licensing deal. As, these cases are significant to understand that how patent rights and competition law work together in the EU. They jointly demonstrate that while innovators should be compensated for their contributions to technological standards, they must also license in a fair and transparent manner to avert market foreclosure. The principles developed in these judgments have become the foundation for assessing SEP disputes in emerging technologies, including AI, IoT, and connected vehicles, core areas of this paper's analysis. It has become a guiding reference for how FRAND and SEP issues should be handled not only in Europe but also in other parts of the world.

B. The global FRAND Determinations and the Role of English Contract Law in the UK

The United Kingdom has become one of the most influential jurisdictions for resolving international disputes over SEPs and FRAND licensing. The British courts have approached FRAND primarily as a contractual obligation which focuses on the promise that patent holders make to the European Telecommunications Standards Institute (ETSI) to license their SEPs on fair, reasonable, and non-discriminatory terms. There is the landmark decision in Unwired Planet v. Huawei ([2020] UKSC 37) transformed the global legal landscape for SEP licensing.[22] In this case, the UK' Supreme Court held that it had jurisdiction to set a single global FRAND rate for Huawei's use of Unwired Planet's SEPs, even though the patents were registered in multiple countries. And the court further reasoned that when a company joins ETSI and commits to license its SEPs on FRAND terms, that commitment gives rise to a contract under English law; the law that governs the ETSI IPR Policy. These finding were significant for the two reasons. First, it allowed the English courts to determine worldwide royalty rates and terms which effectively make the UK a global forum for SEP and FRAND disputes. Second, the Court flatly rejected the claim

[20] Sisvel International S.A. v. Haier Deutschland GmbH, Case KZR 36/17 (BGH, 2020).
[21] Nokia Technologies Oy v. Daimler AG, *Case 2 O 34/19 (LG Mannheim, 2020).*
[22] *Unwired Planet International Ltd v. Huawei Technologies Co. Ltd., [2020] UKSC 37.*

that each national court should set its own FRAND rates for each country where the patents are to be held in order to stress how important efficiency and business security are.

Importantly, the UK Supreme Court also clarified that the ETSI FRAND undertaking; though drafted under French law must be interpreted through English contractual principles because English law governs the litigation before UK courts. Therefore, this approach slightly diverges from the civil-law understanding of the FRAND prevalent in the European Union, where competition-law considerations actually play stronger role and the court's reasoning prioritizes commercial practicality and predictability over abstract competition-law theories, positioning English courts as pragmatic and business-oriented in their handling of SEPs. After, the Unwired Planet, subsequent UK court decisions have reinforced this international leadership role. The High Court dealt with similar problems in IPCom v. Lenovo ([2023] EWHC 1105 (Pat)) [23] when it came to setting FRAND rates and injunction standards. The judgment reaffirmed that UK courts are willing to issue injunctions against companies that refuse to take a global FRAND license determined by the court, thereby encouraging timely negotiation and discouraging "hold-out" tactics by implementers.

Collectively, these cases firmly establish that the United Kingdom as a central venue for global FRAND rate setting and enforcement which demonstrates that UK courts combine contractual clarity with judicial efficiency, providing an attractive and neutral forum for resolving SEP disputes that span multiple jurisdictions. Regarding the emerging technologies such as AI, IoT, and connected vehicles, the UK's legal approach offers a structured pathway for balancing patent owners' rights with global market access which is a key principle of our paper's research inquiry.

C. The Contractual Emphasis and Limited Antitrust Intervention in FRAND Enforcement in the United States

The United States has taken a distinctive path to address the disputes involving the SEPs and FRAND licensing. The American approach differs from that of the European Union, where competition law principles play a central role. However, the American approach primarily focuses on contractual interpretation rather than antitrust enforcement. The disagreements over FRAND terms are treated as matters of private commercial obligation between the patent holder and the licensee rather than as a public violation of the competition law. In this regard, there is the leading case shaping this position is Federal Trade Commission (FTC) v. Qualcomm Inc. (969 F.3d 974, 9th Cir. 2020).[24] Where, the federal trade commission had accused Qualcomm, a dominant supplier of smartphone chipsets, of engaging in anti-competitive practices by requiring manufacturers to pay high licensing fees before purchasing its chips. The District Court initially agreed with the FTC, ruling that Qualcomm's licensing model violated U.S. antitrust law. However, then the ninth circuit court of appeals reversed that decision and holding that Qualcomm's behavior, while aggressive which did not constitute an illegal restraint of trade under the Sherman Act. Therefore, the appellate court concluded that Qualcomm's licensing practices were driven by legitimate business incentives and not by anti-competitive intent.[25] Further, the judges stressed that FRAND commitments are contractual in nature which are arising from the

[23] IPCom GmbH & Co KG v. Lenovo Technology (United Kingdom) Ltd., *[2023] EWHC 1105 (Pat)*
[24] Federal Trade Commission v. Qualcomm Incorporated, *969 F.3d 974 (9th Cir. 2020).*
[25] Stanley, Pierce. "FTC v. Qualcomm Inc.-969 F. 3d 974 (9th Cir. 2020)." Intell. Prop. & Tech. LJ 25 (2020): 201.

patent holder's promise to standard-setting organizations (SSOs) to license their patents fairly. As such, any disputes over royalty rates or licensing terms should be resolved under contract law, not through antitrust penalties.

To put it another way, this ruling has big effects on FRAND enforcement around the world. It shows that the courts would rather keep the market flexible and encourage new ideas than expand antitrust control to include patent licensing. Further, the case also illustrates an institutional divide between the two main U.S. enforcement bodies that are the department of justice (DOJ) which tends to favor a patent-holder-friendly view emphasizing innovation and investment, and the federal trade commission, which historically focused more on protecting implementers from potential market abuse. Together, these developments show that U.S. courts prioritize freedom of contract, private negotiation, and innovation-driven policy over competition law intervention. Therefore, this approach provides the certainty for companies that rely heavily on the licensing revenue such as those in telecommunications and emerging AI and IoT ecosystems. But however, it also highlights the lack of a unified international understanding of FRAND which is an important issue this paper seeks to address by proposing a more harmonized, transparent, and equitable global licensing framework.

D. China and India: Emerging Judicial Hubs for Global FRAND Enforcement

Emerging Judicial Hubs for Global FRAND Enforcement in India and China
The China and India have rapidly emerged as an influential jurisdiction in shaping the global debate on standard essential patents and fair, reasonable, and non-discriminatory licensing. Their courts are increasingly asserting authority not only over local disputes but also over global FRAND rate setting particularly china reflecting their expanding roles in the technology and telecommunications sectors. We discuss both jurisdictions as blow:

i. Linking Antitrust Enforcement with FRAND Compliance in China

The china's first major step in FRAND regulation came with National Development and Reform Commission (NDRC) v. Qualcomm (2015).[26] So, the NDRC which is the china's primary antitrust agency at the time found that Qualcomm abused its dominant market position by charging excessive royalties and imposing restrictive licensing terms on Chinese smartphone manufacturers. The study determined that Qualcomm's method of computing royalties based on the entire handset price, rather than the value of the patented components, was unjust under Chinese competition law. The NDRC levied an unprecedented fine of USD 975 million and mandated Qualcomm to modify its licensing policy. This case established the fundamental link between antitrust law and FRAND principles which emphasizes that the dominant SEP holders are required to license their technology under transparent, equitable, and proportionate conditions.[27]

Following this precedent, Chinese courts have gained increasing confidence in setting global FRAND rates, the role traditionally dominated by U.S. and U.K courts. Although, in the

[26] *National Development and Reform Commission (NDRC) v. Qualcomm Incorporated*, Case No. 2015 NDRC 1 (Beijing, 2015)
[27] Li, Yan Bing. "Antitrust correction for Qualcomm's SEPs package licensing and its flexibility in China." *IIC-International Review of Intellectual Property and Competition Law* 47, no. 3 (2016): 336-351.

InterDigital v. Xiaomi (2021)[28] and Oppo v. Nokia (2023),[29] the Chinese courts had claimed competence to establish worldwide licensing terms following the collapse of negotiations. These decisions highlight and show the China's ambition to establish itself as a neutral and efficient forum for international SEP disputes. The broader significance lies in China's dual focus: protecting domestic manufacturers from abusive licensing practices while promoting predictable global rules for cross-border SEP licensing that aligns with this paper's advocacy for transparent and harmonized FRAND frameworks in emerging technology ecosystems such as AI-driven IoT and connected mobility.

ii. Reconciling Patent Rights with Competitive Regulation in India

India's approach to the SEPs and FRAND licensing is continuously evolving which has noticeably progressed through several landmark court cases such as the Delhi High Court's decisions in Telefonaktiebolaget LM Ericsson v. Xiaomi (2014/2016)[30] and Micromax v. Ericsson (2016)[31] which represent early efforts to address conflicts between patent enforcement and competition law. In both of the cases that are the Ericsson an SEP holder filed the lawsuits alleging patent infringement related to 2G and 3G communication standards, while the defendants argued that Ericsson's licensing practices violated its FRAND commitments by imposing discriminatory and excessive royalties. And the Competition Commission of India (CCI) also initiated parallel investigations which allege that the Ericsson had abused its dominant position in the violation of the Competition Act of 2002. The Delhi High Court had determined that both the CCI and the courts may concurrently exercise the jurisdictions over the FRAND issues which thereby instituting a distinctive dual supervisory process among the principal authorities.[32] Furthermore, in Ericsson v. Lava (2024),[33] the Delhi High Court elucidated that the failure to engage in the negotiations on equitable terms and ongoing exorbitant pricing may also represent an abuse of the power under the Indian law. These cases collectively underscore India's emerging position as a jurisdiction that seeks to protect both innovators and implementers which is encouraging innovation while preventing exploitative licensing conduct. Taken together, the experiences of China and India demonstrate a growing Asian leadership in global FRAND governance. Therefore, we can say that both of the countries are attempting to balance innovation, industrial growth and fair competition through their judicial and regulatory reforms and their efforts highlight the global necessity for a more coordinated, transparent, and equitable FRAND framework, especially as AI, IoT, and automotive technologies rely increasingly on cross-border interoperability.

[28] *InterDigital Inc. v. Xiaomi Communications Co.*, Guangdong High People's Court (2021).
[29] *Oppo Mobile Telecommunications Corp. Ltd. v. Nokia Technologies Oy*, Chongqing First Intermediate People's Court (2023).
[30] Telefonaktiebolaget LM Ericsson v. Xiaomi Technology India Pvt. Ltd., Delhi High Court (2014/2016).
[31] Micromax Informatics Ltd. v. Telefonaktiebolaget LM Ericsson, Delhi High Court (2016).
[32] Ibid.
[33] Telefonaktiebolaget LM Ericsson v. Lava International Ltd., Delhi High Court (2024).

E. The EU Policy Development and Withdrawal

The European Commission's 2023 proposal for a regulation on standard essential patents (COM/2023/232) sought to modernize Europe's SEP licensing landscape by introducing the centralized register, such as the independent essentiality checks and a FRAND determination center which is being operated by the EUIPO. And the goal was to enhance transparency, reduce litigation and to make the FRAND licensing more accessible for SMEs.[34] Major technology licensors and standard-setting organizations criticized the draft regulation for excessive control and the potential duplication of national legal processes.[35] After months of deliberations and political opposition, the Commission retracted the proposal in early 2025, publicly claiming the necessity for "additional impact assessment." This exit created a policy void that rekindled enduring apprehensions of fragmented national strategies, royalty accumulation, and varying assessments of essentiality across Member States.[36] Although, the analysts observe that the withdrawal indicates the EU's difficulty in reconciling harmonization and transformation within the innovative autonomy, particularly in sectors like AI, IoT, and automotive connectivity.[37] Notwithstanding the defeat, the policy discourse persists inside the Council and Parliament, with the stakeholders advocating for a more focused reform centered on FRAND transparency registries and voluntary conciliation frameworks instead of a compulsory licensing tribunal. The EU experience underscores how difficult it is to align the competition policy, patent law and industrial strategy within a single framework. In general, the globe agrees on FRAND licensing, but different national traditions nevertheless lead to different enforcement results. This indicates that we need a coordinated worldwide approach based on openness and fair negotiation norms.

[34] Drexl, Josef, Dietmar Harhoff, Beatriz Conde Gallego, and Peter R. Slowinski. "Position Statement of the Max Planck Institute for Innovation and Competition of 6 February 2024 on the Commission's Proposal for a Regulation of the European Parliament and of the Council on Standard Essential Patents." *GRUR International* 73, no. 7 (2024): 647-665.

[35] Picht, Peter Georg, and Jorge L. Contreras. "Proportionality Defenses in FRAND Cases: a Comparative Assessment of the Revised German Patent Injunction Rules and US Case Law." GRUR International 72, no. 5 (2023): 435-450.

[36] Borgogno, Oscar, and Giuseppe Colangelo. "Devaluing SEPs: Hold-up bias and side effects of the European Draft Regulation." J. Intell. Prop. Info. Tech. & Elec. Com. L. 15 (2024): 74.

[37] Bonadio, Enrico, and Magali Contardi. "Patent pools, internet of things and EU competition law." In A Research Agenda for Patent Law, pp. 25-44. Edward Elgar Publishing, 2025.

Table 1: Comparative FRAND enforcement framework across key jurisdictions

Jurisdiction	Governing Legal Basis	Landmark Cases	Nature of FRAND Obligation	Authority to Set Global Rates	Main Policy Focus and Implications
European Union	Competition law (Art. 102 TFEU) + Contract law	Huawei v. ZTE (CJEU 2015); Sisvel v. Haier (BGH 2020)	Abuse-of-dominance doctrine; good-faith negotiation; proportionality test for injunctions	No, It is limited to the EU territory.	Fair negotiation, transparency, proportionality in enforcement
United Kingdom	Contract law (English law governing ETSI IPR Policy)	Unwired Planet v. Huawei (UKSC 2020); IPCom v. Lenovo (2023)	Contractual FRAND promise; focus on commercial certainty	Yes, It recognized the global jurisdiction.	Global rate setting; predictability; judicial efficiency
United States	Contract law + Limited antitrust	FTC v. Qualcomm (9th Cir. 2020)	Private commercial obligation; antitrust intervention minimized	No	Innovation incentives and market freedom over regulatory control
China	Competition law (SAMR) + Judicial policy	NDRC v. Qualcomm (2015); InterDigital v. Xiaomi (2021); Oppo v. Nokia (2023)	FRAND as public-interest duty; strong state oversight	Yes	Domestic protection + assertion of global competence in rate setting
India	Patent law + Competition Act 2002	Ericsson v. Micromax (2016); Ericsson v. Lava (2024)	Dual oversight (Courts + CCI); FRAND as fair trade requirement	No	Balancing innovation and affordable access in emerging markets

Table 1 highlights the interpretations and enforcement of FRAND pledges by five main jurisdictions. It underscores that, whereas all involved parties aim to balance innovative incentives with equal market access, their legal grounds and methodologies vary considerably. It contrasts the EU's competition-law orientation, the UK's contractual clarity, the US's market-based flexibility and the emerging assertiveness of China and India.

3. SEPs and FRAND Licensing in Emerging Technology Sectors

The functionality of essential patents has been revolutionized by the advent of artificial intelligence, the Internet of Things, and connected automobiles. Initially, SEPs mostly encompassed the telecommunication standards such as 3G, 4G, and 5G; nevertheless, as the contemporary items are ranging from smart appliances to autonomous vehicles, utilize these connectivity standards, licensing issues have proliferated into novel and intricate technology industries. FRAND licensing principles are still central, but their interpretation now faces new challenges as technology becomes more interconnected.[38] AI technologies increasingly depend on interoperability and the capacity of systems and algorithms to collaborate across various devices and platforms. Therefore, the International standards bodies such as ISO/IEC JTC 1/SC 42 and IEEE have begun defining global standards for machine learning, data management and algorithmic transparency.[39] For example, the ISO/IEC 22989:2022 establish the common

[38] ISO/IEC JTC 1/SC 42, *Artificial Intelligence – Overview and Foundational Standards*, ISO/IEC 22989:2022.
[39] Ibid.

terminology and principles for AI systems, while IEEE's P7000 series sets the ethical and technical standards for autonomous and intelligent systems. Although, these frameworks guarantee that different AI models can "talk" to one another safely and predictably.[40] However, as these standards mature, they may give rise to AI-specific SEPs, the patents that become essential to the functioning of standardized AI systems which will create the uncertainty about how FRAND licensing applies to algorithmic methods or training datasets which are often collaborative or open-source in nature. Further, the International standards bodies such as ISO/IEC JTC 1/SC 42 and IEEE have begun to define the standards for machine learning, data management, and algorithmic transparency. In one of the recent literature, Asko Metsola (2025) highlights that the EU competition law has adapted to telecommunications SEPs, it may not yet be suited to handle the complexity of data-driven AI standards, where interoperability relies more on shared datasets than hardware patents.[41]

Moreover the IoT connects billions of everyday devices, cell phones, thermostats, cars, industrial sensors via wireless standards such as NB-IoT (Narrowband IoT), LTE-M, and 5G New Radios (NR). These standards were originally developed for mobile phones and now form the backbone of IoT communication.[42] In practice, a single IoT product, such as a smart watch, might need to use hundreds of SEPs owned by different patent holders which often lead to royalty stacking, where multiple licensors claim overlapping royalties, raising costs for smaller manufacturers.[43] To support our arguments, there is a leading example of Telefonaktiebolaget LM Ericsson v. Xiaomi Technology India Pvt. Ltd. (Delhi High Court, 2014/2016), where the dispute focused on how royalties should be calculated based on the price of the whole device or just the price of the component (e.g., a communication chip)[44] and one of the recent literature by Pourrahim stated that the traditional approach of linking SEP royalties to end-product prices fails to account for the distributed nature of IoT value chains, where technical contribution rather than product price should define the royalty base.[45] As, the ETSI and 3GPP standards are now being adapted to include IoT use cases such as smart logistics and e-health, yet these adaptations also extend traditional telecom licensing issues into new industries that lack experience with FRAND negotiations.[46]

Moreover, the cars are no longer mechanical machine as they are also computing platforms that communicate with traffic systems, other vehicles, and mobile networks through technologies like V2X (Vehicle-to-Everything) communication and 5G connectivity. Because, these technologies rely on SEPs originally developed for telecommunications, as the car manufacturers must now negotiate licenses with telecom patent owners.[47] In the German case Nokia Technologies Oy v. Daimler AG (Regional Court of Mannheim, 2020) which illustrates this tension as Daimler the carmaker argued that suppliers should obtain the necessary SEP licenses, while Nokia insisted that manufacturers which use the final technology must license directly. Although, the court sided with

[40] Wallace, Ken. "IEEE Standard for Fail-Safe Design of Autonomous and Semi-Autonomous Systems: Putting Principles Into Practice." IEEE Reliability Magazine (2025).
[41] Metsola, *The Interplay of Standard Essential Patents*, 56.
[42] Daraseliya, Anastasia, Eduard Sopin, Vyacheslav Begishev, Yevgeni Koucheryavy, and Konstantin Samouylov. "Resource Allocation in 5G Cellular IoT Systems with Early Transmissions at the Random Access Phase." Sensors 25, no. 7 (2025): 2264.
[43] Bonadio and Contardi, "Patent Pools, Internet of Things," 35.
[44] *Telefonaktiebolaget LM Ericsson v. Xiaomi Technology India Pvt. Ltd.*, Delhi High Court (2014/2016).
[45] Pourrahim, "A New Approach to FRAND Royalty Determination in IoT Value Chains," 1104.
[46] ETSI, *Intellectual Property Rights Policy*, Clause 6 (2023).
[4747] Yue, Qiao, Jia Li, and Hui Lv. "Analysis of Standard Essential Patents in the Field of V2X." In *2025 5th* International Conference on Public Management and Intelligent Society (PMIS 2025), pp. 11-19. Atlantis Press, 2025.

Nokia granting an injunction but required a large security deposit to prevent premature enforcement.[48] The case was later settled through the Avanci licensing pool, which allows carmakers to obtain a single license covering multiple patent owners under FRAND terms.[49]

Recent studies have underscored the increasing significance of vehicle cybersecurity in international laws including UNECE WP.29 R155 and the ISO/SAE 21434 standard[50] and these two frameworks were developed particularly to mitigate the increasing risk of cyber-attacks on connected and autonomous vehicles which require manufacturers and suppliers to integrate cybersecurity controls across the entire life cycle of electronic and electrical (E/E) systems. The UNECE WP.29 R155 regulation was adopted by the United Nations Economic Commission for Europe which became the mandatory requirement for the type approval of new vehicle models in the markets starting in July 2022 which included all member states of the European Union, the United Kingdom, Japan, and South Korea, with compliance expanding to cover all new vehicles produced for the EU market by July 2024. While not signatories to the 1958 agreement, other major automotive markets, such as the United States and China, are still affected due to the global nature of the industry and the de facto status of R155 as a standard. To sell vehicles in any of the adopting markets, manufacturers must implement a certified Cybersecurity Management System throughout the vehicle's entire lifecycle while ISO/SAE 21434 provides detailed engineering guidelines for cybersecurity risk management.[51] As both frameworks overlap in several processes but also complements each other WP.29 acting as the regulatory baseline, and ISO/SAE 21434 serving as its technical implementation guide.[52] It further, illustrates that the simultaneous implementation of WP.29 R155 and R156 can improve software-update governance, supply-chain resilience, and incident-response capabilities for connected vehicles.[53] Although these standards do not regulate SEPs or FRAND licensing directly, they interact with telecommunication standards (4G, 5G, V2X) covered by SEPs, showing how intellectual-property governance, safety compliance, and data-security regulation now converge in the automotive ecosystem. In many areas, a fundamental question persists: how to guarantee compatibility while preserving incentives for innovation.

- In the artificial intelligence, It is hard to decide what parts of AI technology are so basic that they should be free for everyone to use (like essential algorithm or standardized dataset) versus what new inventions deserve to be patented.
- In the IoT when building smart devices, one of the major challenges is figuring out how much to pay in patent fees. As, it is difficult to set a fair price for each patented technology inside a device and prevent the total cost from becoming so high that it makes the device too expensive to produce.

[48] *Nokia Technologies Oy v. Daimler AG*, Regional Court of Mannheim, Case 2 O 34/19 (2020)..
[49] Bonadio and Contardi, "Patent Pools, Internet of Things," 37
[50] Bohara, Rohit, Mirko Ross, Sven Rahlfs, and Sara Ghatta. "Cyber Security and Software Update management system for connected vehicles in compliance with UNECE WP. 29, R155 and R156." In *Software Engineering 2023 Workshops*, pp. 41-53. Gesellschaft für Informatik eV, 2023.
[51] Bohara, Rohit, Mirko Ross, Sven Rahlfs, and Sara Ghatta. "Cyber Security and Software Update management system for connected vehicles in compliance with UNECE WP. 29, R155 and R156." In *Software Engineering 2023 Workshops*, pp. 41-53. Gesellschaft für Informatik eV, 2023.
[52] Ibid, 342.
[53] Bohara et al., "Cyber Security and Software Update Management System for Connected Vehicles," 45.

- In the automotive sector, the debate centers on whether suppliers or manufacturers should bear licensing obligations.

The consistent theme is that FRAND licensing must evolve to handle multi-industry integration; a "one-size-fits-all" telecom-era approach cannot address the complex web of AI models, IoT ecosystems and software-defined vehicles. Ultimately, adapting the FRAND for emerging technologies will require transparent licensing databases, cross-industry arbitration, and updated guidance from bodies like ETSI and WIPO for ensuring both patent holders and implementers benefit fairly from technological progress.

4. Key Challenges in SEP and FRAND Implementations

Despite major judicial developments and policy efforts, there are several structural challenges continue to hinder the consistent and transparent implementation of SEP and FRAND licensing frameworks and these challenges have become even more visible as SEPs extend beyond telecommunications into AI, IoT, and automotive ecosystems. One of the most persistent difficulties in multi-component systems such as smartphones, IoT platforms, and connected vehicles is royalty stacking; the accumulation of royalties claimed by multiple SEP holders on the same end product.[54] When each licensor seeks compensation based on the full product price rather than its technical contribution, total licensing costs can become excessive and unpredictable. The absence of information concerning the total royalty obligation associated with overlapping SEPs hinders implementers from evaluating fair market value or strategizing product pricing[55] and the researchers like Mallinson further contend that historically, market-driven bilateral negotiations maintained overall royalties under five percent of product revenues; but however, the fragmentation in nascent sectors jeopardizes this equilibrium.[56]

Another systemic concern is over-declaration where patent owners declare a large number of patents as "standard-essential" even though many are later found non-essential during litigation or independent review which inflates perceived licensing strength and contributes to cumulative royalty uncertainty. Further, in the withdrawn EU SEP Regulation (COM/2023/232) which sought to address this through essentiality checks under the EUIPO, but in its 2025 withdrawal, it leaves the issue unresolved.[57] Empirical studies show that in some technology families, fewer than half of declared SEPs are truly essential, creating negotiation asymmetry between licensors and licensees.[58] Further, the small and medium-sized enterprises (SMEs) often struggle to access standardized technologies due to high transaction costs and lack of transparency in licensing negotiations.[59] Unlike multinational manufacturers, SMEs cannot easily engage in complex cross-licensing or global litigation, and as Pourrahim explains in the internet of things context, the use of end-product pricing as the royalty base disproportionately affects smaller implementers

[54] Mallinson, "Discovering or Setting Aggregate Royalties and FRAND Rates for SEP Portfolios," 2.
[55] Ibid, 5.
[56] Ibid, 7.
[5757] Singh, "The European Commission's Draft SEP Regulation: A Slippery Slope or a Renewed Hope?," 4.
[58] Drexl et al., "Position Statement of the Max Planck Institute for Innovation and Competition on the Commission's Proposal for a Regulation on Standard Essential Patents," 652.
[59] Pourrahim, "A New Approach to FRAND Royalty Determination in IoT Value Chains," 1105.

producing low-margin devices which simplified licensing pools and SME-friendly FRAND frameworks are therefore essential to promote inclusive participation in standardized innovation.[60]

Additionally the divergent national strategies have resulted in forum shopping the process where parties choose jurisdictions that are thought to be more supportive of their position and the divergent results in InterDigital v. Xiaomi (China 2021) and Conversant v. Huawei (UK 2020/China parallel litigation) which illustrate the competition among courts for worldwide jurisdiction in establishing FRAND terms.[61] The Chinese courts are increasingly confident after NDRC v. Qualcomm (2015), now issue anti-suit injunctions to prevent enforcement of foreign judgments while the UK courts assert that the competence to determine the global FRAND rates that fragmented landscape increases the transaction costs and undermines predictability for both patent holders and implementers.[62] Another challenge in the implementations is the open-source collaborations and standardization consortia in AI and IoT that rely on shared data and interoperable frameworks which often conflict with exclusive patent-licensing models. When the SEPs are embedded into open standards that the implementers face legal uncertainty over whether use under open-source terms breaches FRAND obligations and scholars such as Bonadio and Contardi note that patent pools can mitigate this tension by aligning open innovation incentives with fair compensation mechanisms but yet governance transparency remains limited.[63] To conclude, the central challenge of FRAND implementation lies in balancing innovation incentives with accessibility and legal certainty, as the royalty stacking, over-declaration, and forum shopping each highlight the need for a more transparent, globally coherent SEP ecosystem supported by reliable essentiality assessments, aggregate-royalty disclosure, and predictable dispute-resolution mechanisms.

Table 2: Key Challenges in SEP and FRAND Implementation

Challenge	Description	Impact on Stakeholders	Policy Implications & Needed Reforms
Royalty Stacking	Multiple SEP holders demand royalties for the same product, based on total device price.	Raises cumulative costs, discourages SMEs.	Require aggregate royalty disclosure via global SEP register.
Over-Declaration	Non-essential patents declared as standard-essential inflate portfolios.	Creates negotiation asymmetry and uncertainty.	Implement independent essentiality checks under EUIPO/WIPO supervision.
SME Exclusion	High transaction costs and complex licensing processes exclude SMEs.	Restricts innovation diversity and local participation.	Adopt tiered or deferred FRAND models for SMEs.
Forum Shopping	Parties select favorable courts for FRAND disputes.	Results in inconsistent global judgments and higher litigation costs.	Establish Global FRAND Arbitration Tribunal (WIPO–WTO).

[60] Ibid., 1107.
[61] InterDigital Inc. v. Xiaomi Communications Co., Guangdong High People's Court (2021); see also *Conversant Wireless Licensing v. Huawei Technologies Co.*, [2020] EWCA Civ 1298 (UK Court of Appeal).
[62] *National Development and Reform Commission (NDRC) v. Qualcomm Incorporated*, Case No. 2015 NDRC 1 (Beijing 2015).
[63] Bonadio and Contardi, "Patent Pools, Internet of Things," 33.

Open-Source Conflicts	Open collaboration models clash with exclusive licensing systems.	Creates legal uncertainty for developers using open standards.	Develop hybrid patent-pool governance aligned with open innovation.

Table 2 provides an overview of the major structural challenges in SEP and FRAND implementation. It explains how royalty stacking, over-declaration, SME exclusion, forum shopping and open-source tensions collectively undermine transparency and predictability. Each of these challenges is linked to the specific policy reforms which are proposed in Section 5 of this paper.

5. Policy and Reform Proposals

This paper proposes a series of reforms which will enhance the transparency, inclusivity and adaptability of SEP licensing and FRAND implementation in light of comparative and sectoral analysis particularly regarding the emerging technologies such as artificial intelligence, the Internet of Things and connected vehicles, as the aim is to ensure that innovation incentives for patent holders are preserved while access to essential technologies becomes fair and predictable for all implementers from large multinational corporations to small start-ups.

i. Enhancing the Royalty Transparency and Accountability

We propose one of the fundamental reforms to enhance the royalty transparency and accountability. As, one of the persistent issues in global SEP governance is the absence of a unified mechanism to identify who owns which patents, whether these patents are truly essential and how the royalties are calculated. This lack of transparency fuels over-declaration, royalty stacking, and disputes over cumulative licensing fees. We strongly suggest in establishing a global SEP register which should be modeled on the EUIPO's proposed 2023 framework but it may be extended under the joint supervision of WIPO and WTO that would provide a reliable platform for verified essentiality checks, publication of FRAND commitments and disclosure of aggregate royalty ranges for each standard. For example, in the 5G and IoT sectors where multiple companies claim overlapping rights, such a register would allow implementers to distinguish legitimate SEPs from non-essential claims, while enabling regulators and courts to benchmark reasonable rates. Therefore, the enhanced transparency would consequently benefit both parties, the patent holders would achieve increased credibility and diminished litigation while implementers, particularly small and medium enterprises, would enjoy predictable and equitable costs.

ii. SME-Friendly FRAND Frameworks

In addition to transparency, the next critical step is to create SME-friendly FRAND frameworks, because the Small and medium-sized enterprises often face prohibitive licensing costs and legal uncertainty that often prevents them from entering to the advanced technology markets. To address this imbalance, we suggest and propose that a tiered or deferred FRAND model could be introduced which will allow the SMEs to pay royalties based on product revenue or market maturity rather than large upfront fees. For instance, a robotics or smart sensor start-up could delay full royalty payments until its products reach commercial scale, because this approach will promote the inclusivity and aligns with EU an industrial policy objective which encourages

innovation in local ecosystems. It also transforms FRAND from a purely defensive legal tool into a developmental instrument that broadens participation in digital transformation.

iii. Collective Licensing and Patent Pools

To complement these measures, we propose the collective licensing through patent pools can greatly reduce transaction costs and can promote market efficiency. As, the Patent pools make it easier to get to important technologies and make it less complicated to deal with several right holders at once by allowing multiple SEP owners to license their innovations together and the Avanci pool which is a patent licensing platform that brings together numerous patent holders to offer a single, bundled license for essential wireless technology, primarily for connected vehicles and IoT devices that demonstrates how collective licensing can harmonize interests by offering manufacturers predictable and transparent rates for using connectivity standards. However, the current pools often lack in openness and transparency that is limiting the participation by smaller SEP holders and it raises the antitrust concerns. Therefore, we recommend that future patent pools must operate on open, non-exclusive and under the competition-law-compliant principles, supported by regulatory transparency requirements to ensure fair participation and predictable licensing rates. However, we also propose that such pools must remain open, non-exclusive and compliant with competition law to prevent the creation of new monopolistic barriers. So, by encouraging the transparent and antitrust-safe collective licensing, the policymakers can ensure that both patent owners and implementers operate within a fair and efficient framework that accelerates technological diffusion. Therefore, the novelty of our proposal lies in the transformation of the patent pools from purely private coordination mechanisms into policy-oriented instruments that will integrate transparency obligations and inclusive participation of SMEs and developing-country innovators and regulatory oversight to ensure competition-law alignment. Because, this approach reframes collective licensing as not merely an efficiency tool but also as a proactive governance mechanism that strengthens FRAND compliance and supports equitable innovation diffusion across AI, IoT, and automotive sectors.

iv. Global FRAND Arbitration Tribunal

Due to the global nature of SEP disputes conflicts happen all across the world. Therefore, we proposed the Global FRAND Arbitration Tribunal, which would make the current system more organized and consistent. We suggest and propose the Global FRAND Arbitration Tribunal that would provide structural coherence to what is currently a fragmented and inconsistent system. From the UK in Unwired Planet v. Huawei case to China in InterDigital v. Xiaomi case, national courts have both determined that they have the authority to set worldwide FRAND rates, though through different legal reasoning which has led to inconsistent decisions. Therefore, we propose that the FRAND arbitration tribunal under the joint supervision of WIPO and the WTO that will be the specialized tribunal may settle these cross-border issues based on the principles of TRIPS Articles 31 and 40 to ensure that the process remains fair, transparent and consistent. By introducing mandatory disclosure of aggregate royalties and standardized arbitration procedures, such a body would prevent forum shopping, reduce litigation costs, and promote predictability for global technology markets. Therefore, this reform directly addresses the core research question of this paper by proposing a harmonized international legal architecture through the WIPO and WTO

coordinated tribunal that reconciles patent-holder innovation incentives with equitable, transparent and predictable access to global technology markets.

v. AI-Specific Standards and Ethical FRAND Governance

The artificial intelligence is becoming integral to next-generation technology, therefore we propose the establishment of AI-specific standards and ethical FRAND governance. As, the future SEPs will likely cover not only hardware and communication protocols but also algorithms, datasets and model architectures. We suggest that intreegrating the IEEE's Ethically Aligned Design (EAD) principles into FRAND governance would ensure that licensed technologies promote transparency, accountability and safety. For example, when a company licenses a patented AI model such as a computer-vision algorithm for autonomous vehicles or a natural-language processing model for smart assistants under FRAND terms, the commitment should include requirements for algorithmic explainability, dataset transparency, or bias mitigation to guarantee the ethical compliance without restricting innovation. It represents the future of responsible technology governance and positions the FRAND as a framework that will be adaptable to evolving socio-technical realities. We therefore propose the development of a unified "Ethical FRAND" model that embeds IEEE EAD principles within SEP licensing obligations, supported by WIPO and WTO guidance to harmonize global implementation.This model would extend traditional FRAND beyond economic fairness to encompass ethical accountability, requiring patent holders and implementers to demonstrate compliance with human-centered AI standards while maintaining interoperability and market efficiency. In doing so, our proposal advances a concrete reform toward globally consistent, ethically informed FRAND governance for AI-driven innovation.

5.1 Implementation Roadmap

To transform the recommended proposals into a functioning global framework, the coordinated implementation across institutions and time horizons is essential. We divide the process into three stages that are short-term (1-2 years), mid-term (3-5 years), and long-term (5-10 years) and each of these addresses the distinct objectives and institutional responsibilities. In the short term (1-2 years), the European Union Intellectual Property Office (EUIPO) could pilot a Regional SEP Register, completing essentiality checks and voluntary royalty disclosures under its existing infrastructure. At the same time, the World Intellectual Property Organization (WIPO) and World Trade Organization (WTO) could launch a joint working group to design procedural rules for a Global FRAND Arbitration Tribunal and the competition authorities such as the European Commission's DG COMP, China's SAMR, and the U.S. FTC could issue soft-law guidance for clarifying SME-friendly licensing and antitrust-safe patent-pool participation. As, these actions would establish early transparency and procedural benchmarks.

In the midterm that is (3-5 years), the EUIPO model could be scaled globally through a WIPO-led SEP Transparency Platform to integrate the national patent offices to verify essentiality across 5G, IoT, and AI standards. Moreover, the WIPO's Arbitration and Mediation Center could begin accepting the international FRAND disputes under the uniform procedural code, while ISO/IEC JTC 1/SC 42 and IEEE embed Ethically Aligned Design (EAD) principles into AI standardization and FRAND undertakings. And similar rules may be used by regional groups like ASEAN or the

African Union to make sure that emerging economies can participate fairly. In the long term (5-10 years), the fully operational Global FRAND Arbitration Tribunal should be recognized under TRIPS Articles 31 and 40 that would provide binding or widely accepted determinations on cross-border SEP disputes. Consequently the mandatory declaration of aggregate royalties would be standardized across industries to guarantee that companies disclose the total cumulative royalty burden for each standard and at the same time, the core principles of the EU's Digital Markets Act (DMA) and EU Data Act such as fairness, transparency and interoperability should be integrated into FRAND governance through collaborative regulatory frameworks. By this stage, FRAND governance would evolve into an integrated global ecosystem combining transparency, predictability, and ethical accountability. Therefore, this timeline demonstrates that a phased, multi-institutional approach anchored in existing regulatory structures can realistically achieve our paper's goal; which is the harmonized and transparent global FRAND regime that sustains innovation incentives while guaranteeing equitable access to essential technologies across AI, IoT, and automotive markets

Table 3: Global FRAND reform implementation roadmap

Phase/Time Horizon	Institutional Lead(s)	Key Actions	Intended Outcomes
Short Term (1-2 Years)	EUIPO/WIPO/WTO/DG COMP/SAMR/ FTC	Launch EUIPO SEP Register; form WIPO–WTO working group; issue SME-friendly guidelines.	Early transparency and procedural benchmarks.
Mid Term (3-5 Years)	WIPO ISO/ IEEE and Regional Bodies	Scale WIPO SEP Transparency Platform; embed IEEE EAD and ISO AI standards into FRAND.	Consolidated transparency and ethical alignment.
Long Term (5-10 Years)	WIPO + WTO Tribunal and National Patent Offices	Operationalize Global FRAND Arbitration Tribunal; standardize aggregate royalty disclosures; align DMA & Data Act principles.	Fully integrated global FRAND ecosystem.

Table 2 outlines the phased implementation plan for our proposed reforms. It divides institutional responsibilities across short-term, mid-term, and long-term phases to demonstrate how transparency, arbitration and ethical FRAND governance can evolve into a global framework.

6. Conclusion and Future Research Directions

In conclusion, this study has demonstrated that the SEPs and FRAND licensing are no longer confined to telecommunications but now underpin interoperability in the artificial intelligence, the Internet of Things, and automotive technologies. Through a comparative doctrinal analysis across the EU, UK, US, China, and India, this research has achieved three key outcomes; first, it identified how divergent national interpretations of FRAND obligations create uncertainty in the global rate-setting; second, it clarified how competition law, contract principles, and industrial policy differently shape the enforcement; and third, it proposed transparency-based solutions such as global registers, SME-inclusive licensing, and arbitration models to balance and harmonize the interpretation and application of FRAND obligations globally. Our comparative findings and analysis reaffirm that the effective FRAND governance relies on transparency, inclusivity and

global coordination for balancing the innovation incentives with equitable access to the essential technologies.

Overall, this research contributes to the ongoing global discussions on SEP governance by bridging legal analysis with policy design and It further demonstrates that the future of FRAND depends not only on courts and regulators but also on the ability of international institutions, industry consortia and emerging economies to cooperate in shaping consistent and ethical licensing frameworks globally. As, this perspective aligns with the EU's Digital Strategy, WIPO's standardization initiatives and WTO's emphasis on technology transfer, offering a forward-looking roadmap to balance the innovation and access in the digital age.

In our future research, we will be focus on developing measurable indicators of the FRAND transparency and compliance especially for the data-driven and algorithmic standards particularly in the AI and IoT ecosystems. As, the future empirical studies could analyze how FRAND royalties are distributed across different stages of the supply chain from patent owners to the component manufacturers and end-product companies to evaluate the fairness and economic impact. In parallel the multidisciplinary research could be explored and investigated that how SEP and FRAND policies intersect with cybersecurity and safety frameworks such as the UNECE WP.29 regulation on vehicle cybersecurity and the ISO/SAE 21434 standard for secure automotive engineering. Moreover, to integrate the ethical and data-governance principles into FRAND undertakings could redefine how fairness is understood in the AI licensing and to strengthening cooperation through WIPO, WTO and OECD dialogues will be essential for establishing a harmonized, ethical and future-ready SEP framework that promotes innovation while guaranteeing the global technological inclusivity. While this study provides a comprehensive legal and policy analysis, it remains doctrinal in nature. Future empirical validation through case-level royalty data and stakeholder interviews would further refine the proposed global FRAND governance framework.

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