Pioneering a New Paradigm: Building Autonomous Metaverse Driven by AI Agents

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ABSTRACT

In envisioning a metaverse redefined, StarryNift transcends mere innovation to pioneer an autonomous digital realm where the fusion of human ingenuity and AI prowess unlocks boundless possibilities. By seamlessly integrating the foundational tenets of Web3 with the transformative potential of cutting-edge AI technologies, we embark on a journey to revolutionize the very fabric of user engagement, creative expression, transactional landscapes, and growth strategies within this dynamic virtual universe. Our blueprint spans the creation of extensive collaborative networks, the facilitation of seamless user entry points, the diversification of platform accessibility avenues, the establishment of equitable value distribution mechanisms, the cultivation of sustainable ecological incentives, and the unwavering commitment to fairness and transparency. Embracing the visionary essence of the metaverse as an infinite realm of human existence, we pledge to provide a robust infrastructure that empowers users to shape the future of innovation, creativity, and civilization evolution within this autonomous digital frontier.

KEYWORDS

Blockchain, Metaverse, AI, Web3

1 INTRODUCTION

We create StarryNift [1] because we believe the metaverse is a revolutionary evolution from carbon-based life to silicon-based life.

1.1 Background

The emergence of the metaverse [2–4] was an inevitable trend, reflecting humanity's aspirations to enhance productivity, expand living spaces, strengthen capabilities, and pursue a more comfortable lifestyle. History has already shown us that the advancement of human civilization relies on the progress of information processing, including collecting, storing, analyzing, upgrading, and sharing information. The crucial factor in enhancing information processing efficiency is computational power. Before the advent of computers, the human brain served as the central information processor, leading to a relatively slow pace of civilization progress. However, the geometric increase in computing power brought by computers has significantly accelerated this process.

Nowadays, when computational power has been greatly improved, AI (Artificial Intelligence) naturally has naturally taken center stage in history. Whether it is the widely popular Sora [5], which can generate videos from text, or Devin [6], an AI software engineer capable of automatically completing programming tasks, both showcase AI's formidable capabilities in processing information. Moreover, these capabilities are surpassing human imagination. The foundational principle of AI is the emulation of human neural networks, and numerous studies have elucidated the analogies between neuroscience and LLMs (Large Language Models). Unlike carbon-based humans, silicon-based entities are more efficient at storing and processing information, virtually eliminating issues like forgetting. Additionally, these entities can transfer information without loss, unlike humans, who must rebuild cognition with each new generation, often with cognitive biases.

Therefore, the birth of the metaverse represents a transition from carbon-based to silicon-based forms, leveraging computational power to construct a space where reality and virtual deeply integrate in an open and decentralized social sphere, encouraging digital connections between people, as well as digital connections between people and AI, and further creating more possibilities for the prosperity of human civilization. In the metaverse, you can connect with more people, make new friends, shop, dine, watch movies, attend concerts together, and even convert virtual currency into real money. The metaverse is destined to become a significant aspect of future human society due to its ability to transcend physical limitations.

1.2 StarryNift Vision

StarryNift envisions an autonomous metaverse where users can seamlessly interact with AI agents, enhancing their experiences and enabling new possibilities. Our mission is to pioneer a new paradigm, one that integrates the principles of Web3 and harnesses the power of AI, revolutionizing the way we interact, create, transact, and grow within this digital universe. In this paradigm, we aim at:

(1) **Fostering collaboration to enrich limited scenes on metaverse.** Many MMORPGs (Massively Multiplayer Online Role-Playing Game) can, to some extent, be seen as prototypes of the metaverse. However, the development of their environments requires extensive work from designers, modelers, and programmers. By promoting collaborative efforts in the realms of digital collectible design, 3D space construction, and new IP fan creations through the utilization of AI agents, we can bring together projects, communities, and decentralized autonomous organizations (DAOs). This will cultivate an environment that promotes innovation and collective ownership, ensuring that every participant has a voice and a stake in the evolution of the metaverse.
(2) **Providing convenient entrance to facilitate access to the metaverse.** Despite the metaverse concept being very popular and many users eager to explore, there is still a path dependency on the web2 world for access. Users need a smooth transition. We will create an inclusive gateway to the metaverse through integrating Web2 and Web3 approaches, while incorporating multiple mainstream chains. We will enable interoperability,

scalability, and enhance user experiences as the foundation for a vibrant and interconnected metaverse, where users can traverse different platforms and ecosystems, unlocking endless possibilities.

(3) **Diversifying interfaces and adapting to multiple devices.** Given the large anticipated user base in the future, this implies that users will be distributed across multiple chains and will access the metaverse using various devices. Therefore, adapting to multiple blockchains and cross-device compatibility will be essential. We empower players to fully immerse themselves across multiple platforms. Whether it's the convenience of desktops and laptops, the mobility of mobile devices, or the immersive experience of VR devices and spatial computers such as Vision Pro, we strive to ensure that players have the freedom to choose their preferred platform and enjoy an unparalleled level of interaction and immersion.

(4) **Ensuring data control rights to redistribute value.** Current applications often provide users with ample creative space and a high degree of autonomy. However, in reality, companies maintain control over all data, with the majority of the generated value and wealth flowing back to them, while users often receive minimal or no profits. Ensuring users, especially creators, retain ownership of their data and receive fair recognition for their creative endeavors is one of the cornerstones of the metaverse economy. Harnessing the revolutionary potential of blockchain empowers users to take full ownership of their digital identities and assets. Powerful AI agents assists users in efficiently and effectively managing distributed data.

(5) **Designing a rational ecosystem to motivate contributions and innovations.** The absence of an effective profit-sharing mechanism leaves content contributors unable to benefit from their contributions, leading to diminished enthusiasm and stifled innovation. Establishing a robust player-owned economy to reward user creativity and enhance the vitality of the system is essential. We have developed an innovative tokenomics framework that incorporates elements such as Token Allocation, Vesting Schedule, and Value Accrual with fair mode. The approach considering both short-term growth and long-term value will be taken, encompassing "create to earn, social to earn, and AI agents to earn", while a wide range of utilities and benefits will be offered.

(6) **Establishing transparent and verifiable rules to guarantee governance fairness.** In the blockchain-based metaverse, governance rules are embedded in smart contracts. While benefiting from its immutability, it's necessary to confront potential threats to fairness that could result in significant financial loss. Fairness issues can arise not only from the establishment of unfair rules but also from the mismatch between participants' expectations and the actual implementation of the rules [7]. Thus, it's crucial to create a just and autonomous environment for all participants. Guilds, DAOs, holders, and other contributors play a vital role, who vote for the ecosystem development direction. AI agents act as invaluable allies, providing personalized recommendations, intelligent curation, and decision-making suggestions. Through community consensus and decentralized governance, we can establish a more autonomous space, further empowered by AI judges who set the rules of the game, with the support of automated formal verification to ensure fairness and transparency.

Table 1: Challenges and potential solutions

Challenges	Solutions
Limited Scenes	AI, PhysiShape3D
Desperate for Entrance	Integrated Gateway, Cross-chain Wallet
Interface Adaptation	Multi-device support (HCI-XR)
Deprivation of Control	Blockchain, NFT
Lack of Incentives	Tokenomics
Governance Fairness	AI Judge, Formal Verification

As Tim Sweeney said, "The metaverse is not just a virtual world, but a new dimension of human existence, where boundaries dissolve and possibilities are infinite." We are responsible for providing a solid foundational platform, while users take on the role of boldly innovating. Together, we will create an autonomous metaverse that inspires, captivates, and revolutionizes the way we live, work, and play. The challenges and potential solutions are listed in Table 1.

1.3 Our Solutions

It is foreseeable that humanity will increasingly allocate more of their time to the metaverse. During this transition, users will naturally develop two primary needs: (1) gaining control over the ownership of personal assets created in or transferred into the metaverse and (2) having the capability to create and modify personal avatars and living spaces. This precisely encapsulates the two challenges faced by the nascent metaverse at present.

- **CH1: How can users derive benefits within the metaverse?** If we fail to continuously generate wealth and value for users to address their essential needs, a disparity between the real and virtual worlds will emerge, which deters further user engagement in the metaverse.
- **CH2: How to lower the barriers for creation and transformation in the metaverse?** The digital divide is an inevitable challenge, thus lowering the entry barrier is important to foster user engagement. After all, not everyone has the capability, akin to AI, to assimilate all existing knowledge.

Web2 giant companies are propelling the metaverse's growth across diverse dimensions, including high-speed networks like 5G, spatial computers like Vision Pro, and content creators and experience enhancers like Roblox. However, as a crypto-native team, StarryNift envisions a new era, where we embrace the transformative power of Web3 and forge a groundbreaking path through leveraging AI advancements, offering users an unparalleled and transformative digital experience while improving information processing capabilities. StarryNift aims to solve the above mentioned two major challenges in the following ways.

- **Sol1: How can users derive benefits within the metaverse?**
  (1) **Collaborative Ecological Community.** We extend invitations to various brands, projects, and DAOs encouraging joint forces. Through themed carnivals, marketing quests, co-creation campaigns, and aggregated traffic, we foster ecosystem growth while providing participants with many choices.

By facilitating collaborative initiatives and engaging activities, diverse stakeholders can contribute to the community and enjoy rewards.

(2) **Evolvable Decentralized Identity.** StarryVerse [8] citizenship cards serve to capture both on-chain and off-chain data, enabling a visualized and programmable Decentralized Identity (DID) that represents your virtual existence with the metaverse. Six diverse dimensions mirror users' distinct reputation and endeavors on the StarryVerse platform. Given that, citizens can enjoy enhanced social experiences and benefit from tailored airdrops.

(3) **ZK Rollup Layer2 Scaling Solution.** ZK Rollup Layer 2 scaling solution can significantly enhance the transaction speeds, lower gas fees, increase scalability, strengthen privacy protection, and offer the seamless onboarding of decentralized applications (DApps) into the ecosystem. Holders can share the prosperity of the platform with native token fueling the network.

(4) **Launchpad for NFT and Inscription.** Introducing a Launchpad for Multi-chain NFTs and Inscriptions can enable users to engage with a diverse range of unique digital assets and empower creators and projects by helping them garner attention. By facilitating broader visibility and accessibility, builders can monetize their work and commit to sustained growth and success. Users benefit from a wider array of collections and the opportunity to grow and benefit.

- **Sol2: How to lower the barriers for creation and transformation in the metaverse?**

(1) **Open Spaces with Multi-Function.** By merging artistic creativity with cutting-edge technology, we strive to build interoperable spaces that encompass diverse styles and worldviews. Our dedication lies in enriching both Web2 and Web3 use cases, including leisure games, entertainment performances, social experiences, and more, by unlocking unlimited possibilities.

(2) **Autonomous AI Agents Transformer.** Utilizing AI agents in the metaverse involves implementing autonomous NPCs for dynamic interactions, employing AI algorithms for content generation, leveraging user data for personalized experiences, and integrating virtual assistants for user support and behavior prediction. These strategies enhance user engagement, streamline content creation, optimize user experiences, provide real-time assistance, and enable predictive insights, ultimately driving the development of an autonomous environment.

(3) **DePIN Empowering Computing Power.** DePIN can revolutionize the platform by enhancing computational capabilities and data processing efficiency. The democratized DePIN computational network makes it possible to better match computational resources. This meets the massive computational demands brought about by AI model training, complex mathematical calculations, and higher-quality 3D spatial rendering.

(4) **Real-time Immersion with Mixed Reality.** By integrating mixed-reality technology, users can seamlessly blend the physical and digital worlds. This enhancement enables users to explore virtual spaces, interact with digital art, and engage with the metaverse in a more dynamic and immersive manner.

2 GENESIS AGE: USE CASES AND APPLICATIONS

StarryNift officially embarked on its journey in 2021 to create a metaverse. By 2023, we had taken our first steps from zero to one in various areas such as gaming and community, citizenship, launchpad, and tokenomics, where they operated independently yet synergistically. Although not yet perfect, we indeed created a enchanting mini metaverse that has attracted millions of participants. Therefore, we refer to this phase as the Genesis Age.

2.1 Game and Entertainment 3D Space (StarryVerse)

StarryNift is leading the way in integrating gaming and entertainment within the Metaverse, offering a broad spectrum of interactive experiences that cater to diverse interests. Our platform innovatively blends GameFi, community-driven 3D spaces, collaborative gaming, AI agent and AIGC technologies, creating a dynamic ecosystem of activities that engage, inspire, and connect.

2.1.1 Games.

- **NFT-Related Games.** StarryNift offers strategic and interactive gameplay, featuring planet occupation, NFT battles, spaceship expedition, treasure hunts and reward mining designed for NFT holders. Players can also rebirth NFTs to enhance their attributes, breed for more NFT offspring and stake them for earning rewards. This approach not only diversifies the gaming experience but also provides NFT owners with opportunities to gain within our ecosystem.
- **Dedicated Gaming 3D Spaces.** StarryNift crafted specialized 3D spaces with immersive and stunning visuals for gaming enthusiasts. The Warrior Stadium scene, for example, hosts a dynamic "Jump and Run" game, providing a thrilling game challenge. It allows multiple players to compete or collaborate in real-time, thereby fostering a more engaging and communal gaming atmosphere. This initiative underscores our commitment to offering a diverse and interactive range of gaming experiences, where players can connect, compete, and share moments of victory together.
- **Interactive 3D Event Games.** StarryNift's metaverse hosts a variety of games, including mini-games tied to 3D space events, enhancing participant engagement. For example, during music concerts, players can collect floating NFT image fragments or engage in a virtual dance battle for a chance to win rewards. Additionally, another event challenges participants to quickly identify songs in 3D space, with winners earning exclusive NFT claims. These examples illustrate the platform's dynamic integration of gaming with virtual events, enriching the user experience.
- **Co-Created Games.** In StarryNift's Co-Created Games, creativity merges with community engagement, offering a canvas for shared artistic expression. Through activities like the April Fool's Day Art Contest and Graffiti Art Contest, participants weave their artistry into the fabric of StarryNift's metaverse.

Whether it's infusing Code Green characters into iconic paintings or crafting graffiti that blends the essence of Peking Monsters with StarryNift's vibrant world, each contribution enriches our collective virtual experience.

- **NPC-Enhanced Games.** StarryNift introduces games where NPCs play a pivotal role in enhancing the experience. These digital companions guide, assist, and interact with players, enriching the narrative and gameplay. A prime example is the Graffiti Finding and Illumination Game, where NPCs guide players to hidden graffiti and evolve based on discoveries. This interaction deepens adventure and creativity, showcasing NPCs' potential to animate virtual worlds with personalized, evolving storylines.

2.1.2 Entertainment.

- **Digital Galleries and Exhibitions.** Transforming how art is experienced, our digital exhibitions, such as the VR-supported 3D Gallery, host themed events and display artworks, connecting artists with a worldwide audience. A standout example is a custom 3D space NFT exhibition, where we developed a Customised Exhibition Hall to showcase the NFT Collection collaborated with Steve Aoki. This innovative approach not only spotlights individual artists but also offers a unique, immersive platform for sharing and appreciating digital art globally.
- **Music Festival 3D Spaces.** StarryNift enriches its metaverse with dedicated 3D spaces for music events like EDM and rock festivals, creating immersive environments that connect artists and fans, breaking down geographical barriers for unforgettable experiences. Highlights include the Peking Monsters x StarryNift 3D Rock Music Festival, showcasing custom scenes such as Retro Rock, Metal Max Wasteland, and Psychedelic Lost Land. These environments, created by our skilled artists and 3D modelers, meet diverse thematic needs, ensuring each festival's uniqueness and immersion.
- **Holiday Celebration Festivals.** StarryNift brings the festive spirit to life in its metaverse, organizing special 3D space events for various holidays to enhance user interaction and community bonding. During the New Year, we light up the virtual sky with dazzling fireworks and offer a blessing message board feature, allowing everyone to post holiday greetings and wishes. By integrating these features, StarryNift ensures each festival and holiday is marked with unique, shared experiences, making the metaverse a more engaging and communal space for everyone.
- **AIGC for Customized 3D Spaces.** Leading the Web3 Metaverse, StarryNift empowers users with UGC editors and AIGC tools, such as the Skybox AIGC generator, to create and personalize 3D spaces and decorations. This technological leap allows users to tailor their virtual environments with unprecedented creativity and individuality, marking a new era of customized digital expression.
- **AI Chatbot Integration.** The introduction of the Starry AI Collection heralds a new chapter in entertainment and companionship within the StarryVerse. This innovative platform enables users to craft and interact with a variety of AI bots, including personalized companion and entertainment bots. Users can seamlessly integrate these AI bots into their 3D spaces, creating bot buddies or digital twins that enhance social interactions, making every visit a unique and engaging experience.

2.2 Brands Marketing and Growth Platform (Community)

At StarryNift, we've transformed the art of collaboration, bringing brands and projects into the spotlight of the Metaverse with unparalleled success. Our journey has been marked by strategic alliances and technological innovations, making us the go-to platform for brands seeking to enhance their branding and growth in a digital-first era. From exchanges to DAOs, NFT projects, and public blockchains, our collaborative ventures span the breadth of the Web3 spectrum, showcasing our commitment to community empowerment and mutual growth.

We are constantly elevating brand presence through strategic collaborations. We've forged impactful partnerships with giants such as Binance, Sui, Peking Monsters, Ready Player Me, Azuki and the integration of the OKX X1 Network, showcasing our commitment to leveraging cutting-edge technology to enhance user experience and foster a thriving Web3 community. These collaborations have not only bolstered our partners' growth but have also been instrumental in bridging the Web2 and Web3 worlds, crafting a smooth integration that enriches both ecosystems.

2.2.1 Versatile Brand Exposure 3D Spaces.

- **Branding Specific Spaces.** StarryNift features VR-supported 3D environments specifically designed for brand partnerships and exposure, such as the FireChat and MetaAlliance Branding Pavilion. These spaces allow projects to showcase banners that, when clicked, can redirect users to the brand's website. Additionally, they can host exhibitions/events and enable engagement with audiences through voice and messaging in immersive 3D settings. This enhances brand visibility, fosters deeper community connections, and is perfect for AMAs and promotions.
- **Co-created Community Spaces.** This 3D environment fosters business collaboration, allowing projects, DAOs, and KOLs to connect and work together. Personalized with various art styles, each space offers a distinct presence within the metaverse, exemplified by spaces like StarryNift Turkey Dao and OKX Ventures NeoAero Square. Here, projects host 3D AMA sessions, livestream events, and utilize advertising areas, while users engage in immersive socialization and interact with projects' AI assistants, fostering connection, information sharing, and audience engagement.
- **Immersive Brand Integration.** StarryNift offers a variety of immersive 3D environments, allowing users to engage in activities akin to real life. These spaces feature diverse scenes that can seamlessly integrate relevant brand placements, fostering exposure opportunities. For instance, financial institutions can collaborate to create virtual branches within these spaces, offering futuristic banking experiences and reinforcing our commitment to versatile brand partnerships in the digital realm.

2.2.2 Integration of MerchHub.

A pivotal extension of our branding and engagement capabilities is MerchHub, an exclusive metaverse shopping destination that bridges the physical and digital realms. Here, partners can showcase and sell original IP gifts, offering a unique user experience and inspiring creativity. MerchHub not only serves as a platform for exceptional rewards and co-creation opportunities, but also

underscores our commitment to supporting the creator economy and enabling brands to connect more deeply with their audience.

2.2.3 *Collaborative Growth Initiatives.*

Our platform's Decentralized Identity (DID) system recognizes users' participation in Web3 projects, granting achievement certifications and rewards. Additionally, we host events distributing rewards to holders of other projects, promoting brand visibility and growth. These strategies foster a mutually beneficial ecosystem, facilitating collaboration and expansion for brands within the StarryNift community.

2.2.4 *Tailored AI Solutions.*

We are advancing our technology by integrating AI to create project-specific Q&A bots, enabling users to quickly access project insights, improving the experience with instant, relevant information. We're dedicated to refining AI tools to enable projects to create their own dynamic spaces in the Metaverse. This allows them to showcase their Web3 identities and achievements with precision and flair, forging a personalized AI space tailored to their needs.

2.3 Decentralized Identity and Social System (Citizenship)

StarryNift's Citizenship protocol signifies a pivotal evolution in digital identity, artfully integrating Web2 and Web3 data to craft comprehensive user profiles. This innovative system not only encapsulates a user's digital footprint across both realms but also enriches the Metaverse citizenship ecosystem through strategic partnerships and multi-dimensional user engagements. This advancement allows for a nuanced understanding of user behaviors and preferences, facilitating rapid and accurate understanding among users and businesses alike. This protocol not only signifies a major evolution in how digital identities are managed but also enhances the overall experience within our expansive digital realm.

2.3.1 *Citizenship Protocol: A Multifaceted Approach.*

Since its launch, over 500,000 users have adopted the Citizenship Card, unlocking gaming, social, and entertainment scenarios within StarryVerse. The Citizenship protocol by StarryNift represents a significant leap forward in creating a holistic digital identity. It blends traditional web data with blockchain activities, offering a rich, multifaceted user portrait that spans across General, DeFi, SocialFi, GameFi & Metaverse, NFT, and DAO dimensions. This system enables users to mint achievement SBTs, tailor achievements within the identity system, and showcase these distinctions across various projects, enhancing user identity's richness and accessibility.

2.3.2 *Projects Integration and User Data Enhancement.*

Collaborating with an array of projects across the Web3 spectrum, StarryNift has expanded the Citizenship protocol to include more intricate and comprehensive user data. This integration not only fosters a deeper understanding between users and businesses but also promotes a more rapid and precise engagement. Through partnerships with networks like opBNB and the introduction of technologies like zero-slippage swapping algorithms via StarrySwap, StarryNift has broadened the utility and appeal of the Citizenship Card, making it a cornerstone of user engagement in the Metaverse.

2.3.3 *User Insights with Citizenship Analytics.*

Our Citizenship SDK and identity protocol offer projects seamless integration into the StarryVerse, facilitating community building, social engagement, and the establishment of trusted digital identities. This comprehensive identity system enables projects to accurately target, attract, educate, and retain high-quality users, laying a solid foundation for their sustained growth and success.

2.3.4 *Data Ownership and Privacy.*

At the heart of StarryNift's Citizenship is the unwavering commitment to data ownership and privacy. Leveraging Zero Knowledge Proofs (ZKP), the platform ensures that users retain complete control over their data, fostering a trust-based environment. This emphasis on privacy and ownership is crucial, offering peace of mind for users as they navigate the vast and often unpredictable digital landscape of the Metaverse.

2.3.5 *AI-Driven Digital Identity.*

AI technologies significantly enrich the Citizenship experience within StarryNift by offering tools for users to vividly express their digital identities. StarryAI empowers users to create interactive AI bots, acting as dynamic extensions of their digital personas, enhancing social interactions. Concurrently, AIGC tools enable the customization of avatars and 3D spaces, allowing users to showcase their individuality. These technologies together offer a platform for users to showcase their unique identity and style, highlighting StarryNift's dedication to creative freedom and innovation in the digital world.

2.4 New IP Incubation and Ecosystem Prosperity (Launchpad)

StarryNift has emerged as a beacon of innovation in the NFT and Web3 space, focusing on the incubation of new Intellectual Properties (IPs) and the flourishing of the entire ecosystem. The StarryNift Launchpad is a platform that aims to support and facilitate the launch of new NFT projects and collaborations. It provides a space for projects, artists and creators, artists to showcase their collections and gain exposure within the StarryNift ecosystem. StarryNift launchpad not only cultivates its own intellectual property (IP) creations like Code Green but also serves as an incubator for external projects and artists such as AI ANIMO.

2.4.1 *Proprietary IPs Incubation.*

StarryNift's proprietary IP incubation is a process where we nurture and develop our own intellectual property (IP) creations. We have a dedicated team of talented artists, designers, developers, and storytellers who work together to bring unique and captivating IP series to life. These IP series can include characters, storylines, artwork, and other creative elements.

Code Green, our original flagship IP, symbolizes our commitment to originality and creativity within the NFT space. This series of alien viruses, conceived by StarryNift's Chief Content Officer, showcases our platform's ability to generate compelling narratives and engaging digital collectibles.

StarryNift's strategy encompasses not just the creation and promotion of NFTs but also the integration of these digital assets into broader narratives and ecosystems. It is designed as multiple series with evolving attributes and potential for future gameplay

integration, illustrating our holistic view of NFTs as living components of the Web3 world.

- **Virus Citizen and Fantasy World Collections.** These collections offer a blend of rarity and uniqueness, with each NFT designed to reflect the diverse and vibrant personalities of the Code Green characters.
- **Special Editions.** Including Chinese Valentine's Day Code Green, Classic Film & New Miner Collection, and Celebrity Collection, these special editions merge pop culture with the quirky world of Code Green, offering collectors a rich variety of themes.
- **Co-creation Initiatives** We've pioneered co-creation by integrating community-created art into our blind boxes, demonstrating our commitment to collaborative creativity and shared success within the Web3 domain.
- **Partnering with Industry Tycoons.** In a landmark collaboration, we've partnered with industry giant BinanceNFT to release limited-time NFT collections, significantly expanding our reach and providing our users with exclusive access to unique digital collectibles. This strategic partnership not only elevates our platform but also enriches our ecosystem with diverse offerings and opportunities for engagement.

2.4.2 Empowering External IPs and Artists.

Beyond our in-house creations, StarryNift serves as an incubator for external projects and artists, providing them with the tools, platform, and support needed to bring their visions to life.

The **AI ANIMO** (*StarryNift* X *Mia%Alt5* X *Sui*) collection is a representation of StarryNift 's commitment to assisting Web2 artists transition to Web3 and take advantage of decentralization. With a full set of NFT tools we provide, Mia%Alt5, an AIGC artist and filmmaker, created this NFT using AIGC technology and composability of Sui Move language. It's our first co-creation with Mia%Alt5 and comes sealed in a mystery box with three assets: AIGC Avatar+Composable 3D Space+Embedded Sui Token Lucky Draw.

We actively empower our incubated IPs with creative events, such as incorporating AI ANIMO fragments into music festival scenes for engaging mini-games. Participants can collect floating ANIMO image fragments for a chance to enter a USD lottery pool. In this game, AI ANIMO Holders will enjoy an additional buff that increases their chances of winning. This initiative exemplifies our commitment to enriching the IP incubation process and fostering ecosystem prosperity, demonstrating our commitment to enhancing the value and engagement of our IPs.

2.4.3 StarryNift Marketplace.

The StarryNift Marketplace, the official trading hub of the StarryNift Metaverse, offers a secure and user-friendly platform for trading and showcasing a wide array of NFTs, including virtual land, avatars, and artwork. It complements the Launchpad by offering a trading space for NFTs from new projects and fostering a vibrant community of creators and collectors. This integrated approach ensures a dynamic and inclusive environment, boosting the visibility of innovative NFTs and supporting the seamless transition from creation to trade, aligning with StarryNift's vision of ecosystem growth.

2.5 Creator and Player-Owned Incentive and Tokenomics (Earn)

In the ever-evolving landscape of Web3 and NFTs, StarryNift stands out as a pioneering platform dedicated to creating a vibrant ecosystem where creators, players, and contributors are empowered through innovative tokenomics and incentive models. Our approach is designed to ensure that everyone involved — be it through creating, playing, or participating — can earn and benefit from the ecosystem's growth and prosperity.

StarryNift introduces a variety of innovative earning mechanisms and earning opportunities, seamlessly blending the realms of creativity, gameplay, and community engagement:

2.5.1 Citizen Engagement and Rewards.

- **Citizenship Engagement Rewards.** The "Earn" section is designed to reward citizens for their active participation and engagement within the metaverse. By completing daily tasks such as signing in, exploring 3D spaces, and interacting with other users, citizens can earn XP rewards. These incentives are more than just rewards, signifying StarryNift's commitment to fostering a vibrant and interactive community.
- **Expanded Reward Mechanisms.** StarryNift enriches its "Earn" section by offering additional XP through activities like friend referrals and the "Raffle Pool." Citizens gain XP for each new member they bring, with rewards increasing with more invites. The Raffle Pool provides a chance to win more XP, either through free entry or by trading earned XP for extra tickets.
- **DID Achievement Rewards.** StarryNift's Citizenship protocol and DID system reward users for completing milestones in Web3 projects. This enhances digital identities by recognizing diverse ecosystem involvement. Achievements across Web3 are acknowledged within StarryNift, rewarding XP and enriching users' digital citizenship. This interconnected rewards system amplifies collective digital identities.

2.5.2 NFT Holder Benefits and Trading.

- **NFT Holder Rewards.** Our platform values the dedication of NFT holders and offers exclusive benefits to reward their loyalty. Through NFT airdrops, exclusive game events, and access to premium content and experiences, NFT holders enjoy unique privileges. Additionally, by staking their NFTs, holders can earn additional income, leveraging innovative models like crypto mining pools where NFT rarity and price enhance mining profits.
- **NFT Trading and Collection.** In the StarryNift Marketplace, participants have the unique opportunity to profit directly from trading activities. By engaging in the buying and selling of NFTs, including Code Green and equipment items, users can leverage market dynamics to earn significant returns. This platform not only facilitates a secure and efficient trading environment but also actively rewards high-volume traders and collectors.
- **NFT Creation Earnings.** The StarryNift "Create to Earn" program empowers creators to earn by designing and minting artworks, 3D avatars, and spaces as NFTs. The StarryNift Marketplace showcases these NFTs, allowing direct sales to a broad audience. This approach not only monetizes creativity but also enriches the marketplace with unique NFTs, fostering a culture of creation and collection within the community.

2.5.3 *Event Participation and AI Tool Creation.*

- **Event Participation Rewards.** StarryNift fosters an active ecosystem where users can earn rewards by participating in community or platform events. By engaging in activities like integrating Code Green characters into iconic art or graffiti, participants not only showcase their creativity but also have the opportunity to receive rewards for their contributions.
- **AI Tool Creation Rewards.** In the StarryNift ecosystem, leveraging platform features for content or tool creation rewards users with XP. Specifically, the StarryAI Collection exemplifies this by enabling users to design AI bots, blending creativity with innovation for rewards. This initiative highlights StarryNift's commitment to rewarding users for engaging with its features and contributing to the ecosystem's growth.

3 INTERSTELLAR AGE: PILLARS AND ARCHITECTURE

The boundaries of the metaverse will continue to expand until they encompass everything, just as the universe contains countless stars. Every exploration by users is like a romantic "interstellar travel".

In Section 2, we reviewed our accomplishments to date. In Section 3, we will introduce our future roadmap, each element filled with uncertainties and challenges. Consequently, we approach each item as a long-term project. The concepts and implementations discussed herein are founded upon current technologies, and it's plausible that new, innovative, and practical technologies will emerge in the future. We commit to timely updates to incorporate these advancements as they arise.

We have designed a four-layer technological architecture, including Application Layer, Communication Layer, Auxiliary Layer, and Fundamental Layer. Various pillars and the overall architecture are shown in the Fig. 1. First and foremost, everything is built upon the base blockchain layer, i.e. the main network, which is the bedrock for reliability and security. Currently, we have successfully integrated with EVM [9] and MoveVM [10], with plans to incorporate additional ecosystems in the future [11–14]. Secondly, we design the fundamental layer to provide a variety of essential support services, and we also plan to propose our own Layer 2 solution to address the significant transaction throughput challenges and the demand for low transaction fees brought by the metaverse. Thirdly, the application layer encompasses a variety of AI-enabled applications, including agents and NPCs in the game, alongside DID data integration analyzers and co-created 3D spaces. All these components serve to enhance user experience, acting as gateways for users to enter the metaverse. Fourth, the communication layer primarily utilizes oracle networks to supply off-chain information to the blockchain. Employing communication protocols, exploration protocols, and other such protocols grants AI agents enhanced permissions for gathering information and executing user operations. Lastly, we will also provide an auxiliary layer to optimize the user experience and guarantee fairness, which consists of an offline rendering network, formalized automated smart contract analyzers, and detectors, as well as the governance DAO.

3.1 Fundamental Layer

The fundamental layer primarily consists of Starry Layer 2, Starry Data Lake, knowledge bases, and the PhysiShape3D Library.

3.1.1 *Starry Layer 2.*

We are thrilled to witness that StarryNift has attracted millions of participants, yet we must address the significant challenges of scalability and elevated transaction fees that come with it [15, 16]. Moreover, the complexity of smart contract development and the interoperability issues among multiple ecosystems remain vexing and error-prone. Ultimately, bugs in smart contracts can be very costly, as they can't be changed once deployed. Another issue that cannot be overlooked is that blockchain is not designed to store vast amounts of data. However, the metaverse will inevitably generate a massive volume of data, creating an inherent contradiction. This compels us to consider alternative ways to store data off-chain, which may introduce extra potential points of failure and complexity.

Our Layer 2 solution, designed for the metaverse, aims to offer users and developers a premier experience, rather than trapping them in the dilemma between security and network effects. In the following sections, we will introduce several key components.

3.1.1.1 Volition.

Volition is an innovative blockchain data management technology that allows users to choose where their data is stored, while leveraging zero-knowledge proofs [17] to ensure the integrity of data and the validity of transactions. This flexibility becomes crucial as user preferences for data availability can vary across different scenarios. Take a common example from the metaverse: Bob acquires an extremely rare and valuable item within a decentralized game, manifested as an NFT [18]. He is more than willing to pay for top-tier security to safeguard this asset so that he can sleep well at night. However, the next day, Bob obtains an item of very low value, perhaps an NFT worth only a few cents. In this case, he might not be genuinely concerned about the potential loss of this NFT and, consequently, would not prefer to bear the cost of on-chain data availability. Under no circumstance would he consider withdrawing this low-valuable NFT to Layer 1.

(1) **ZK-Rollup.** Zk-rollup empowers users the ability to "deposit" their assets into Layer 2 and conduct transactions there. A sequencer orders these transactions into a consistent historical sequence. Subsequently, transactions are packed into a batch or block, and a validity proof is generated, which is then submitted to Layer 1. The smart contract on the main net is only required to verify the validity of the zero-knowledge proof without processing each individual transaction, achieving scalability (expected to be 10,000 TPS) and reducing transaction fees while maintaining security.
It is noteworthy that we opt for STARK proofs instead of the more conventional SNARK proofs. Although STARK proofs are larger and incur higher costs for on-chain publication compared to SNARK rollups, STARK proofs offer several irreplaceable advantages. Firstly, STARKs do not require a trusted setup ceremony, enhancing transparency and trustworthiness. Secondly, considering the progression of quantum computing, the STARK proofs are generally regarded as quantum-resistant,

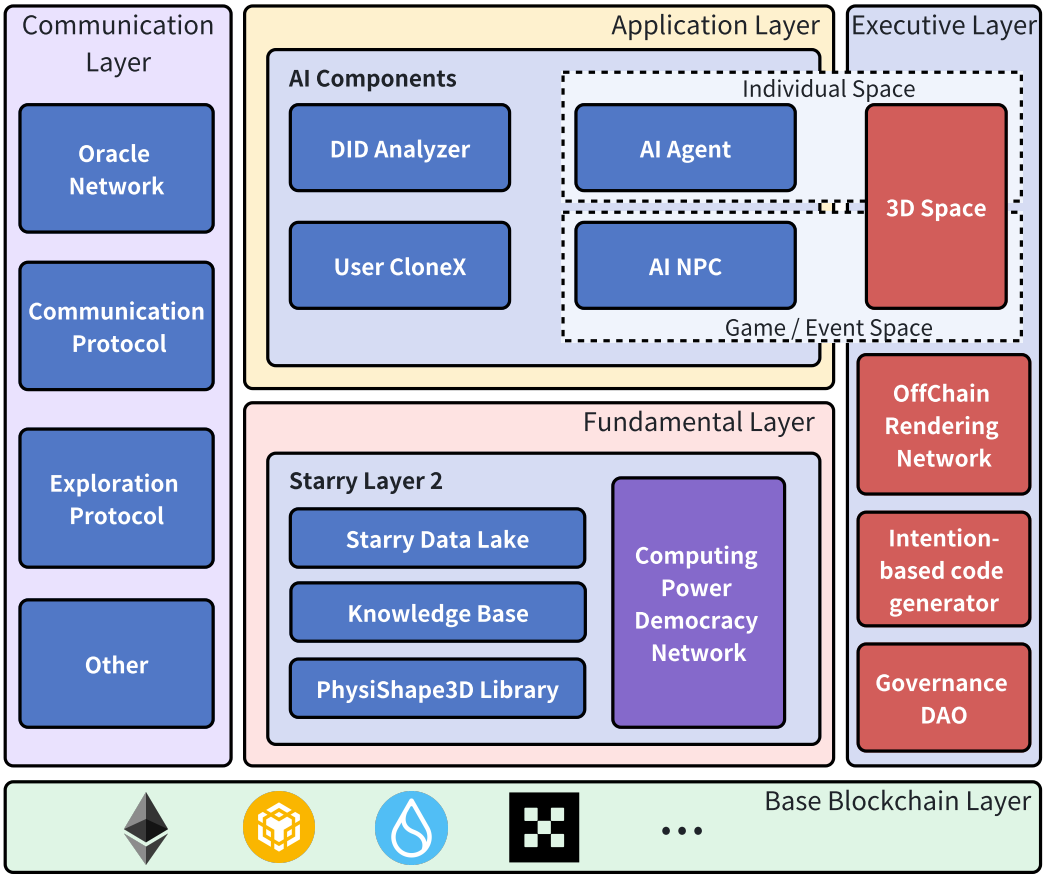

Figure 1: Overall architecture of StarryNift

offering long-term security assurances. Thirdly, from a practical standpoint, SNARKs rely on highly complex cryptographic techniques, making implementation errors difficult to avoid. In contrast, STARKs do not face this issue.

(2) **Validium.** Validium returns to the concept of keeping layer 2 data off-chain, unlocking much greater scalability than rollup constructions. Validium relies on zero-knowledge proofs instead of fraud proofs for validating computation. Validium will establish a Data Availability Committee (DAC), whose members are required to sign data and maintain its availability at all times. Even if only one committee member remains honest, users will be able to access the needed data and make withdrawals successfully. It depends on a trusted third party and, although it might sacrifice some transparency and reliability, its main advantages are lower transaction fees on layer 1 and superior privacy protection than Rollup mode.

Volition, when implemented on the Starry Layer 2, will operate with two distinct state trees, each corresponding to one data availability mode. Accounts are positioned in the respective state tree based on the selected mode. To alter the data availability mode for a specific account simply requires transferring funds into a new account within the other tree. The flexibility allows for tailored control over data accessibility and security preferences.

3.1.1.2 API Abstraction and SDK.

Starry Layer 2 introduces a robust suite of REST APIs designed to streamline the integration of asynchronous blockchain operations into synchronous calls. In addition, Starry Layer 2 will offer SDKs to simplify the development process, enabling developers to seamlessly integrate with the Starry Layer 2. Such optimization of the development workflow will benefit companies that are dedicated to venture into the metaverse. Established companies will be able to more swiftly migrate their mature products into the metaverse, while startups can achieve a rapid launch. User-friendly APIs and SDKs will allow developers to customize and optimize their applications according to the specific requirements of their use cases, enhancing stability and compatibility. For instance, they could leverage our APIs to mint NFTs, effortlessly establish an NFT market, or even create a novel game or social event.

3.1.2 Starry Data Lake.

In the contemporary digital ecosystem, both DApps and AI are fundamentally driven by data. However, the diversity of data modalities, coupled with the increasing volume of both relational and non-relational data from a variety of devices and applications, presents an unavoidable challenge for large-scale data access. The exponential growth of transactional and state data on blockchain platforms, decentralized applications, and the corresponding off-chain data exacerbates this issue. Traditional solutions involve centralizing this data in platforms like BigQuery [19] or Apache [20], which contradicts the principles of openness and transparency cherished in the blockchain world.

To construct a data lake that aligns with decentralized nature of the metaverse, the following properties need to be met:

(1) The capacity for infinite scalability.
(2) Permissionless data access coupled with low query costs.
(3) Trustworthiness and verifiability.

We are working on building our own decentralized data lake and query engine called Starry Data Lake. Generally speaking, there are three roles: data providers, data consumers, and workers. The system's credibility and neutrality are endured through a robust tokenomics design and collateral system.

Data providers are responsible for ensuring the quality and supply of data. They validate data ingested from blocks by comparing hashes, then split data into small compressed chunks and save into persistent storage. These chunks will be distributed to workers randomly. Raw data are encouraged to be uploaded on chain. Data providers update the metadata (schema, the reserved storage, etc.) on the blockchain when new data is uploaded. As the data lake gradually matures, and increasing number of data providers and storage options become involved, undergoing scrutiny by on-chain governance DAO. This will hopefully solve the scalability problem to some extent. Workers contribute storage and computing resources and receive tokens as rewards. Proven reliable workers may earn higher rewards. Data consumers can query the data lake via operating a gateway. The number of requests depends on the number of Tokens locked in the gateway associated on-chain address.

It is worth noting that advancements in database technology and the decrease in prices of high-quality SSD storage will also enable the Starry Data Lake to offer better services.

Starry Data lake is a type of DePIN (Decentralized Physical Infrastructure Network), offering functions including data expansion, storage, retrieval, etc. We believe that it will not only facilitate the development of trustworthy digital identities but also provide a rich resource for AI. Meanwhile, it will support a variety of data needs within the StarryVerse, including DeFi, tokenized real-world assets (RWA), decentralized social networking (DeSoc), GameFi, etc.

3.1.3 *Knowledge Base.*

Experts across multiple domains and disciplines are rare among humans, but the evolution of computational power and architectural advancements make it possible to bring AI closer to a state of omniscience. Despite significant progress, we have yet to truly achieve Artificial General Intelligence (AGI), and hallucinations and erroneous outputs still occur frequently. A good user experience in the metaverse depends not only on immersive visual experiences but also on sensible interaction. For instance, when a user engages in dialogue with an NPC (Non-Player Character) in a game, the NPC can provide responses that are most fitting to the game's setting, or when a user wants to understand how Ethereum operates, an AI expert can provide accurate and precise explanations. Therefore, it is necessary to build specialized knowledge bases. Through the integration of techniques like Retrievable Augmented Generative (RAG), AI can embed domain-specific knowledge directly, significantly enhancing the accuracy of its outputs and enabling it to function as an expert within specific fields. Users are encouraged to contribute their professional knowledge, creative writings, or artistic creations as foundational knowledge, thereby enriching AI's understanding and application in diverse areas.

Retrieval Augmented Generation (RAG) [21], offers a promising way for AIs to access both parametric and non-parametric memory, providing provenance for their decisions and updating their world knowledge. RAG acts like a search engine, finding the knowledge or dialogue history most relevant to a user's query and combining it with the original query to create an information-rich prompt, guiding the model to generate more accurate outputs. This essentially applies the principle of In-Context Learning.

Fig. 2 shows the procedures of naive RAG, encompassing three fundamental stages:

(1) **Indexing** - Segmenting the document into shorter chunks and constructing a vector index through an encoder.
(2) **Retrieval** - Retrieving relevant document fragments based on the similarity between the question and the chunks.
(3) **Generation** - Generating an response to the query conditioned on the context of the retrieved content.

Another solution being explored is allowing AI models to access the Internet by calling search APIs. However, for AI in the metaverse, solving the issue of internet connectivity is still a challenge. The current smart contract solutions are isolated within their supporting blockchains and have have almost no ability to interact with other blockchains, the Internet and the rest of the world. Actually, they are intentionally separated from the external world, and for a simple reason: they need to be deterministic. Therefore, the oracle network is introduced to feed external information into smart contracts. More details can be found in Section 3.3.1.

3.1.4 *PhysiShape3D Library.*

Innovation does not occur in isolation. Human's progress, whether in technology or art, is developed based upon existing knowledge. As Issac Newton famously stated, "If I have seen further, it is by standing on the shoulders of giants". The deeper the understanding of the world, the more revolutionary innovations will emerge. To drive innovation, it is necessary to learn as much as possible about everything. That is why we propose Decentralized PhysiShape3D Library (DPL).

On Web2, there are several encyclopedia platform projects working towards this goal, such as Wikipedia. However, there are three main limitations:

(1) **Dimension Information Loss.** The information on existing platforms is almost entirely text or two-dimensional, yet we live in a three-dimensional world. The loss of a dimension significantly reduces the effectiveness of information transmission and greatly increases the difficulty for users to understand.

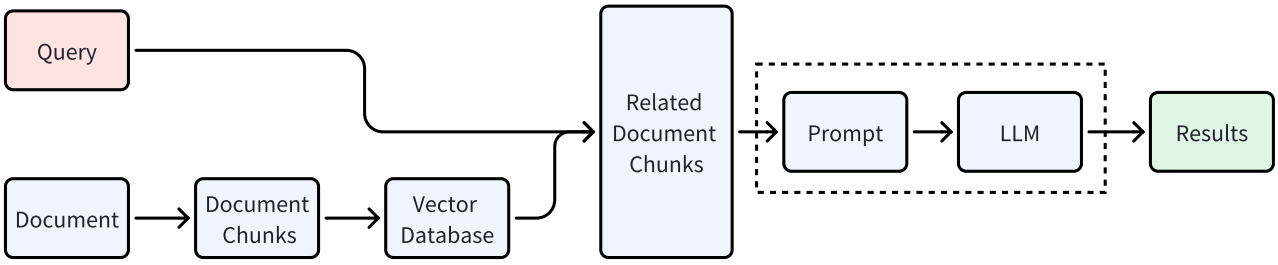

Figure 2: Procedures of naive RAG.

(2) **Mammoth Workload.** The vast and intricate expanse of information in the world is immense and complex, making it exceedingly difficult for a single team or even an entire company to establish a relatively complete system.
(3) **Indirect Information Expression.** Physical properties can only be conveyed through text, leading to information loss when attempting to describe the perceptible real world.

The fusion of blockchain technology with artificial intelligence presents a promising solution to these limitations, lowering technical barriers and increasing engagement enthusiasm. Firstly, a token incentive mechanism could motivate more individuals to collaborate in creating a Decentralized PhysiShape3D Library. The advancement of AI technology has made AI-assisted 3D rendering feasible, allowing for rapid modeling of real-world objects. Additionally, significant advancements in XR technology provide creators with more immersive experiences, enabling more detailed observation, adjustment, and refinement of 3D models.

DPL encourages artists, designers, and even laypersons to model various objects in their lives, including their appearance, internal structure, physical properties, etc, with the aid of AI rendering. The PhysiShape3D development platform offers basic kits akin to LEGO blocks and also allows designers to create their own kits. Once verified by the platform, these kits can used by other users. Highly praised kits and modeled objects will bring rewards to their contributors. These items are natural valuable NFTs and excellent well-labeled training data for AI model. Such training data will also address issues of ownership and transparency in AI generation.

(1) **Gaming.** DPL provides an array of basic materials directly to game developers, reducing the difficulty of development and the cost of modeling. When innovative gameplay emerges, even ordinary users can quickly build a brand-new gaming world without worrying about copyright issues..
(2) **Education.** More sensory stimulation can enhance learners' perceptual abilities and improve learning outcomes. Advanced XR technology and the robust DPL system can offer learners especially children more immersive experiences to achieve better educational outcomes.
(3) **Industry.** DPL serves as a foundational reference for designers when they are creating new products, aiding in their improvement. It allows for the completion of product designs within the metaverse, with feedback to the real world for production. This includes crowdfunding and pre-sales in the metaverse, simulating real sales.
(4) **Social.** Interest in different types of things naturally forms communities of like-minded individuals, fostering more active engagement among users on the chain.
(5) **Cultural Heritage Preservation.** There are many ongoing plans for the digital preservation and restoration of human civilization. The rebuilding of Notre Dame after its fire, using models from the Assassin's Creed game as a reference, is a well-known example. DPL will contribute to the digitalization of human civilization.
(6) **Branding.** Brands can build their historical product galleries on DPL, which not only helps consumers better understand a brand but also aids in precise marketing efforts.

PhysiShape3D library shows the transformative potential of combining blockchain and AI technologies to revolutionize how we create, share, and interact with digital information and physical properties in a decentralized manner.

3.1.5 Starry Computing Power Democracy Network.

Nowadays, the demands for substantial computational resources are evident across various fields, particularly for artificial intelligence models and spatial rendering. Unfortunately, both are fundamental to the metaverse. As semiconductor fabrication technology approaches its limits, Moore's Law seems to have reached a bottleneck. That means we may encounter periods where available computational power falls short of these growing demands. Consequently, enhancing the utilization of GPUs and democratizing access to computational resources has become an imperative necessity.

We have conceptualized the Starry Network, which is a Computing Power Democracy Network, to satisfy the following needs.

(1) **Scalable Computing.** Given the current technological constraints, User tolerance for the metaverse rendering distortion issues is high. However, as users' expectations for immersive content escalate, the forthcoming generation of 3D rendering technologies will inevitably require higher computational power. Therefore, it is necessary to establish a decentralized global network to cater to the massive computational demands for both next-gen 3D rendering and AI training.

(2) **Enhanced Infrastructure Utilization.** The distribution of GPUs is obviously uneven, leading to a disparity between supply and demand. This imbalance results in substantial idle computational resources alongside considerable demands. Additionally, with the gradual acceptance and implementation of new consensus protocols, such as Proof of Stake (PoS), computational resources previously dedicated to Proof of Work (PoW) will be released. This transition underscores the need for a decentralized network to efficiently coordinate the global supply and demand of computational resources.
(3) **Digital Asset Management.** The advent of immersive media and artificial intelligence technologies necessitates innovative methods for identity verification and origin tracing.

The Starry Network architecture comprises two components:

- An off-chain rendering network ecosystem composed of creators, node operators, rendering networks, and rendering application layer providers. Within this ecosystem, node operators contribute computational power via GPU nodes, enhancing the network's rendering capabilities.
- A blockchain infrastructure that manages financial transactions through mechanisms such as the Starry Network and hosted contracts. Leveraging the transparency of the blockchain public ledger, interactions between creators and node operators are publicly verifiable. This transparency ensures that creators, node operators, and foundation teams can verify the accuracy of all transactions. In case of discrepancies, transactions can be easily traced and rectified, promoting a high degree of accountability and trust within the network.

3.2 Application Layer

The application layer serves as the direct interface for user interaction within the metaverse. User experiences within this environment can broadly be categorized into two parts: one involves creation within personal spaces and interaction with AI bots or AI agents, while the other encompasses experiences within gaming spaces. The quality of user experience is contingent upon the sophistication of the AI and the quality of 3D rendering.

3.2.1 DID Analyzer.

The essence of the metaverse lies in its ability to credibly support the rights and identities associated with digital assets. This marks a departure from the centralized digital identities characteristic of the Web 2.0 era, where users maintain separate accounts across various platforms. Such fragmented account management not only fosters monopolies due to the lack of data interoperability but also transforms the Web 2.0 landscape into a series of informational silos. Therefore, a universal identity system is essential for facilitating social interaction, creativity, labor, gaming, and trading within the metaverse.

At StarryVerse, we issue a Citizenship Pass [22] to every user, endowing them with both identity and governance rights. Through the analysis of multifaceted data, we generate a unique Soul-Bound Token (SBT) for each user. Our strategy efficiently retrieve all relevant user information from the Data Lake, encompassing both on-chain and off-chain data. This comprehensive data amalgamation, including details from the user's SBT and CloneX status, facilitates a distinct Decentralized Identity (DID) analysis. The application of an AI analyzer in DID serves dual purposes: (1) It assesses user behavior to prevent sybil attacks, and (2) it enhances the analysis of user behavior data, enabling the construction of detailed user profiles. These profiles not only aid in delivering more accurate information recommendations to users but also provide businesses with extensive data to inform their commercial strategies. Consequently, this benefits businesses in identifying potential customers and empowers AI Agents to gather information across the web more effectively, making decisions that align closely with user preferences, subject to authorization.

An additional noteworthy aspect of AI DID analyzer is its role in fostering social interactions. The platform can leverage analysis outcomes to display the top ten users likely to be of interest, while concealing the identities of the top three. If a user wishes to access recommendations for the top three, they would be required to expend tokens. This innovative approach not only enhances user engagement but also introduces a novel model for interaction within the digital ecosystem.

3.2.2 AI Bot and CloneX.

Christina Rossetti, a renowned poet, once articulated a profound sentiment, stating, "I loved you first, but afterwards your love outsoaring mine." This quote elegantly captures the essence of evolving love and the dynamic interplay of emotions between individuals. Thus, the notion of conceptualizing an imaginary friend, partner, or significant others has always been attractive and fascinating. Such a companion, envisioned through the lens of advanced technology, could offer unparalleled company, sharing moments of joy in gaming realms, serene walks down deserted streets, attending concerts with melodious tunes, or lying on a soft lawn admiring the splendor of fireworks. This virtual companion will gently awaken you instead of a jarring alarm, encourage a healthy diet, and motivate you to achieve fitness goals, becoming the epitome of understanding and support.

Our efforts are currently channeled towards seamlessly integrating AI and blockchain technology to materialize an AI Bot capable of companionship and performing simple tasks. We have introduced 'Stacy' and 'Stanko' as preliminary manifestations of this vision, acting as the user's virtual girlfriend or boyfriend. In the next phase, each user can initiate the one's own CloneX Bot, the digital avatar of a user within the metaverse. Users will have the capability to customize their CloneX Bot with specific training materials, including daily interactions with various AI Bots, communications in gaming and social scenarios, and DID data across different dimensions, while ensuring privacy through data localization and zero-knowledge proofs.

These advanced digital beings, embedded within personal 3D spaces, not only facilitate interaction with their human counterparts but also engage with other Clone Bots. This interaction further refines their understanding of human behavior and linguistic preferences, paving the way for a future AI model or even inhabited by silicon-based life forms capable of comprehending human emotions and complex sentiments.

When it comes to a novel scenario akin to the new age of "live streaming", individuals who finds enjoyment in conversing with other CloneX bots or users, they can invite them into their own 3D spaces. Correspondingly, one can also apply to access another's 3D

space. Given the potential volume of invitations, a ranking system could be established to rank applicants based on the amount of tokens spent or tipped to the host. Intuitively, the more tokens one spends or donates, the higher one's rank on the ranking list. This mechanism aims to enhance the enjoyment of social interactions, increase social efficiency, and free up social time (allowing one's robot to chat instead of spending real-time). From this perspective, it enriches and strengthens the social fabric within the metaverse.

3.2.3 AI Agent.

J.A.R.V.I.S. (Just A Rather Very Intelligent System) in the film "Iron Man" can be regarded as an embodiment of the conceptualization of AI agents, as opposed to the more rudimentary AI bots. AI Bots are designed to perform one or several relatively simple tasks. These tasks are typically predefined, and the bots operate within a relatively narrow scope of functionality, such as the GPT-based StarryVox AI Chatbots. Apparently, an AI Agent possesses a degree of autonomy, capable of perceiving, reasoning, and acting within its environment to achieve its objectives.

Recent research indicates a trend where models of similar parameter sizes are becoming increasingly powerful, thanks to progress in computational capabilities. This progression suggests that the AI Agents we envisage will not remain a fanciful dream but will become a mainstream reality. We require an AI agent that serves dual roles: as an expert to enhance our productivity and as a companion to offer emotional value.

As shown in Fig. 3, A conceptual framework of an LLM-based agent has three components: brain, perception, and action [23, 24]. Serving as the controller, the brain module undertakes basic tasks like memorizing, thinking, and decision-making. The perception module perceives and processes multi-modal information from the external environment, and the action module carries out execution using tools and influences the surroundings. Generative Artificial Intelligence tools, such as GPT-4 [25], Llama 3 [26], and Gemini [27], has shown impressive performance in tasks like text generation and text-to-image generation. However, they also have inherent limitations, including generating hallucinations [28], lacking explainability [29] in generated text, poor understanding of domain-specific knowledge, and limited knowledge of the latest developments. To overcome these limitations and enhance the model's capabilities, there are two main approaches: Fine-tuning the model to update it, and enabling it to interact with the external world to acquire knowledge in various forms and ways.

Fine-tuning has its advantages in allowing the model to learn some private domain knowledge. But it also poses several problems: first, because generative models rely on internal knowledge, they still can't avoid producing hallucinations, which is unacceptable in scenarios requiring high understanding and accuracy since it's hard for users to discern if the model is making unfounded statements. Second, in real-world scenarios, vast amounts of data are generated every moment, and understanding a concept can evolve rapidly, such as interpretations of a policy or adjustments to a metric. Fine-tuning is not a trivial task considering data preparation, computing resources, the effectiveness of tuning, and training time. Keeping the model updated with newly generated data is impractical, and fine-tuning results cannot be guaranteed; achieving monthly updates is already an ideal state. Another solution is the RAG we mentioned in Section 3.1.3.

In conclusion, a real AI Agent needs not only to understand the world but also to have real-time access to a wide range of current information, from minor details like the weather or the outcome of a sports game to major aspects such as changes in cryptocurrency prices on exchanges. Therefore, we believe the capabilities of AI agents will be significantly promoted once they can access external information through oracle networks and gain an understanding of their surrounding world via PhysiShape3D libraries.

Upon meeting the aforementioned criteria, our AI Agent will become an indispensable assistant within the silicon-based realm, bridging the communication gap between the carbon-based world and its silicon counterpart. Its understanding of user behavior and preferences allows it to offer a highly personalized experience. This AI Agent will not only serve as a meticulous caretaker of emotions and a constant companion for mental support, but will also:

(1) Provide insights into the real world, aiding users in accomplishing tasks across both realms efficiently.
(2) Facilitate interactions with other users' AI agents on behalf of the user, given proper authorization, thus enhancing collaborative and social engagements.
(3) Leverage its deep understanding of the user, derived from a comprehensive analysis of both on-chain and off-chain data, to assist in creative endeavors and customization. This capability enables users to swiftly and conveniently craft and modify unique personal spaces that align with their tastes and preferences.
(4) With user consent, the AI Agent can represent the user in various activities within certain boundaries, from participating in games to creating digital assets. Utilizing the oracle network and its internal knowledge base, the AI Agent can also engage in strategic decision-making that reflects user behavior, securing airdrops and ensuring full participation in a thriving ecosystem without overlooking any opportunities or incentives in the metaverse. Users can leverage their AI Agents to benefit from on-chain activities.

In conclusion, this development heralds a future where humans can transcend survival pressures and physical constraints within the metaverse, paving the way for unprecedented freedom and creativity.

3.2.4 AI NPC.

AI NPC can essentially be viewed as an extension of the AI agent within the game. If an AI NPC is made more lifelike, even to the point of passing the Turing test—meaning it's indistinguishable from a human during gameplay—then the level of immersive interaction for the player will be significantly strong. This would greatly increase player engagement and loyalty to the game. Creating a deep and intelligent "all-purpose friend" in the virtual world, with the metaverse materializing it, lends it a sense of reality and vitality, further enhancing interactivity and perception.

To enhance users' immersive interactions with NPCs, it's essential that NPCs can interact with each other and respond to changes in the surrounding environment. Here are two solutions to achieve this objective.

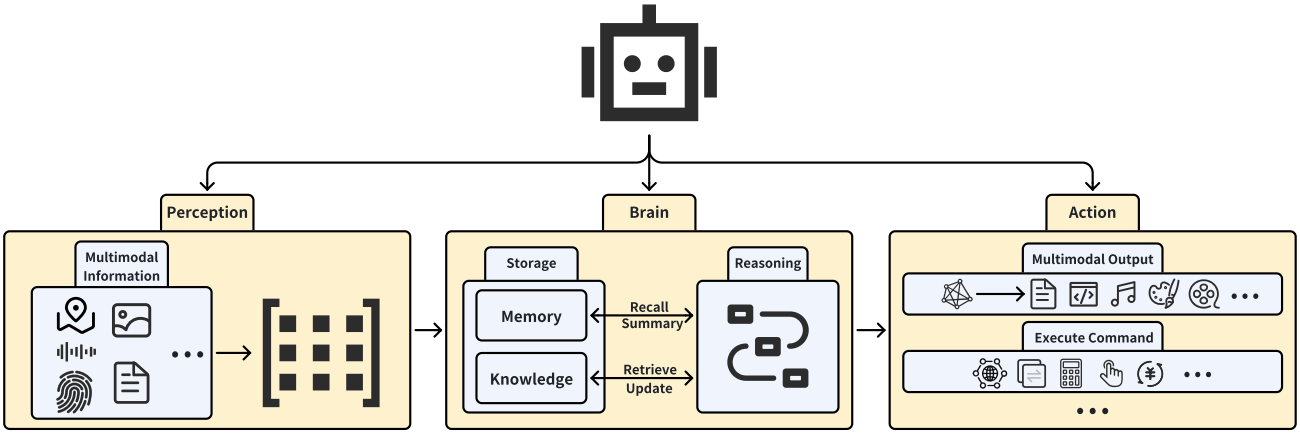

Figure 3: Conceptual framework of AI agent

The first approach leverages current large language models' natural language understanding capabilities by recording and reasoning by converting the information of NPCs and environment into natural language descriptions [30, 31]. The core of it lies in the memory stream, which maintains a comprehensive history of an NPC's experience (caring creation timestamp and most recent access timestamp). This memory stream plays a crucial role in retrieving records pertinent to strategizing the NPC's actions and ensuring adaptive responses to environmental changes. Furthermore, these records undergo a recursive synthesis process, evolving into increasingly complex observations that inform and direct the agent's behavior.

However, under many circumstances, compared to neural program induction systems, which have a much smaller model size, state-of-the-art large language models (LLMs) demonstrate inferior reasoning capabilities. This is evidenced by their lower performance and generalization, whether prompted with natural language or truth-value matrices [32, 33]. Therefore, the LLM is not a panacea.

The second approach is based on program synthesis[34–36]. Fundamentally, the behavior of an NPC (Non-Player Character) can be understood as the execution of a program. Therefore, we can provide a basic logic library based on the experiences of the NPC within its environment, akin to axioms in mathematics. Through reinforcement learning techniques, NPCs can learn these basic logics and continuously extract them during interactions with users, other NPCs, and the environment. They then deduce and synthesize programs that comply with these paradigms. This method of deductive synthesis helps enhance the NPCs' capability to handle complex problems.

3.2.5 AIGC Plus.

AIGC (Artificial Intelligence Generated Content) refers to the process of automatically creating text, images, videos, music, or other media content using artificial intelligence technology. AIGC systems rely on machine learning and deep learning models that can analyze vast amounts of data, learn the patterns and styles specific to a domain, and produce new and unique content. Our ideal AIGC can support the metaverse in several ways.

First, in the areas of NFT minting and game space creation, AIGC has a natural advantage, offering a level of historical knowledge, creativity, and speed of generation that traditional non-AI tools cannot achieve. Secondly, advances in AI technology have made customized metaverse creation at your fingertips increasingly feasible. It's important to note that the quality of content generated by AIGC is greatly influenced by the data on which it was trained. In this respect, a PhysiShape3D could provide significant support.

Due to advanced techniques like diffusion and AE/VAE, text-to-image has gradually matured. However, the availability of 3D training data on the Internet is relatively limited, which hinders the development of 3D generative AI models.

Unlocking the potential of hierarchical generation is essential to achieve higher-quality 3D generation. The process begins with advanced 2D generative models rendering a user's text into a 2D conceptual sketch. Subsequently, 3D models extrapolate the geometric structure from these sketches [37, 38].

In order to produce plausible and consistent 3D geometry, we adopt the following strategies:

(1) Score Distillation Sampling (SDS) loss with novel views and photometric loss from reference views
(2) Zero-1-to-3 [39], a readily available image translation model conditioned on viewpoints, possesses the ability to model the distribution of novel perspectives based on a reference image.
(3) Systematically increasing training views and adjusting the sampling timestep contribute to improving coherency.

Then we meticulously adjust the parameters of the diffusion model based on multiple-view renderings of the 3D instance undergoing optimization. This tailored 3D-aware generative prior is crucial for enhancing the 3D texture quality, while simultaneously maintaining consistency across different views.

Text-to-3D not only facilitates rapid content creation and spatial transformation on StarryVerse for users, but also catalyzes the

vigorous growth of NFTs related to the Starry IP and the NFT market as a whole.

3.3 Communication Layer

3.3.1 *Decentralized Oracle Network.*

Blockchain is a deterministic environment that does not permit uncertain elements or factors, and smart contracts must produce consistent results regardless of when and where they are run. Therefore, virtual machines cannot allow smart contracts to make network calls, as this would lead to indeterminate outcomes. In other words, smart contracts cannot perform I/O (Input/Output) operations, meaning they cannot actively acquire external data. Instead, they rely on oracle network to supply data to smart contracts. Ideally, a user's smart contract sends a request to an on-chain Oracle contract, which then obtains external data through off-chain APIs. More precisely, the external data is supplied to the on-chain Oracle contract, which in turn provides the data to the user's smart contract. However, platforms like Ethereum operate as closed systems, where direct interactions with the external world can potentially compromise the security and integrity of the Ethereum Virtual Machine (EVM). To mitigate this risk, oracles serve as an intermediary layer, bridging the gap between the on-chain and off-chain ecosystems.

Decentralized Oracle Network (DON) [40, 41] is created to improve and expand the capabilities of smart contracts on the specific blockchain. DONs aim to offer three basic resources including networking, storage, and computation, with robust confidentiality, integrity, and availability properties, as well as accountability. DONs are formed by committees of oracle nodes that work together to perform specific tasks, and designed to implement in a blockchain-agnostic way. Compared to centralized oracle networks operated by one or a few nodes, decentralized oracle networks demonstrate better performance in mitigating risks such as node failures or data tampering through attacks.

As shown in Fig. 4, the general operational mechanism of an oracle is as follows:

(1) When a smart contract requires data from outside the blockchain, it initiates an event.
(2) Off-chain interface monitors for these event logs.
(3) Upon detecting an event, the off-chain interface processes the required transaction and subsequently returns the data to the smart contract through a transaction.

3.3.2 *Communication Protocol.*

Standardized communication protocols play a pivotal role in decoding and forwarding user requests to the relevant artificial intelligence agents. This process ensures that when users articulate their needs, these protocols are capable of interpreting the intentions behind the requests, subsequently redirecting them in the appropriate format and protocol to AI agents tasked with handling these inquiries. Upon receiving the information, these AI agents process the data and generate responses. In this manner, standardized communication protocols facilitate the smooth and accurate transmission of information across various systems and platforms, thereby enhancing the efficiency and response speed of the entire ecosystem. This level of streamlined communication is crucial for the development of efficient and reliable AI systems, as they are required to process a diverse range of user requests swiftly and accurately, providing the necessary services or information in return.

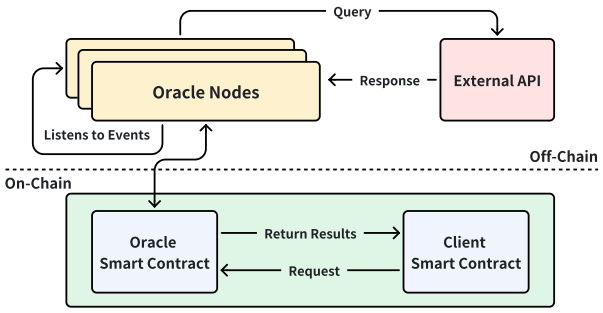

Figure 4: General procedures of oracle network

The issues pertaining to communication and exchange among AI Bots, CloneX Bots, and AI Agents are addressed by this protocol. This establishes a foundational step towards achieving AI interaction, as any intermediary relay of information inevitably incurs losses, regardless of whether the medium is natural language, code, or imagery. The ideal scenario would involve obstacle-free communication between AI models, devoid of any information loss. This would enable models to interact without the need to re-extract features, ensuring the integrity of transmitted information, enhancing understanding accuracy, and accelerating inference speed.

Our insight suggests that such an ideal state of communication can be realized through multi-modal alignment or inter-model fine-tuning. These approaches aim to overcome the barriers of information loss and feature re-extraction, paving the way for more efficient and precise AI interactions.

3.3.3 *Exploration Protocol.*

By implementing the Exploration Protocol, AI Agents are endowed with the capability to autonomously search for and aggregate appropriate services and projects within the blockchain environment. This signifies a paradigm shift from reliance solely on pre-programmed instructions or static data sources towards a dynamic exploration of on-chain information. AI agents can now identify and leverage resources that are most beneficial for their current objectives. This process encompasses several pivotal steps and technologies:

(1) *Dynamic Exploration and Discovery*
- **On-Chain Data Analysis.** AI agents commence by analyzing data on the blockchain, including but not limited to smart contracts, transaction records, the status of Decentralized Applications (DApps), and user activities. Through this analysis, AI can pinpoint services or projects that most likely meet its criteria.
- **Smart Contract Interaction.** Engaging directly with on-chain smart contracts allows AI agents to gain in-depth insights into the specifics of services, including functionalities, usage conditions, costs, and other relevant metadata.

(2) *Autonomous Decision-Making and Selection*

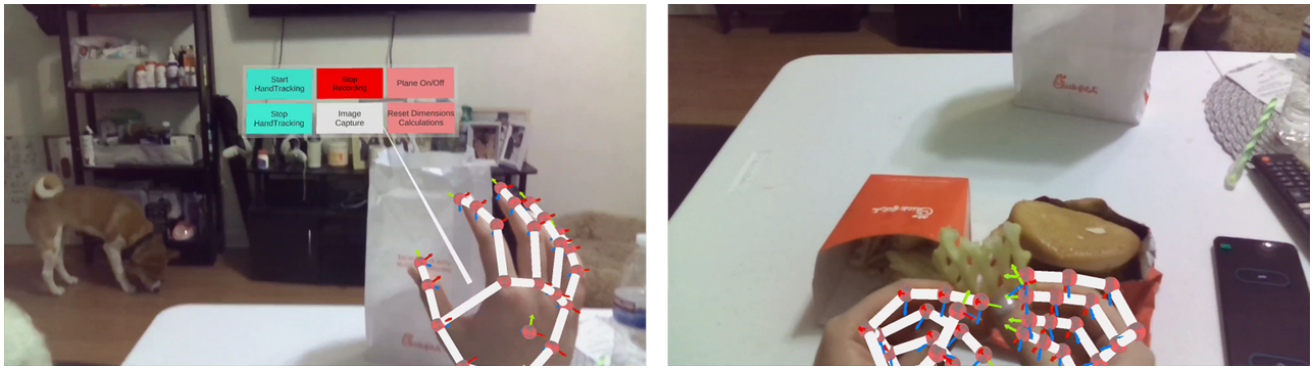

Figure 5: Eating in a mixed-reality environment using an XR headset.

- **Evaluation and Filtering.** Based on information gathered during the exploration, AI agents must evaluate potential services and projects, filtering those that best suit current needs. This may involve analyzing service performance, reliability, cost-effectiveness, and relevance to the task at hand.
- **Optimization Strategies.** To enhance efficiency and outcomes, AI agents may employ various optimization strategies, such as machine learning models to predict future performance of services, or automatically adjust search and selection strategies based on past experiences.

(3) *Automated Execution and Feedback Loop*

- **Automated Interactions.** Once the most suitable service or project is identified, AI agents can automate interactions, such as signing smart contracts, paying fees, or collecting required data.
- **Continuous Learning.** Through a feedback loop, AI agents learn from each exploration and execution, continually refining their search strategies and decision-making processes to adapt to the evolving on-chain environment and needs.

The Exploration Protocol significantly enhances the autonomy and flexibility of AI agents, enabling them to navigate and utilize resources within the vast blockchain ecosystem. This drives the development and innovation of automated services, offering users more accurate and efficient service options. This technological advancement not only empowers AI agents with robust capabilities but also opens new avenues for the development of blockchain applications.

3.4 Auxiliary Layer

3.4.1 3D Co-creation Space and rendering network.

WebGL (Web Graphics Library) is a JavaScript API for rendering interactive 2D and 3D graphics within any compatible web browser, without the need for plugins. It's essentially a low-level graphics API designed to leverage the full capabilities of OpenGL ES (Embedded Systems) within the web environment. This allows developers to create detailed graphics and visual effects directly in the browser, utilizing the GPU (Graphics Processing Unit) for accelerated processing. Extended Reality (XR) augments the metaverse by merging the real and virtual worlds, which produces a more immersive environment and provides higher degrees of freedom for users. To enjoy XR, users can employ a variety of devices with increasing immersion and unobtrusiveness, from smartphones and PCs to XR headsets and Brain-Computer Interfaces (BCI). The releases of the latest XR headsets, such as Apple Vision Pro and Meta Quest 3, further boost the deployment of XR devices in layer 2 applications to augment the metaverse. In particular, beyond merely displaying a virtual space to users, current XR devices leverage head-mounted displays, cameras and a variety of sensors to bridge the digital and physical worlds, and a user is able to operate the avatar through straightforward body or hand motions in addition to key buttons. This section mainly introduces our efforts in exploring XR opportunities and addressing potential security issues.

(1) **Bridging Real World and Metaverse Through Multi-modal Sensing**

XR devices are more than just head-mounted displays. They superimpose 3D objects onto the real world to create a new environment for maximizing user experience in the metaverse. This is achieved by the integrated use of their embedded inward displays, RGB cameras, depth cameras and spatial computing algorithms. Furthermore, XR headsets are equipped with a variety of sensors, including microphones, speakers, accelerometers, and gyroscopes. The design purpose is to enable users to enjoy seamlessly blended real world and virtual world. For example, in addition to the well-known visual mixed reality, XR devices can also support spatial acoustics, which are more than the left and right sound channels and can simulate specific acoustic signal propagations and reflections in different indoor and outdoor environments. When connected wirelessly to haptic gloves and vests, XR devices can further provide haptic feedback, such as enabling users to experience touch forces.

Besides the above three types of feedback (i.e., visual, audible and tactile), XR devices also revolutionize the way users interact with the devices or with virtual objects. In particular, the embedded RGB cameras, depth cameras and inertial sensors are powered by AI models to enable human motion tracking. Accordingly, the user can enjoy the metaverse with straightforward head and hand motions rather than clicking arrow keys to control a virtual avatar. For example, Fig. 5 illustrates how we apply an XR headset to capture a user's eating information [43], which can enable the eating-to-earn games to reflect real eating activities. The emerging BCI is expected to be employed on XR

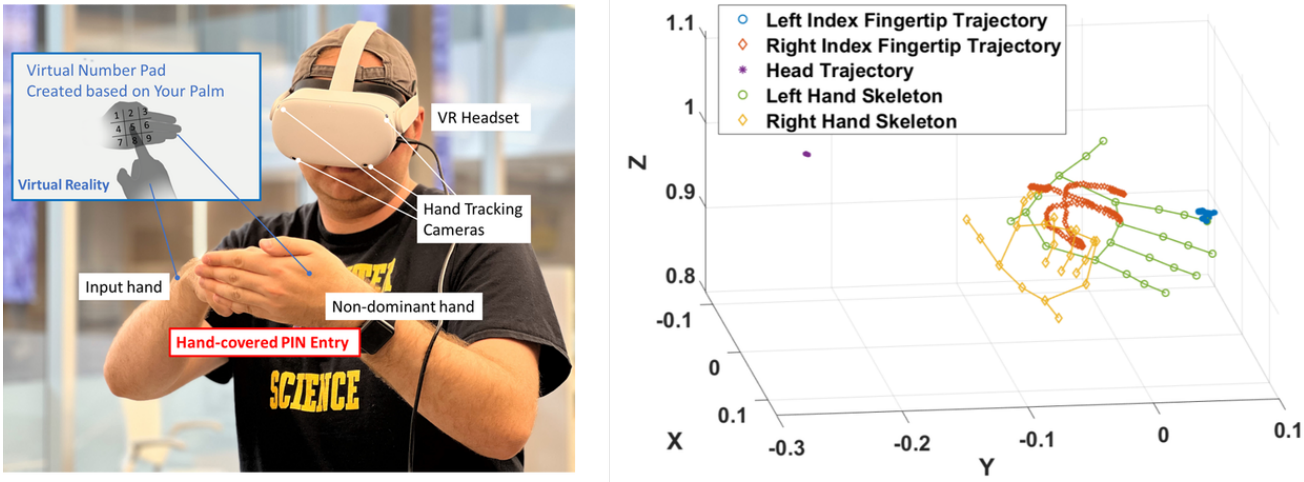

Figure 6: Typing in a virtual environment with tangible click feedback (adapted from Paper [42]).

devices, which is considered to be the ultimate interface for users to interact with the metaverse. It also can broaden user populations by covering mobility disabilities.

(2) **Rendering the Digital Twin of Real World Environment and Objects**
XR contains both augmented reality and augmented virtuality. While the former focuses on adding virtual objects to improve the experience in the real world, the latter attempts to add real objects in the virtual world. StarryNift proposes to render the 3D digital twin or copy of real-world objects in the metaverse to advance personalized 3D spaces and decorations. These "real-world objects", such as luxury cars, handbags and arts, in the metaverse may not just be static 3D copies but can be digital twins to carry their real-world functions for interacting with users. StarryNift aims to equip common users with a powerful tool to construct or co-construct the metaverse without professional skills. Everyone can bring in "real-world objects", like in Minecraft. To achieve this and bring real-world objects into metaverse, StarryNift proposes to leverage the latest 3D scanning technology and generative AI. The 3D scanning technology leverages RGB cameras and depth cameras to scan every angle of a target object, which is stitched by computer vision techniques to render both its 3D model and detailed color map in the virtual space. However, the current 3D scanning technology is still limited by low resolution. We thus apply generative AI models to achieve superresolution and complete the missing details. Similarly, real-world environments, such as indoor rooms and outdoor nature scenes, can also be captured by 360-degree video cameras, which can be played in the metaverse to generate close-to-real environments. We can further apply generative AI to extend the time-length-limited video and enhance it with dynamic details, such as grasses blown by wind and ocean waves.

(3) **Enhanced Human-computer Interaction**
When users migrate from PCs to XR headsets to access the metaverse, how to interact with the headsets to type, operate an avatar and navigate is still a essential question not well-solved. Though XR devices can leverage visual sensors to capture hand motions, it is not easy to type on a virtual floating keyboard due to the lack of tangible feedback. The user cannot gain the feeling of when a key is successfully clicked or not, which results in significant typing errors. Aiming to maximize user experience in the metaverse, we plan to develop a novel tangible typing interface for all XR headsets [42]. The interface creates a mixed reality keypad to provide haptic feedback to both hands when they coordinate in a private hand-covered manner to complete key entries. In particular, the interface tracks the user's both hands and generates corresponding hand avatars in the virtual space. Each hand avatar is represented by 23 landmarks (or joints) reflecting the joint-level motions of the physical hand in real-time. The users can thus see their "hands" to interact with the virtual environment. Moreover, a virtual keypad is created based on the user's left-hand avatar and customized by individual hand sizes and hand joint positions/orientations. Fig. 6 illustrates the deployment of the proposed tangible typing interface on Meta Quest 2.

(4) **Digital Identity Security and Privacy Preservation**
Before accessing the metaverse, a user needs to pass web2 authentications through a terminal device, such as a PC and an XR headset. For example, the user can use the above tangible key input interface to quickly enter a password with high precision. We further develop a low-effort XR user authentication system based on extracting the acoustic domain head biometrics that are naturally born with head-mounted devices [44]. Specifically, when the user puts on an XR headset, a unique rigid body is formed by the user's head and the device, containing two chambers, the skull and the hollow space enclosed by the VR device and the face. When an authentication session is initiated, the proposed system emits an ultrasonic signal using the VR device's speakers. The signals traveling on this rigid body are reverberated (e.g., damped and reflected) by the individually

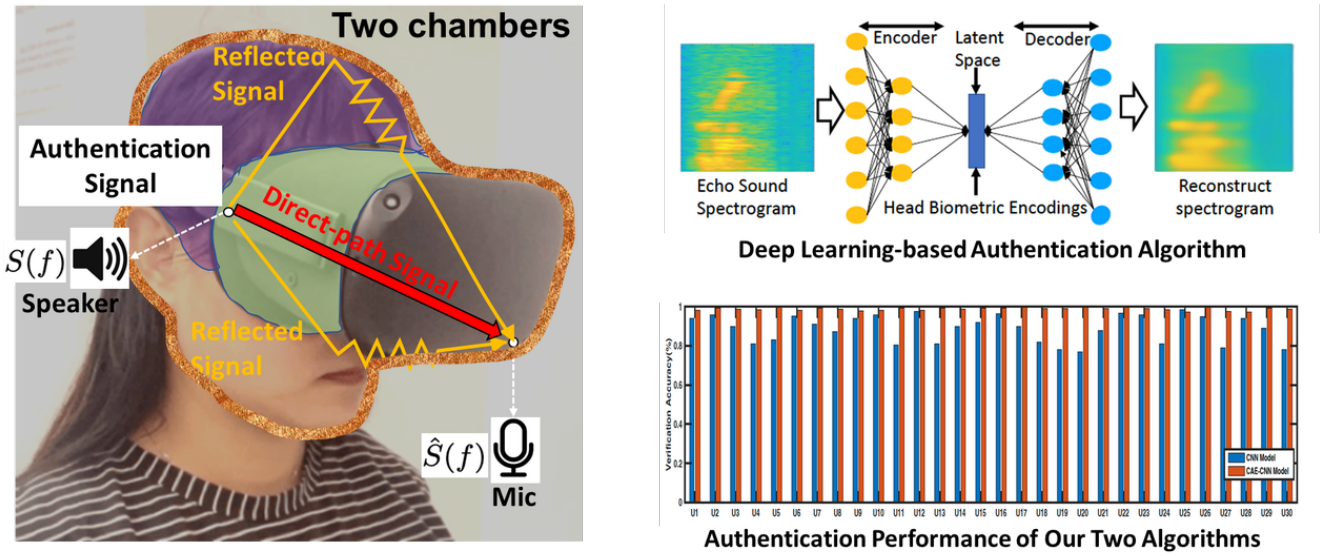

Figure 7: Novel authentication techniques for virtual reality users via acoustic sensing (adapted from Paper [44]).

unique head size, skull shape, mass and face pattern. The resulting signals reaching the microphone thus carry the user's biometric information and can be analyzed for authentication. We developed an AI architecture consisting of auto-encoders and decoders to achieve unobtrusive authentication with acoustic head sensing, as shown in Fig. 7.

After the web2 authentication, all users' activities in the metaverse should be anonymous. More specifically, different interactions of the same user with web3 systems should neither be linkable to each other nor to the user's real identity. Because we find that users' data during interactions, such as motion data and microphone data, could be identifiable, it is critical to remove human-identifiable information and prevent a variety of side channels from linking profiles.

In particular, we find that when users enjoy anonymity in the metaverse using an avatar, the 3D motions of the avatar's head, hands and body may carry identifiable human behaviors, which can be connected to the user's physical identity. Furthermore, while the advancement of AI facilitates extracting human behavioral biometrics more easily, it poses a threat to behavioral biometric security, too. For example, we find that the encoders of generative AI can extract human behavioral elements embedded in the user's motion-controlled avatar. Accordingly, the identification may not require recurrent motion patterns or complete motion tasks to be included in the training mode, making the attack practical.

We aim to remove identifiable information from the user's motion data and use the neutralized motion data to drive 3D avatars. The proposed method needs to achieve two objectives: 1) removing the behavioral biometric information from avatars' motions to protect privacy, and 2) the resulting influences on the user's avatar control must not be noticeable by humans to ensure usability, so that the user still feels that the avatar is under real-time motion control. We thus plan to develop an AI encoder to extract the user's behavioral element and then develop generative AI algorithms to translate the user's motions into standard motions, which contain no identity information. We then send the standard motion data to the avatar in the metaverse. To obtain standard motions, we develop a Generative Adversarial Network (GAN) and leverage a set of participants' specific motion tasks to generate neutralized motion data, which presents random-guess probabilities to identify these users.

(5) **Location-based Digital Assets and Social Interaction in Mixed Reality**

We also envision that our users do not need to be limited to an indoor room to access the metaverse and enjoy layer 2 applications. They can wear XR devices to travel anywhere and simultaneously enjoy StarryNift games and entertainment. Along this direction, we plan to build a location-based digital asset platform, which allows users to explore any real-world building structures, landmarks and billboards to own and modify their digital copies in the metaverse, like a parallel universe. For example, a user can rent or purchase the digital copy of a billboard in Times Square and post advertisements. Other users can see the advertisements when they are physically at Times Square and simultaneously wearing XR devices. They can also trade the ownership or decorate and doodle on their digital assets.

3.4.2 *StarryVerse Governance and Fairness.*

As more and more various applications proliferate on StarryVerse, there is a notable variation in their quality, which poses several challenges, especially in terms of governance mechanisms. The governance of a decentralized project typically follows the conventional software development framework, which is often structured in a hierarchical, top-down approach including three

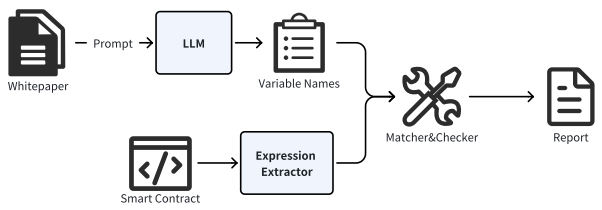

Figure 8: Workflow of checking inconsistencies between whitepaper and code

stages: (1) governance design, which asks the team to establish a clear vision and principles; (2) governance content, which demands the team delve into the specifics of the governance structure; and (3) governance implementation, which means the team should implement the governance design [45].

There are two types of governance mechanisms: off-chain and on-chain governance. Off-chain governance primarily uses social approaches to achieve consensus in decisions. Conversely, on-chain governance relies on coded mechanisms within the platform. Governance tokens are utilized for decision-making purposes, typically in a decentralized manner, and are regarded as a manifestation of the authority to propose and vote. Additionally, project owners often possess certain administrative privileges. The issue of ownership is contentious, as centralization does not align with the essence of web3. Although the concentration of excessive permissions is considered risky, it can have positive implications in complex and urgent situations. However, we still believe that the development team should justify their reasons for retaining such powers.

When it comes to what should be governed, we focus on whitepaper and codebase. A whitepaper essentially serves as a tangible representation of requirements, typically encompassing an overview of the project, its operational principles, and the token economics involved. It forms the foundation for a project's reliability and sustainability. The codebase, on the other hand, is the implementation of the application, directly affecting the functionalities of the project and every participant involved. Therefore, the correction of code errors and the consistent evolution of the codebase are crucial.

Existing research and our observations indicate that the discrepancy between smart contracts and whitepapers plays a significant role in governance issues. We adopt a prototype tool to detect inconsistencies between the whitepaper and the implementations. The workflow is demonstrated in Fig. 8. The tool utilizes the programming ability of Large Language Models to obtain possible variable names of the configuration in the code. We extract the configuration settings from the whitepaper through a static expression extractor. We then check if they match the code and generate a report to aid in bridging the gap.

To delve deeper, as we advance into a new phase of computational power, if we could utilize Large Language Models to extract various constraints more precisely from whitepapers, and employ symbolic execution tools to enumerate all possible outcomes, matching them to identify any inconsistencies, it would enable us to make timely adjustments. This process could even be implemented prior to deploying on blockchain.

3.4.3 Intention-based Code Generator.

Large-scale model code generation has garnered significant attention from both the industrial and academic sectors. For instance, the AI software engineering approach implemented by Devin allows for the direct conversion of requirements into code or even the generation of entire projects [6, 46, 47]. However, it is observed that the current quality of generated code often falls short, with frequent issues such as errors, low executability, and poor compatibility. These issues can incur potential substantial costs once such low-quality smart contracts are deployed.

The emergence of these obstacles is attributed to the discrepancy between natural language and smart contract code, specifically the inconsistency between the semantics of natural language and code. In response, we propose a new paradigm for code generation from requirements. This approach leverages the text comprehension capabilities of Large Language Models and incorporates a formal verification step prior to code generation to achieve comprehensive coverage of requirement semantics with minimal human intervention.

Initially, advanced large language models, with the assistance of Retrieval-Augmented Generation (RAG) technology, translate requirements into a formal specification called smart contract intermediate representation (SCIR). We also designed a two-stage white-box static transformation that extracts intentions from the requirements using a template-based intention classifier. Intentions represent the core transaction logic, which is then transformed into SCIR. In order to minimize ambiguity, SCIRs from different sources will be merged and provide the top-5 candidates, allowing users to select the most appropriate one. Notably, SCIR can be regarded as a form of pseudo code, making it comprehensible and adjustable for users without programming skills.

The final executable smart contracts are synthesized based on SCIR, predefined template Abstract Syntax Trees (ASTs), and optional user inputs. The template AST is modified and eventually synthesized into code that can be verified, thus ensuring that program aligns with the behaviors defined by the requirements and code execution will not violate any predefined safety policies. Additionally, advanced technologies like invariant detection [48–52] and generation will also be considered to secure smart contract from vulnerabilities.

3.4.4 AI Judges and DAO.

In the human realm, rules are solidified through laws and regulations, whereas in the blockchain-based metaverse, these rules are embedded within the code, more specifically, within smart contracts. The concept of AI acting as a judge within blockchain systems, particularly in Decentralized Autonomous Organizations (DAOs), to enhance the functionality and user experience of these systems without compromising their decentralization and security, is both fascinating and concerning. The formidable memory and understanding of text by AI, including its ability to draw connections between different cases, is truly astonishing. Its efficiency, impartiality devoid of emotional bias, and the automation of decision-making processes have made it highly sought after. However, it is undeniable that ensuring fairness and preventing manipulation present significant challenges, such as adversarial attacks in machine learning. For instance, if AI models are made public, their

Figure 9: The architecture of tokenomics.

Figure 10: Token allocation.

decision-making could be influenced or even subverted by carefully designed inputs; conversely, if the models are kept private, verifying their internal operations becomes impossible.

Regarding how to optimistically yet cautiously advance the development of AI judges, we offer the following insights:

(1) Advanced zero-knowledge proofs and other sophisticated cryptographic techniques could potentially apply a form of 'magic' to AI models, concealing their inner workings from attackers while still proving that the models are functioning correctly.
(2) The concept of an AI jury system could also be a breakthrough, not just relying on a single AI for decisions but employing various AI judges within a Decentralized Autonomous Organization (DAO) framework. This system would allow for challenges similar to fraud proofs, and incentive mechanisms might offer a solution by maximizing rewards for fair and impartial judgments.
(3) AI judges within juries should be subject to a "retirement system", which involves the deferred disclosure of verifiable AI model. When an AI judge makes a decision, a ZK-SNARK is published. This ZK-SNARK serves as proof that the model generating the decision was indeed used, with a commitment to disclose the AI model after a specified period. Once the model is made public, users can verify its fairness by checking if the correct model was released, using its hash value. The retirement system ensures that by the time the model is disclosed, it has become obsolete.

4 TOKENOMICS

In this section, we will introduce you to our tokenomics. The architecture is shown in Fig. 9.

4.1 Token Allocation

4.1.1 "Short-term Growth" vs "Long-term Value" Weight Balance.

In general, token allocation typically involves setting aside tokens for the Ecosystem, Partners and Advisors, Investors, Treasury, DAO, and Team. To strike a balance between short-term growth and long-term value, we will adopt an approach that considers both aspects. The overall token allocation are shown in Fig. 10.

From short term growth perspective, we will incorporate common practices such as "Play to Earn, Create to Earn, and Stake to Earn." Additionally, we will explore innovative methods aligned with our roadmap, such as "AI Agents to Earn" and "Social to Earn". This ensures that our token allocation aligns with our vision and provides diverse opportunities for our community to participate and benefit. Partners and advisors encompass various entities, including KOLs, Guilds, Projects, and experts. We welcome collaborations with ambassadors, volunteers, and builders who share our value and contribute to our ecosystem. Token funds allocated for short-term growth will be distributed proportionally to the users and contributors mentioned above. This distribution will be carried out through mechanisms such as cold-start airdrops, marketing events, liquidity mining rewards, or other bootstrapping activities like market making.

As for safeguarding long-term value, we are fortunate to have visionary global tier one investors like SIG, Binance, and OKX, who will support us in the long run. Additionally, influential Web3 entrepreneurs like Jihan Wu, founder of Bitdeer (NASDAQ: BTDR), and Richel, founder of Synfutures, are both individual investors and consultants, providing valuable guidance and support. Treasury funds will be utilized for long-term goals, such as token buyback and burn programs. These initiatives will be supervised by both the DAO and Team, who will act as safeguards and have voluntarily extended the token vesting period to ensure the community's long-term development. We firmly believe that this fair launch model, aimed at distributing tokens in a sustainable manner, will foster a more cohesive and powerful community. It empowers all contributors in a decentralized and healthy way, aligning with our mission and values.

4.1.2 "NFT Holders" & "Active Users" & "Eco Supporters" Airdrop Allocation.

A balanced token allocation is a crucial aspect of our tokenomics model. It aims to ensure fair distribution of tokens to all contributors while maintaining a healthy level of decentralization and

competition among token holders. This approach fosters organic growth within our ecosystem. While it is important to remember and protect the interests of our initial supporters, we also strive to cultivate a more inclusive community that attracts a growing user base and caters to diverse demands. This long-term strength lies in the collective participation and engagement of our community. To achieve this, we are committed to allocating up to 10% of tokens for an initial airdrop. These tokens will be distributed using a comprehensive model that takes into account various factors, including holders, users, supporters, and partners. This ensures a fair and equitable distribution that benefits all stakeholders.

Our Code Green Holders, who have been with us since the beginning, hold a special place in our community. Tokens will be presented to holders through mechanisms such as staking, governance, and rewards sharing. The Code Green NFT will play a significant role in the model algorithm, considering parameters such as price, scarcity, time, and other relevant production factors. For certain tournaments with substantial incentive pools, the Code Green NFT may serve as a threshold for participation. In other entertainment events, the Code Green NFT could be used as VIP tickets for entry into the world we have created. Generally speaking, we aim to provide both functionality and benefits to holders through significant events. However, we also encourage fans to appreciate the artistic value of these cute designs and view them as precious collections rather than purely speculative assets. We aspire to witness increased decentralization through the adoption of more active addresses and on-chain transactions. Multiple airdrops will be executed over time, aligning with our unwavering commitment to cocreation empowerment.

Citizenship is a central theme in the development of the StarryVerse civilization, encompassing various narratives and worldviews. We highly value proactive citizenship pass holders who not only engage with our world but also bring in new friends, socialize with fellow citizens, and contribute to our ecosystem through interacting with other platforms developed by strategic partners like Trantor and Synvision. As a token of appreciation, these users will be incentivized. The reward plan is designed to provide greater opportunities and rewards to users based on their accumulated XP and the level of their card. The more XP you accumulate and the higher your card level, the greater your chances and potential rewards. In addition to enjoying leisure games, creating 3D spaces, and participating in entertainment events, we have exciting plans to roll out more social functions and AI tools in early 2024. These additions will offer a completely new and immersive experience, combining the power of AI and Web3 technologies.

We extend a warm welcome to friends from other ecosystems, such as BNB holders, OKX wallet users, and Inscription players, to join us and share in our prosperity. We value achievements from various perspectives and believe in fostering collaboration and growth across different communities. To provide more clarity and transparency, we will release quantified diagrams and detailed plans in accordance with our product launch road map. These resources will offer a comprehensive overview of our vision and the steps we are taking to bring it to life.

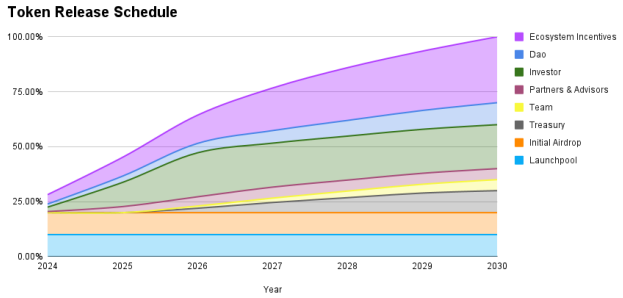

Figure 11: Token release schedule.

4.2 Vesting Mechanism

4.2.1 Sustainable Vesting Schedule & Moderate Inflation Rate.

The token vesting schedule plays a crucial role in managing token price volatility and ensuring the long-term sustainability of a project. A longer cliff time and vesting schedule for team members, investors, and advisors demonstrate our confidence and commitment to building a project for the long haul. Moreover, spreading out token rewards over an extended period can facilitate sustainable growth.

At our project, we are dedicated to creating a leading and enduring ecosystem. To showcase our commitment, we have voluntarily extended the token vesting period for both the team and treasury. This ensures steady development and dynamic operation of the ecosystem. Our team will only take 5% of the token allocation which is comparatively lower than the most projects since we wish to share more benefits with our ecosystem, DAO and partners. Besides, team and treasury tokens will have a 1-year cliff, followed by a linear vesting over 5 years. Our equity and token investors will receive limited vested tokens during TGE and the slow release approach reflects our focus on long-term value investment. Details of token release schedule are shown in Fig. 11.

We believe that our community deserves both short-term rewards and long-term benefits for their continuous support. The initial airdrop will be unlocked after listing on centralized and decentralized exchanges (CEX and DEX). Furthermore, additional incentives with larger percentages will be released based on active engagement and community growth achievements and momentums. Together, we can accelerate our progress and achieve our dream of becoming the most influential metaverse.

4.2.2 Dynamic Adjustment Mechanism & Information Symmetry.

We believe in maintaining open and transparent communication with our community and stakeholders in an efficient and effective manner. However, it should be pointed out that our mechanisms may be adjusted dynamically based on various factors such as market conditions, product pivots, DAO governance, and exchange requirements.

While we adhere to cautious and stringent rules similar to traditional finance, including clear financial statements and regular auditing, we also recognize the need for flexibility in the Web3

world due to its fast-changing pace and decentralized governance. Our priority is to ensure information symmetry and avoid moral hazards, always keeping our users' benefits as our top priority. While specific details may shift, the general direction will remain secure. We are committed to managing the inflation rate within a reasonable range and closely monitoring the maximum inflation rate through pressure tests. This ensures that we maintain a sustainable and stable ecosystem for our users. Community trust and support are crucial as we navigate the ever-evolving landscape of the crypto industry.

When evaluating the impact of a token's supply on its price, it is important to consider the concept of Maximum Inflation. In the context of crypto tokenomics, Maximum Inflation refers to:

$$\pi_{max} = T_{mu} - S = (100\% - V_{LTT} - S) \div S \quad (1)$$

π_{max} denotes maximum inflation. T_{mu} denotes maximum token amount to be unlocked; S denotes Initial Circulating Supply; V_{LTT} denotes long term treasury fund.

The inflation rate will undergo a provisional evaluation and will be conveyed to our community upon the completion of finalizing tokenomics, prior to the TGE.

4.2.3 *Value Accrual.*

Many projects conduct token generation events before launching their products. However, valuing these tokens can be challenging due to the lack of true intrinsic benchmarks and tangible use cases. Unfortunately, some teams take advantage of these chances as cash grabs, accumulating wealth without delivering on their road map.

In contrast, we are fully committed to our vision and goals. We have dedicated almost 3 years to building and finding our unique path after pivoting to create something different. Our long decision process to prepare for a token generation event is not a disregard for our community's voice or for market trends. Instead, we firmly believe that trust and binding within the community can only strengthen over time if the token accrues value and demonstrates utility. We understand the importance of delivering on our promises and ensuring that our token holds real value. By prioritizing utility and value accrual, we aim to build a strong and trustworthy community that stands the test of time.

Our tokens offer a wide range of utilities and benefits. They can be used to access the services of AI agents, serving as assistants for gaming and advertising. Users can use tokens to claim gifts and surprises in our Merchandise Hub, which caters to both Web2 and Web3 users. Tokens also grant VIP access to our entertainment events and offer opportunities to win limited editions of SBT and virtual equipment. Additionally, tokens can fuel the citizenship upgrade, enabling individuals to achieve greater social recognition. Furthermore, token holders can share the benefits of our launchpad and gain access to the whitelists of StarryLabs incubated projects. In the future, tokens can be used as gas to deploy dapps on new protocols and side chains. These governance tokens symbolize the users' authority to oversee and propose suggestions for the project's development (e.g. improving platform features). As our development progresses, we will unveil more utilities and functions for our tokens.

While some meme coins have gained market traction without token utility, we believe that strong token utility is essential for the long-term health of the ecosystem. It not only stimulates market engagement but also draws new participants into the cryptocurrency sector. Our goal, by emphasizing value accumulation and broadening utility, is to promote enduring growth and stability across the entire industry.

Figure 12: Token utility.

5 SUMMARY

StarryNift emerges as a beacon of innovation within the Metaverse, offering a comprehensive solution to reshape digital frontiers. With a focus on collaboration, accessibility, and sustainability, StarryNift addresses the evolving challenges of the digital realm. Leveraging blockchain and AI technologies, it pioneers new paradigms in gaming, entertainment, and decentralized identity, fostering engagement and empowerment within its vibrant ecosystem. The architectural framework of StarryNift comprises four layers: Fundamental, Communication, Application, and Auxiliary. Complementary AI enhances the PhysiShape3D Library and brand new requirements to code transition paradigm, bridging the gap between data acquisition and user experiences within the metaverse. A wide range of creativity AIGC tools, multi-role AI agents, intelligent data analysis, and expanded AI empowerment, enrich users' immersive and personalized metaverse experiences across diverse dimensions. AI judges and government in the future propel the development of an interconnected and autonomous world, pushing the boundaries of what is possible in both Web2 and Web3 applications.

Designing sustainable tokenomics presents challenges, from inflation to equitable distribution. StarryNift addresses these challenges through a balanced allocation strategy, fair distribution mechanisms, and a vesting mechanism for stability. Dynamic adjustments and a focus on value accrual ensure transparency and drive enduring growth across the industry. As we stand on the cusp of realizing our vision, StarryNift invites the community to join us in shaping the future of the metaverse. With unwavering determination and a commitment to innovation, we embark on a journey towards shared success. Together, let's turn our vision into a reality, where collaboration and creativity thrive, and opportunities abound for all.

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