From Latency to Engagement: Technical Synergies and Ethical Questions in IoT-Enabled Gaming

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ABSTRACT

The convergence of video games with the Internet of Things (IoT), artificial intelligence (AI), and emerging 6G networks creates unprecedented opportunities and pressing challenges. On a technical level, IoT-enabled gaming requires ultra-low latency, reliable quality of service (QoS), and seamless multi-device integration supported by edge and cloud intelligence. On a societal level, gamification increasingly extends into education, health, and commerce, where points, badges, and immersive feedback loops can enhance engagement but also risk manipulation, privacy violations, and dependency. This position paper examines these dual dynamics by linking technical enablers, such as 6G connectivity, IoT integration, and edge/AI offloading, with ethical concerns surrounding behavioral influence, data usage, and accessibility. We propose a comparative perspective that highlights where innovation aligns with user needs and where safeguards are necessary. We identify open research challenges by combining technical and ethical analysis and emphasize the importance of regulatory and design frameworks to ensure responsible, inclusive, and sustainable IoT-enabled gaming.

CCS CONCEPTS

• **Social and professional topics** → **Corporate surveillance**; • **Networks** → **Network mobility**; • **Human-centered computing** → **Ubiquitous and mobile computing theory, concepts and paradigms**; **Mobile computing**.

KEYWORDS

IoT, Edge AI, Gamification, 6G

1 BACKGROUND AND MOTIVATION

Since the early days of personal computing, video games have been a catalyst for technological innovation, continuously driving advances in both hardware and software [24, 29]. In the 1980s and 1990s, gaming interactions were primarily confined to human-computer interaction. This paradigm shifted in the 2000s, as broadband Internet and wireless networking enabled online multiplayer experiences. Gaming was now also defined by social encounters between geographically distributed players. The rise of mobile devices, tablets, and specialized consoles further diversified gaming platforms, while recent innovations, such as 5G-enabled handheld devices (e.g., *Razer Edge 5G*) and standalone VR headsets (e.g., *Meta Quest 3*) signal a transition toward pervasive, network-native play characterized by seamless connectivity and continuous computation. Today, gaming extends beyond specific platforms or locations, as gamification (the application of game-like designs to non-game contexts) is integrated into daily routines and social practices [14].

The Internet of Things (IoT) introduces a new dimension to this evolution. IoT devices range from low-power sensors to wearables enabled by Artificial Intelligence (AI), and their integration into everyday life creates new opportunities and challenges for interactive applications. Both online games and IoT systems depend on ultra-low latency, scalable computation, and adaptive resource allocation, often requiring a balance between resource-constrained devices and nearby edge infrastructure [16]. AI further reinforces these connections by enabling personalization, real-time analytics, and intelligent orchestration across distributed devices. Beyond technical considerations, the convergence of gaming, IoT, and AI raises ethical and societal questions. Gamification (e.g., collecting points, badges, and leaderboards) has been proven effective in various domains, including education [2], health [23], and commerce [6]. However, while gamification can encourage constructive behaviors, it also carries risks of manipulation, addictive engagement, and the commercialization of user attention [21, 32]. These concerns become particularly pressing in IoT-enabled pervasive computing environments, where gamified interactions are embedded into everyday practices and are difficult to regulate or supervise.

This position paper examines the intersection of these domains by exploring the synergies between gaming, IoT, AI, and 6G. Gaming can serve as a driver for IoT innovation while simultaneously demanding a critical reflection on the ethical implications of pervasive play. Our discussion highlights that regulation should focus on the commercialization of gamification, rather than technical options or gamification itself.

2 CONVERGENCE OF GAMING, IOT, AND AI

The area of ubiquitous computing is established by a large set of connected devices. It is shaped by the demand for interactive experiences with strict latency guarantees [9], the rise of data-driven intelligence, as well as services that incorporate aspects of gaming, IoT, and AI. This section explores the intersection of these technologies and paradigms, where their requirements overlap, and how they jointly shape new services.

2.1 Multi-Device and Pervasive Gaming Ecosystems

Modern gaming is no longer confined to a single device, but spans across multiple devices and platforms [5]. Players interact across a heterogeneous ecosystem of devices, including smartphones,

tablets, wearable sensors, AR/VR headsets, and cloud-enabled consoles [31]. This multi-device environment influences IoT system architectures, where devices with varying computational capabilities and connectivity options cooperate to provide a service [17]. Gaming scenarios such as location-based experiences [7] or sensor-driven interaction illustrate how IoT and gaming naturally converge.

2.2 AI-Powered Synergies

AI plays a central role in all three domains, as it enables non-player character behavior, adaptive difficulty, and personalized content delivery in gaming [26, 30]. In IoT, AI supports context recognition, resource optimization, and connectivity [19]. The intersection of these capabilities opens up new opportunities, for example, games that adapt dynamically to player context using IoT sensor data, or IoT services that utilize gaming-inspired interfaces to enhance user engagement. Edge and cloud AI further support these synergies by offloading computationally demanding inference tasks [11].

2.3 Latency, QoS, and QoE Challenges

Both gaming [18] and IoT [13] are highly dependent on low latency and reliable network performance. Latency above a few tens of milliseconds can degrade competitive gaming experiences [4], just as it can reduce the reliability of safety-critical IoT applications. Quality of Service (QoS) guarantees are essential, but ultimately, user-perceived Quality of Experience (QoE) determines success. Predictive adaptation, traffic prioritization, and resource-aware computation offloading are crucial for aligning QoS with QoE in these highly dynamic environments [25, 27].

2.4 The 6G Perspective

Theoretically, 5G mobile networks have already enabled cloud gaming, mobile VR, and latency-aware IoT applications [12]. However, the next generation, 6G, promises to push these boundaries further with sub-millisecond latency, massive device connectivity, integrated edge intelligence, and support for holographic communication [28]. These advances directly benefit IoT and gaming, allowing seamless multi-device integration [33], ultra-realistic immersive environments [8], and adaptive service delivery in highly mobile contexts [10]. Therefore, the envisioned 6G capabilities can act as an enabler of pervasive, AI-enhanced gaming experiences.

3 CHALLENGES AND OPPORTUNITIES

The convergence of gaming, IoT, AI, and 6G causes a reciprocal effect, as many IoT applications become gamified, and games become deeply embedded in everyday life. It presents unprecedented opportunities, but it also raises significant challenges. We analyze these from two complementary perspectives: the *gaming side*, which focuses on technical and experiential requirements, and the *societal side*, which addresses ethical and social issues that can arise from gamifying everyday interactions.

3.1 Gaming-Centric Challenges and Opportunities

From a gaming perspective, the demand for immersive and seamless experiences is the main requirement, for which the following technical conditions must be fulfilled:

- **Latency:** Most games demand real-time responsiveness. Latency above 25 ms can disrupt gameplay and diminish Quality of Experience (QoE) [4]. IoT and 6G offer opportunities for ultra-low-latency, distributed architectures that can support next-generation gaming.
- **Device heterogeneity:** Players increasingly use smartphones, VR headsets, consoles, and IoT-enabled wearables [3]. The challenge lies in ensuring cross-device interoperability, while the opportunity lies in leveraging IoT for pervasive, multi-device play.
- **Edge/AI integration:** Offloading computation to the edge or using on-device AI enables more dynamic and adaptive gameplay. However, this raises challenges in resource allocation, synchronization, and power consumption.
- **Scalability:** Multiplayer and persistent online worlds generate massive traffic. 6G and IoT can provide scalable communication backbones, although challenges remain in ensuring fairness and QoS. This aspect also demands for edge computing concepts.

3.2 Societal and Ethical Challenges of Gamification

Beyond technical concerns, gamification increasingly shapes education, commerce, and daily life. This pervasiveness introduces dilemmas such as:

- **Behavioral influence:** Gamification mechanisms such as points, badges, and rankings can foster engagement, but also risk manipulation and over-dependence, particularly in children and vulnerable users [15].
- **Commercialization of play:** While games can create positive experiences, their integration into IoT systems may blur boundaries between entertainment and commercial exploitation.
- **Privacy:** IoT-enabled gamification relies heavily on personal data to adapt experiences accordingly. This raises issues of trust, transparency, and informed consent [20].
- **Equity and accessibility:** If gaming becomes a pervasive mode of interaction, access to devices and services becomes a factor of social inclusion or exclusion (e.g., paywalls [22])

3.3 A Comparative View: Challenges, Opportunities, and Technical Enablers

We provide an overview highlighting the interplay between technical innovation and social responsibility (Figure 1). This figure summarizes the challenges and opportunities from gaming and societal perspectives, with the technical enablers identified in Section 2 and challenges we identified in Section 3. The aim is to illustrate where technology aligns with user needs and where additional safeguards and design considerations are required.

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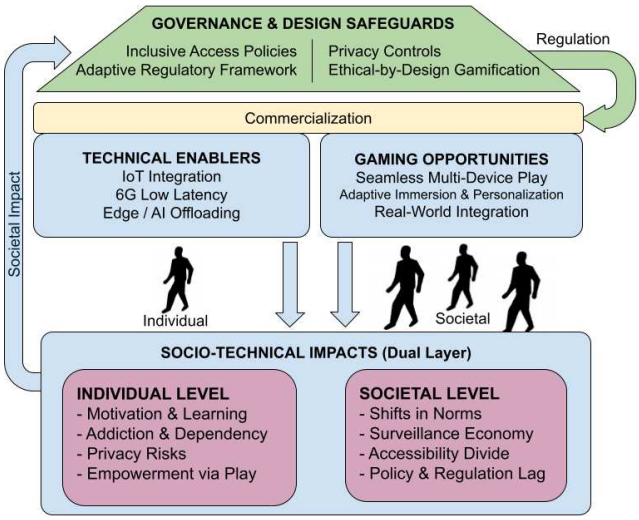

Figure 1: Integration of technological and ethical challenges in society and regulation.

From a technical point of view, the problems of latency, scalability, and device heterogeneity appear to be solvable. Emerging technologies such as 6G and edge computing already demonstrate the ability to reduce latency, increase throughput, and manage large-scale device integration [13]. With continued innovation, the gaming ecosystem can overcome most infrastructure-related constraints and deliver seamless IoT-enabled experiences. Integrating these enablers with gaming methods, multi-device support (including IoT), and immersion with real-world objects could enable more social gaming experiences. The societal dimension presents far more persistent challenges. Addressing behavioral influence issues, privacy protection, and commercializing play requires more than technology, addressing issues of behavioral influence [15], privacy protection [20], and commercialization of technology. To address these concerns, society must first establish a broad awareness of the risks and opportunities such innovations bring to individuals and society [1]. Awareness must extend beyond individual users to enable society and legislative bodies to determine how deeply gaming technologies should impact everyday life. Communicating both the issues and the opportunities, such as the potential for gamification in education and health, ensures that debates and discourse remain aware of the risks.

Awareness, however, is only the first step. Governance must also construct regulatory frameworks that can adapt quickly to technological advancements. We argue that the focus of such regulations should be on the commercialization of technology or gaming concepts, rather than those concepts themselves.

3.4 Future Work

As described in Table 1, future technical research should go beyond improving latency, QoE, and distributed computation to explore the applications that new technical advancements will enable. Societal research must incorporate social impact assessments into the development process, focusing on privacy, autonomy, and fairness. Regulators require clear, evidence-based recommendations to ensure emerging applications align with democratic values, public well-being, and the moral codes of their respective societies. These recommendations should be provided before technologies are widely available and their social implications become apparent.

Table 1: Societal and ethical challenges in IoT-enabled gamification and future research directions.

Technical Research Directions	Societal Research Directions
Focus on privacy-preserving and explainable gamification systems, with adaptive consent mechanisms and safeguards against manipulative design patterns. Detect and mitigate harmful engagement strategies.	Investigate the psychological effects of gamification on various demographics, establish ethical design principles to prevent dependence, and study how users can be supported to balance engagement with well-being.
Develop inclusive and accessible IoT-enabled gaming frameworks, fairness-aware resource allocation models, and transparent monetization strategies that minimize exclusion and promote fairness.	Analyze the cultural implications of the commercialization of play, support the creation of adaptive regulatory frameworks, and explore governance models that ensure access to IoT-enabled experiences.

Subsequently, we should not confine recommendations such as these to academic discourse; we must communicate them to policymakers, industry stakeholders, and the broader public by integrating social and ethical considerations as a core part of technological innovation rather than treating them as separate afterthoughts.

4 CONCLUSION

This position paper has shown that gaming has consistently pushed the boundaries of computing and networking technologies. Its convergence with IoT, AI, and emerging infrastructures defines new opportunities. Advances such as 6G provide credible pathways to resolve many issues, as these enablers can deliver ultra-low latency, reliable QoS, and high QoE, ensuring that the technical foundation for pervasive gaming continues to become stronger. However, societal and technological challenges require deliberate answers. We cannot solve the issues of behavioral influence, privacy, play commercialization, and accessibility with technology alone. We must foster risk awareness while communicating the benefits of gamification in education and health. With such awareness, societies can make democratic decisions about how deeply gaming technologies should influence daily life. At the same time, policymakers must establish adaptive regulatory frameworks that are responsive to changing conditions.

Therefore, the convergence of gaming and IoT requires more than technical progress. It demands social and political processes that evolve together with and in response to innovation.

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