



Towards Transparency and Loyalty : Leveraging Blockchain NFTs in Hotel and Food Supply Chain

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Abstract: Managing the Customers Engagement and Retention Rate is one of the major challenges faced by any organization having a complex Supply chain. Certain Technological Limitations and the variety of choices available to the consumer raises concern about the sustainability of the Hotel. Non-Fungible Token(NFT) Technology, an application of Blockchain technology emerges as feasible and promising solution. By using certain characteristic features of NFT Technology like the Traits and One-of-kind helps manage the Customer Engagement, alongside helping foster a healthy and engaging community. The NFT-based Loyalty Programs introduces incentives and rewards to the endconsumers based on their Loyalty and engagements with the Hotel. Consumers are motivated through Loyalty based programs in the form of NFTs which provides Transparency and security alongside Customer Retention. The alignment of the NFT-based Loyalty System with the Decentralized SCM promotes a high engagement rate and ensures transparency for the rewards being distributed to the end-consumers. Furthermore, hotels are able to provide distinctive experiences and benefits that are tailored to each individual customer thanks to the integration of NFT technology into loyalty programs. Hotels can automate the delivery of prizes based on predetermined criteria, including frequency of visits, total spending, or participation in promotional events, by utilizing smart contracts on the blockchain. In addition to making the entire customer experience more smooth and convenient, this also guarantees equity and openness in the awarding of rewards.

Keywords: Blockchain; Hotel Supply Chain; Proof of Hotel Interaction; NFT; Customer Relationship; Customer Loyalty

1. INTRODUCTION

For organizations, loyalty programs provide a fundamental structure that is purposefully created to foster client retention and strengthen brand loyalty. They consist of a variety of methods and techniques that have been painstakingly designed to recognize and reward patron loyalty, thereby creating a positive feedback loop. Similar to the complex mechanisms of a supply chain, in which several organizations cooperate to produce and deliver goods to customers, a loyalty program functions via a web of interrelated procedures. These procedures include everything from the first client interaction to the continuous support and incentive delivery. Numerous initiatives targeted at improving customer satisfaction and strengthening loyalty can be found within the range of loyalty programs. These include, but are not limited to, interacting with customers in a tailored manner, analyzing data to get insights into consumer behavior, effectively administering reward programs, and offering first-rate customer support. The overarching goal of these initiatives is to increase customer happiness and loyalty, strengthening the relationship that exists between the customer and the brand. However, how loyalty programs are managed and implemented has a big impact on how effective they are. Companies that want to build long-lasting connections with their clients

need to execute these programs with precision and grace. Businesses may sustainably drive profitability and keep a competitive edge in the market by implementing tactics that resonate with their target audience and continuously refining their approach based on feedback and growing consumer preferences. Moreover, loyalty programs need to change to be relevant in the fast-paced business environment of today, which is defined by rapidly advancing technology and fluctuating customer expectations. The incorporation of cutting-edge technology like blockchain and artificial intelligence opens up new possibilities for improving the efficiency and openness of loyalty programs. By utilizing these technologies, companies can guarantee the security and integrity of loyalty rewards while also utilizing data analytics to provide more individualized solutions. Moreover, providing outstanding client experiences becomes crucial for companies trying to stand out in a crowded market. Whether via digital platforms or in-person contacts, seamless integration across many touchpoints is crucial to delivering unified and memorable consumer experiences. Businesses may create stronger relationships with their customers and maintain development and competition by investing in omnichannel loyalty programs and emphasizing customer-centricity. Loyalty programs are fundamental to customer relationship management because they provide



companies with a strategic framework for cultivating enduring relationships with their target audience. By means of thorough preparation, creative strategies, and an unwavering emphasis on providing value, companies can foster long-lasting connections that surpass transactions, propelling continuous prosperity in a constantly changing market environment. In addition, loyalty programs are seeing a significant change in the digital age, as customers are empowered by technology and faced with an abundance of options. Point-based systems are being replaced by more advanced techniques that put an emphasis on engagement and personalization. Through the utilization of copious amounts of data resulting from consumer interactions, companies are able to customize loyalty programs to match the unique inclinations and actions of each client, providing highly personalized rewards.

Furthermore, new channels for consumer advocacy and involvement have been made possible by the emergence of social media and online communities. By utilizing these platforms, loyalty programs can encourage members to share their recommendations, successes, and experiences with one another and build a feeling of community. Furthermore, modern consumers have made sustainability a top priority. They are looking for brands that share their values and show a commitment to social and environmental responsibility. By rewarding consumers for making ethical decisions and encouraging eco-friendly behavior, loyalty programs can be extremely effective in promoting sustainable consumption. Businesses can frame their loyalty programs as change agents and appeal to socially conscious consumers by providing discounts on eco-friendly products or allocating a part of rewards to environmental causes. A pillar of contemporary corporate strategy, loyalty programs provide a strong foundation for building long-lasting relationships with clients. Businesses can create loyalty programs that prioritize customer-centricity, embrace innovation, and leverage data and technology to create programs that not only encourage repeat business but also promote brand advocacy, community participation, and sustainable growth in a dynamic economy

2. RELATED WORK

Blockchain is a disruptive technology which is emerging as a game changer in various domains and industries [1]. Blockchain Technology possesses certain characteristics like Trust, Transparency and Immutability, etc which are complementary to certain respective Industries [2]. Supply Chain Management is one of such domains where Blockchain technology could create a positive impact and would help resolve the major challenges faced in the industry [3]. Hotel Industry is one of such industry which faces major challenges while it comes to Supply Chain Management and Handling [4].

Generally while talking about critical areas in Supply Chain Management in Hotel Industry, there are mainly two critical areas i.e. Trust and Traceability in the initial stage of the Supply chain [5]. These critical areas are the sole problem generators in most of the cases [6]. After doing comprehen-

sive study, research and implementation of a system based on Blockchain Technology for Supply chain management in Hotel Industry, to enhance the overall Trust, Transparency and Traceability in the Food SCM and simplifying the SCM flow in the industry [7] now comes the second critical area i.e. Loyalty and Customer Satisfaction.

Loyalty and Customer Satisfaction few of the most prominent factors which are mainly responsible for either making or breaking of the particular industry [8]. These factors contribute to customer retention which is considered as the backbone of any Business [9]. Thus taking care of Brand Trust and Loyalty would not only help the business flourish but also help the business gain certain competitive advantage over the competitive businesses. Currently, there are various ways in which a loyalty program can be implemented by a particular industry. Particularly talking, the two major general categories in which the loyalty programs can be segregated are the Physical Loyalty Programs and Virtual Loyalty Programs [10]. While considering both the categories there are certain factors like engagements, process flow, transparency and curiosity which makes them suitable for particular group of consumers [11]. The most adopted and popular category for loyalty programs is the Virtual Loyalty Program. Being, simpler to access, available at the tip of finger and simple process flow are few of the reasons which makes these programs popular when compared to the general Physical Programs [12]. [13] discuss the scalability challenges of traditional loyalty programs and propose blockchain-based solutions to accommodate growing customer bases and transaction volumes. Their research focuses on optimizing blockchain protocols and infrastructure to support large-scale loyalty program implementations.[14] explored the integration of blockchain technology to enable cross-platform loyalty programs. Their research mainly focuses on interoperability loyalty solutions that allow customers to earn and redeem rewards seamlessly across different brands and industries, fostering greater customer loyalty and engagement. While considering the challenges, [15] highlighted that even in virtual loyalty programs there are certain challenges which raise a question about customer satisfaction and trust. High Engagement and Curiosity about the reward being granted is one of such major challenge which needs to be addressed [16].

According to [17] Non - Fungible Tokens(NFTs) an application of Blockchain technology can be seen as a promising solution to overcome the challenges which are faced in the virtual loyalty programs as described in above section. NFT technology possesses certain traits like Transparency, Traceability, Scarcity and Systematic Distribution which are extremely co-ordinating and align to the goals of the Loyalty programs in hotel industry [18]. An exploratory case-study by ([19] analyses the customer's motivation, economy and autonomy while participating in the Loyalty programs developed by the respective authority. The case study establishes an overview of how Blockchain's key nature influences customers to take active participation in program. While talking about the overall satisfaction of the customer [20] highlights the how certain loyalty programs

like membership cards or discount promotions affect the customer satisfaction and in-turn leading to a boost in the business. The authors consider a set of data which has been taken from an array of surveys involving the output or thoughts from the customers. Following a proper Architecture, Framework and Protocol is the most important point to consider as conveyed by [21]. Even a simple issue in the loyalty program could devastate the complete supply chain ecosystem of Hotel Industry. Thus aligning with the standards and implementing the Loyalty program as per framework should be considered. [22] have presented in their case-study for Blockchain and NFT based Loyalty Programs for Agribusiness sector. The authors firstly describe the characteristics of the NFT Technology which would help them in the development of the platform. The authors then highlight the various protocols like ERC-721, which is the choice by them to continue with for the development of the NFT based Loyalty Programs. Another case-study of decentralization of Romanian Tourism through Blockchain and NFTs by [23] depicts the use of Blockchain for payments and NFTs for maintaining brand trust and enhancing the loyalty amongst them. The authors use the reference as Stramosi NFTs which are minted on MultiversX blockchain. The authors try to list how the NFTs would revolutionise the Tourism Industry but also authors list certain challenges which would act as a barrier to the system including the flexibility and the scalability of the system. The question focused on the point "Do customers prefer the hotels that use NFTs ?" Has been addressed by [24]. The result of the research mentioned by the authors is positive and authors have mentioned based on the surveys and results that people are actually ready to adapt with NFT technology as due to its characteristics and mainly Transparency.

Various types of protocols are available when we consider for implementing a Loyalty Program on Blockchain using NFT standards. Following are few of the protocols which are developed by respective authors -

Membership based NFT Loyalty [25] - As stated by the authors the system is developed on Blockchain and there is good scope for system. Although, authors have also mentioned certain challenges while the actual use of the system I.e. direct investment on the membership tokens, human psychology, etc.

Investopolis [26] - The authors have designed and implemented a system to tokenise a customer loyalty on the Blockchain. The system is implemented for investment platform and the application of Blockchain used in their case is Fungible Token. The challenges for the system they developed is the flexibility and the scalability of the system. Directed Acyclic graphs - based NFT Network [27] - The model developed by the authors is based on networking model (i.e. Directed Acyclic Graphs). The model values the connections between the NFTs and thus creation of a network of NFT's. The challenges faced by the author again includes flexibility, scalability and complexity.

3. METHODOLOGY

A. Proposed Methodology:

This investigation delves into the complex marriage of loyalty programs with Non-Fungible Token (NFT) technology, specifically designed for the discriminating hospitality industry, with a primary emphasis on hotels. By bringing previously unheard-of levels of transparency, security, and interoperability to established loyalty paradigms, the convergence of these cutting-edge technologies promises to revolutionize them. These digital tokens, safely tucked away inside the unchangeable ledger of blockchain networks, bring about a revolutionary change in the administration of loyalty programs by giving prizes an intrinsic sense of scarcity, authenticity, and verifiability. Our investigation into the application of NFT-based reward programs in the hospitality industry is based on this transformational potential. The deliberate application of NFTs in loyalty schemes requires a careful assessment of the blockchain infrastructure. This involves a thorough analysis of consensus techniques, token standards, and blockchain platforms to determine the best possible scalability, efficiency, and interoperability with current systems. Ethereum is the best platform to implement NFT-based loyalty programs because of its extensive developer community and strong smart contract capability. Furthermore, it is essential to have a thorough understanding of token standards like ERC-1155 and ERC-721 since they form the basis for encapsulating loyalty benefits as unique NFTs that are enhanced with essential metadata like award kind, value, and expiration date. Furthermore, a thorough approach to data security and interoperability is necessary for the smooth integration of NFT-based loyalty programs with current supply chain management (SCM) blockchain systems. Advanced middleware solutions are painstakingly designed to provide smooth communication between the SCM blockchain and the loyalty program platform, allowing loyalty transactions to be synchronized in real time with important supply chain events. This middleware serves as a strong link between the two systems, reducing operational overhead and delay while maintaining unwavering data consistency and integrity. Additionally, the implementation architecture is strengthened by cutting-edge security mechanisms that were painstakingly created to preserve loyalty incentives and sensitive client data from possible intrusions. Granular access controls, multifactor authentication procedures, and strong encryption methods are used to protect user privacy and stop illegal access to loyalty incentives stored as NFTs. Regular security audits and unwavering commitment to industry best practices guarantee strict compliance with legal frameworks like GDPR and PCI DSS. The NFT-based loyalty program ecosystem's user experience has been thoughtfully designed to make it easier for loyalty incentives to



be issued, transferred, and redeemed. Customers are empowered to interact with the loyalty program with ease and to maintain complete custody and control over their digital assets thanks to intuitive user interfaces that are easily connected with blockchain wallets and decentralized applications (DApps). These interactions are governed by smart contracts, which are the foundation of blockchain-based automation. They enforce specified rules and permissions to guarantee compliance and prevent fraud. The blockchain ensures that all transactions pertaining to NFT-based loyalty awards are accurately documented, giving stakeholders more accountability and transparency as well as an unchangeable audit trail of program activity. In addition, the combination of our previously designed supply chain management system for the hotel and food industries with NFT-based loyalty programs creates a powerful synergy that leads to supply chain optimization and unmatched loyalty management. Through the utilization of pre-existing infrastructure and amassed knowledge, this smooth integration optimizes data interoperability, reduces processes, and improves customer satisfaction. Maintaining continuity and scalability is crucial as it facilitates smooth expansion to meet the constantly changing needs of the business environment and the unpredictable swings in market conditions.

B. Modelling:

1) Proof of Hotel Interaction Protocol for NFT based Loyalty Programs:

Theory:

By awarding users with non-fungible tokens (NFTs) based on their interactions with restaurants, NFT loyalty systems encourage patron engagement. Token creation, distribution, accumulation, value computation, reward redemption, and dynamic adjustment are all governed by rules defined in the protocol.

Token Generation:

NFT token generation is determined by factors including social media engagement, purchasing patterns, recommendations, and client visits. New NFTs are minted in accordance with preset guidelines, such as awarding tokens for each \$100 spent or per five visits.

Distribution of Token:

Token distribution is affected by a number of factors, such as the amount of transactions, frequency of visits, activities related to referrals, and participation on social media. Users receive tokens from algorithms based on how engaged they are, those who contribute more heavily are awarded more tokens.

Point Accumulation:

Points are accrued by users based on particular interactions, which are prioritized. For example, spending \$1 may result in two points, but each visit would earn one point. The total of all weighted interactions is a user's total loyalty score, or points. Token Value Estimation: Customer spending patterns, utility, scarcity, and demand are some of the variables that affect token value.

Token Value Calculation:

Token value depends on factors like demand, scarcity, utility and customer spending habits.

Token Redemption:

Users can redeem accumulated tokens for rewards like discounts, free meals, exclusive experiences, or merchandise. Redemption rules ensure fairness and transparency, allowing users to access rewards commensurate with their loyalty score.

Token Generation:

$$T = f(\text{Criteria}) \quad (1)$$

Token Distribution:

$$D(t) = g(\text{Factors}) \quad (2)$$

Point Accumulation:

$$\text{Points } P_i = \sum_{j=1}^n \text{Points}_j \text{Points}_j = \text{Value}_j \times \text{Weight}_j \quad (3)$$

Token value calculation:

$$V(t) = h(\text{Factors}) \quad (4)$$

Rewards redemption:

$$\text{Rewards } R_i = \sum_{k=1}^m \text{Rewards}_k \quad (5)$$

Where,

T – Total tokens generated in the NFT loyalty program.

D(t) – Distribution function determining the allocation of tokens over time.

P(i)- Loyalty score or points accumulated by a specific user i. - Points earned from a specific interaction or activity j , such as eating food, making transactions, etc.

Value(j)- Value assigned to each interaction or activity of j

Weight(j)- Weight or importance factor associated with each interaction or activity j

V(t) - Value of tokens generated in the loyalty program at time t

R(i)- Rewards earned by a specific user I

f(Criteria) - Function describing the criteria for generating tokens based on user activities like eating food, making transactions, etc.

$g(\text{Factors})$ - Function determining the distribution of tokens based on specific factors such as user engagement, frequency of interactions, etc.

$h(\text{Factors})$ - Function calculating the value of tokens based on certain factors like user spending, loyalty level, etc.

Example:

Let's look at the example of Sarah, a patron of a restaurant that takes part in the NFT loyalty program on a regular basis. Sarah spends \$50 on average each of her two weekly visits to the restaurant. She uses social media to interact with the restaurant in a proactive manner, discussing her experiences and extending invitations to her friends. Using the protocol: Sarah's visits, purchases, recommendations, and social media activity all result in token generation from her activities. Sarah receives tokens according to how often she comes, how much she spends, how many referrals she makes, and how active she is on social media. Each visit, purchase activity, recommendation, and social media interaction adds points to Sarah's loyalty score, which is calculated based on the weighted interactions. The value of each token is determined dynamically, taking into account many aspects like market movements, economic situations, Sarah's spending patterns, and the demand for tokens. Sarah can exchange her accrued tokens for benefits provided by the restaurant, such as unique dining experiences, freebies, or discounts on subsequent purchases. The step-by-step breakdown can be viewed as :-

Token Generation:

Sarah's token generation function $T = f(\text{Criteria})$ considers her visits, spending, referrals, and social media engagement. Suppose Sarah earns 10 tokens for every \$100 spent, 5 tokens for each visit, 20 tokens for every successful referral, and 30 tokens for active social media engagement per week.

Token Distribution:

Based on Sarah's interactions, her token distribution function $D(t) = g(\text{Factors})$ allocates tokens proportional to her visit frequency, spending habits, referral success, and social media engagement. For example, if Sarah's total engagement score is 100, her tokens could be distributed as follows: 30% for visits, 40% for spending, 20% for referrals, and 10% for social media engagement.

Point Accumulation:

Sarah's loyalty score accumulates points, where $P =$ Loyalty score or points accumulated by a specific user. Each interaction contributes points based on its weighted value. Let's say Sarah's points accumulate as follows:

Visits: 2 points/visit \times 10 visits = 20 points

Spending: 2 points/dollar \times 500 dollars = 1000 points

Referrals: 5 points/referral \times 2 referrals = 10 points

Social Media: 30 points/week \times 1 week = 30 points

Total points accumulated by Sarah =
 $20+1000+10+30 = 1060$ points.

Token value Calculation:

The token value function $V(t) = h(\text{Factors})$ dynamically adjusts based on market trends, demand, and Sarah's engagement level. If the current token value is \$0.10, then Sarah's 1060 tokens would be worth $1060 \times 0.10 = \$106$.

Reward Redemption:

Sarah can redeem her accumulated tokens for rewards offered by the restaurant, such as discounts, free meals, or special promotions. For instance, if Sarah decides to redeem 500 tokens for a \$50 discount on her next meal, she effectively utilizes her loyalty points.

2) State-of-Art Research

The proposed Proof of Hotel Interaction Protocol for NFT-based Loyalty Programs offers several advantages over existing models, as discussed in the literature review. Here, we compare the proposed protocol with the Membership-based NFT Loyalty, Investopolis, and Directed Acyclic Graphs-based NFT Network models.

Membership-based NFT Loyalty:

State of art: Proposed proof of hotel interaction protocol focuses on incentivizing customer engagement by rewarding users with NFTs based on various interactions with the hotel, such as visits, spending, referrals, and social media engagement.

Challenges Addressed: Proof of hotel interaction protocol addresses challenges such as direct investment on membership tokens and human psychology by providing a flexible and transparent reward system that does not require upfront investment from users.

Advantages: Unlike the Membership-based NFT Loyalty model, proof of hotel interaction protocol does not require users to make direct investments in membership tokens, thus lowering barriers to entry and increasing participation. Additionally, proof of hotel interaction protocol offers a more diverse range of rewards, including discounts, free meals, and exclusive experiences.

Investopolis:

State of art: While Investopolis focuses on tokenizing customer loyalty on the blockchain using fungible tokens, proof of hotel interaction protocol utilizes NFTs to provide unique and verifiable rewards to users based on their interactions with the hotel.

Challenges Addressed: Proof of hotel interaction protocol addresses challenges related to the flexibility and scalability of the system by implementing a



dynamic token generation and distribution mechanism that adapts to user engagement levels.

Advantages: Unlike Investopolis, which may face scalability issues due to the use of fungible tokens, proof of hotel interaction protocol offers greater flexibility and scalability by leveraging NFTs. Additionally, proof of hotel interaction protocol offers a more personalized and engaging loyalty experience for users through the use of unique digital assets.

Directed Acyclic Graphs-based NFT Network:

State of art: While the Directed Acyclic Graphs-based NFT Network model values connections between NFTs to create a network, proof of hotel interaction protocol focuses on rewarding users based on specific interactions with the hotel.

Challenges Addressed: Proof of hotel interaction protocol addresses challenges related to scalability and complexity by implementing a streamlined token generation, distribution, and redemption process that is easy for users to understand and engage with.

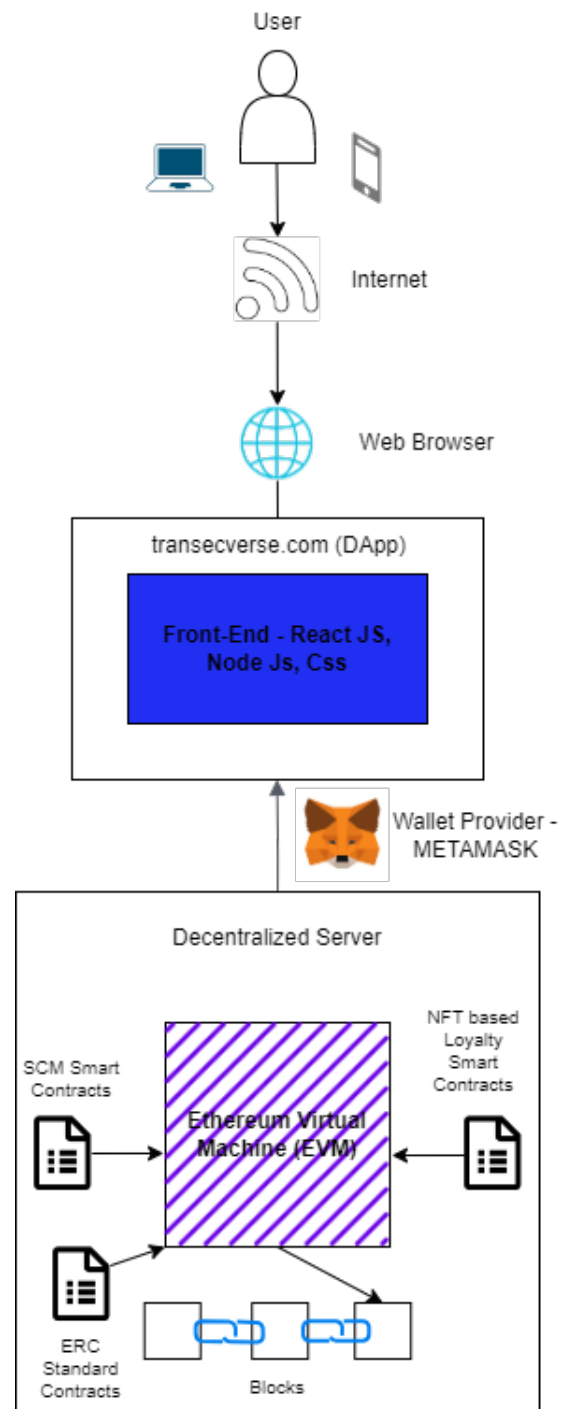
Advantages: Unlike the Directed Acyclic Graphs-based NFT Network model, which may face challenges related to complexity and scalability, proof of hotel interaction protocol offers a more straightforward and user-friendly approach to loyalty program management. Additionally, proof of hotel interaction protocol offers a clearer value proposition for users by providing tangible rewards for their interactions with the hotel.

After comparing to the models mentioned above our findings can be addressed as follows - While the mentioned models focus on incentivizing the customers using various approaches but the major problem which is common in all three of the models is the flexibility and scalability. The models face challenges to give a freehand to the Hotels or respective entities to decide the weightage and value to the rewards. Further, the dynamic points system allotment is seem to be missing or flexibility for the entities to decide what factors to value the most and what not. Scalability is also one of the most common problem as the entities are not able to scale the system to make the community more engaging and profitable. When we talk about a solution to these challenges the protocol developed by us takes care about these majors challenges(). The Proof of Hotel Interaction protocol provides the hotel with a flexible weight and value assignment and the factors for which the Hotel aims engagements. The POHI model further more increases the scalability of the complete loyalty program the hotel wants to implement for their customers. Based on the factors like revenue allotments to Loyalty Programs, conditions in the market and number of sales, the Hotel can flexibly vary the weight and value factor to align with Hotel ecosystem conditions.

4. SYSTEM IMPLEMENTATION

A. System Design

Figure 1



System Implementation

Theory:

1) User Interface (UI): The UI is developed using web technologies and interacts with users through HTTP

requests. It is built using frameworks like React.js or Angular.js for dynamic rendering of loyalty program features.

2) Connection: The UI communicates with the backend smart contracts via Web3.js, which is a standard library for smooth connection between Frontend UI and Backend Smart-Contracts.

3)Blockchain Wallet Integration: Blockchain wallet integration involves utilizing Ethereum wallets like Metamask which are already integrated with the platform built by us i.e. "Hotel and Food Supply Chain management on Blockchain" Wallet integration allows users to sign transactions securely, manage their NFT-based loyalty rewards, and monitor blockchain activity.

4) Smart Contracts: Smart contracts are deployed to the Ethereum blockchain using tools like Truffle or Hardhat. They are programmed to adhere to ERC-721 or ERC-1155 standards for non-fungible tokens. Smart contracts manage the issuance, transfer, and redemption of NFT-based loyalty rewards, enforcing program rules and logic.

5) Blockchain based SCM Integration: Integration of the NFT based Loyalty Program with the Blockchain-based SCM for Hotel industry provides a seamless experience and satisfaction to the end consumer resulting into a greater throughput.

6) Token Standards (ERC-721/ERC-1155): Token standards ERC-721 and ERC-1155 define the structure, behaviors, and interfaces of NFT-based loyalty rewards. Loyalty rewards are minted as NFTs on the Ethereum blockchain, with each token representing a unique reward asset.

B. Pseudo Code

Following is a pseudocode for a simple smart contract that mints and transfers ERC-721 non-fungible tokens (NFTs) representing loyalty rewards:

```
SPDX-Licence-Identifier: MIT
pragma solidity 0.8.0;

import "@openzeppelin/contracts/token/ERC721/ERC721.sol";
import "@openzeppelin/contracts/access/Ownable.sol";

contract LoyaltyRewards is ERC721, Ownable {
    //Declare variables
    uint256 public tokenIdCounter;
    mapping(uint256 => string) private
        _loyaltyRewards;

    // Event emitted when a new loyalty reward
```

```
is minted
event RewardMinted(address indexed owner,
uint256
indexed tokenId, string reward);

//Constructor
constructor() ERC721("LoyaltyRewards",
"LOYALTY") {
    tokenIdCounter = 1;
}

// Mint new loyalty reward NFT
function mintReward(address to, string memory
reward)
external onlyOwner {
    _mint(to, tokenIdCounter);
    _loyaltyRewards[tokenIdCounter] = reward;
    emit RewardMinted(to, tokenIdCounter,
reward);
    tokenIdCounter++;
}

// Get reward associated with token ID
function getReward(uint256 tokenId) external
view returns
(string memory) {
    require(!_exists(tokenId), "Token ID does not
exist");
    return _loyaltyRewards[tokenId];
}

// Transfer loyalty reward NFT
function transferReward(address from, address
to, uint256
tokenId) external {
    require(!_isApprovedOrOwner(_msgSender(),
tokenId),
"Transfer caller is not owner nor
approved");
    _transfer(from, to, tokenId);
}
}
```

A smart contract called LoyaltyRewards, created to administer ERC-721 non-fungible tokens (NFTs) signifying loyalty benefits, is defined by the Solidity code that is provided. Two other contracts, ERC721 and Ownable, provide functionality that the contract inherits. Standard NFT functions are provided by the ERC721 contract, enabling the creation, management, and transfer of NFTs. Access control is a feature of the Ownable contract that makes sure that only the contract owner may carry out specific tasks. NFTs, which stand in for loyalty incentives in the LoyaltyRewards contract, are linked to a distinct token ID and a description of the loyalty award. Functions to mint new loyalty reward NFTs, get the loyalty reward linked to a token ID, and move loyalty reward NFTs between addresses are all included in the contract. This agreement makes it



easier to establish and maintain loyalty.

5. RESULTS

In this section, we conduct a comprehensive analysis of traditional loyalty systems, and NFT-based loyalty systems within the hospitality sector, considering various key performance metrics and factors.

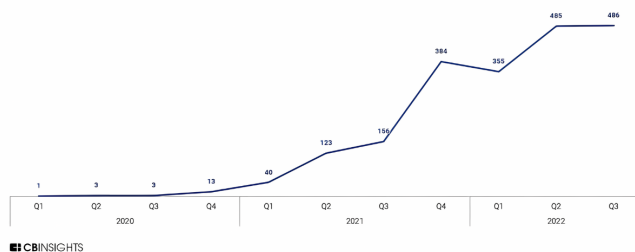
A. Rise in Popularity and Trends of NFT based Loyalty Program:

The graph attached below given by show a shift in popularity and trends in the NFT Technology domain further creating a space for NFT based Loyalty programs. Due to rising demands in Gen-Z and value-seekers NFTs are catching attentions and the user base is growing day-by-day. Loaded with heavy features and characteristics the NFTs are started to been seen as a pivotal element for Loyalty Programs and are thus forecasted to replace the existing classical systems and platforms.

Figure 2

NFTs for customer loyalty are garnering attention

News mentions of "NFT" and "loyalty," Q1'20 - Q3'22



Source: CB Insights

B. Metrics Comparison:

Based on the result analytics received from the Early Adopters of the platform altogether via Online Surveys, Physical meets, Phone calls we have formulated the output into number of important parameters, such as User Engagement, Redemption Frequency, Retention Rate, Transparency, Security, Scalability, Technical Complexity, Scalability Constraint, Regulatory Compliance, User Education, we have compared each loyalty system's performance as per the response received from the Early Adopters.

1) Performance metrics Comparison:

User Engagement:

This refers to the amount of time and effort users put into interacting with the loyalty program. A high level of engagement suggests that people value the program and are driven to take part. Metrics include feedback, social media engagement, event attendance, and frequency of visitors. The sum of these actions yields an engagement score that represents the total amount of user activity.

Redemption Frequency:

This metric assesses the regularity with which users exchange their incentives or loyalty points. A high frequency of redemption points to the value and accessibility of the rewards. The ratio of the total number of redemptions to the total number of redemption opportunities is used to compute this metric.

Retention Rate:

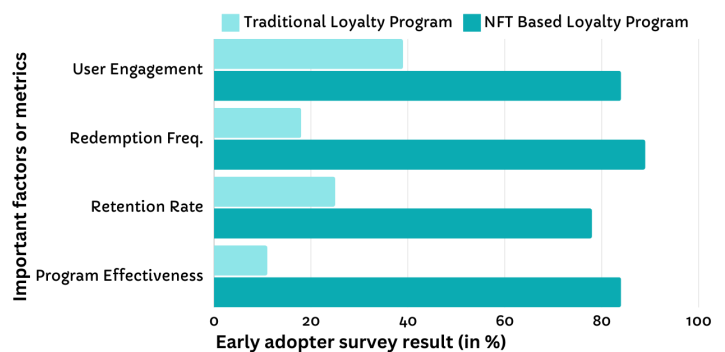
The percentage of users who continue to participate in the loyalty program over a given time frame is indicated by the retention rate. It illustrates how well the program keeps people interested. A high rate of retention indicates that consumers are regularly finding the program valuable. It is determined by comparing how many users were there at the start of a certain time to how many users were there at the end.

Program Effectiveness

Program effectiveness assesses how well the loyalty program has performed overall in reaching its objectives, which include raising redemption rates, improving retention rates, and raising user engagement. Metrics including user satisfaction ratings, ROI, and revenue effect are used to evaluate it. High program efficacy is a sign of a successful loyalty program that helps the company and its customers.

The figure below represents the Performance Metrics in percentage when compared to Traditional Loyalty System NFT based Loyalty System developed by us -

Figure 3



Source:Early Adopter Survey

2) Benefits Metrics Comparison

Transparency:

Users will be able to comprehend exactly how points are accrued, tracked, and used if there is transparency. By giving clear instructions and easily available information regarding the loyalty program, it fosters confidence. With an unchangeable transaction log, blockchain improves transparency by enabling users to confirm program

integrity and guaranteeing responsibility throughout the process.

Security

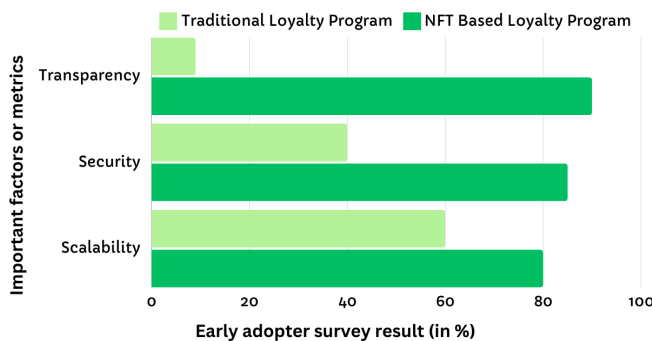
Security protocols safeguard user information and the integrity of the loyalty program. This covers safe authentication procedures, encryption, and frequent audits to stop security lapses. By generating a tamper-proof ledger, stopping illegal changes, and guaranteeing data integrity, blockchain improves security and offers a safe environment for administrators and users alike.

Scalability

Program scalability is its capacity to accommodate user and transaction expansion without experiencing performance problems. Robust system architecture, such as blockchain protocols like sharding and cloud-based infrastructure, are used to spread the workload and increase capacity. Scalability guarantees that the application may grow with ease while keeping up dependability and performance as the user base increases.

The figure below represents the Benefits Metrics in percentage when compared to Traditional Loyalty System NFT based Loyalty System developed by us -

Figure 4



Source:Early Adopter Survey

C. Challenges Metrics Comparison

Technical Complexity:

Technical Complexity: NFT systems, blockchain, and smart contracts are just a few examples of the intricate details that go into establishing and running the loyalty program. These difficulties can be overcome by streamlining interfaces and automating backend operations, which will save expenses and improve system usability.

Regulatory Compliance:

This guarantees that the loyalty program complies with regulatory requirements, such as those pertaining to financial rules and data protection. Features that support compliance maintenance, legal avoidance, and user trust-building include data encryption, frequent audits, and

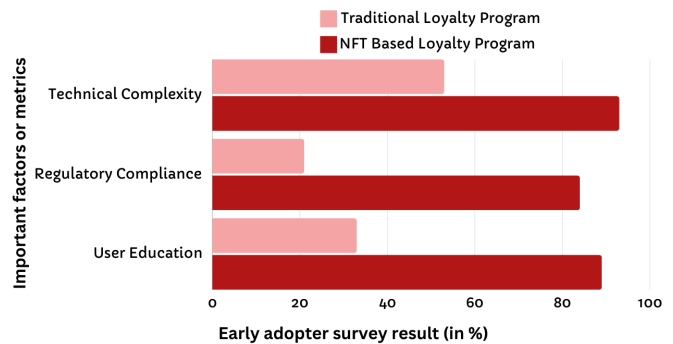
transparent reporting.

User Education:

Provides information and instruction to users on how to accrue and utilize points, comprehend the advantages of NFT, and use the system safely. Tutorials, FAQs, customer service, and user-friendly design are examples of methods. Users with more knowledge are more likely to interact with the application and get anything out of it.

The figure by the side represents the Challenges Metrics in percentage when compared to Traditional Loyalty System and NFT based Loyalty System developed by us -

Figure 5



Source:Early Adopter Survey

6. CONCLUSION

With a particular focus on hotels, we conducted a thorough exploration of Non-Fungible Token (NFT)-based loyalty programs in the hospitality industry in this study. Our review of the literature revealed the revolutionary potential of incorporating NFT technology into conventional loyalty frameworks, and we critically examined emergent trends. We saw a paradigm shift in the management of loyalty programs, marked by improved transparency, security, and interoperability, by utilizing the intrinsic qualities of NFTs, such as uniqueness, scarcity, and verifiability.

Our research showed that a sophisticated grasp of blockchain architecture, token standards, and interoperability protocols is required for the tactical implementation of NFT-based loyalty programs. Organizations may create scalable, effective, and future-proof loyalty networks by carefully choosing and configuring blockchain platforms, consensus techniques, and token standards. Furthermore, stable data interoperability and security are ensured by a smooth interaction with middleware and current supply chain management (SCM) systems, which makes it easier to synchronize loyalty transactions and supply chain events in real time. In NFT-based loyalty program ecosystems, the user experience plays a critical role in promoting consumer



satisfaction, engagement, and retention. Customers can easily connect with loyalty programs while keeping custody and control over their digital assets thanks to blockchain wallets, decentralized applications (DApps), and user-friendly interfaces. These interactions are governed by smart contracts, which provide an unchangeable audit trail of loyalty-related blockchain activity and enforce preset rules and permissions to guarantee compliance and reduce fraud. In summary, NFT-based loyalty programs offer unmatched security, creativity, and transparency, and they mark a paradigm leap in the administration of loyalty programs. In the cutthroat hospitality market, companies may reinvent consumer engagement, foster brand loyalty, and open up new growth and differentiation opportunities by embracing this transformative technology and combining it with state-of-the-art solutions. The future is full with opportunities for adding value, encouraging loyalty, and improving consumer experiences in the digital era as we keep innovating and exploring the potential of NFT-based loyalty programs.

7. FUTURE WORK

Using cutting-edge technologies can open up new avenues for improving client engagement and loyalty as NFT-based loyalty programs develop. The following are some directions for further study and development, each corresponding to a particular technology:

Machine learning (ML) and artificial intelligence (AI): Examine how to combine AI and ML algorithms to assess consumer spending trends, preferences, and behavior patterns to enable personalized and anticipatory incentive distribution. Create recommendation engines that use AI to make personalized, relevant reward and incentive suggestions for each customer, improving their loyalty experience as a whole.

Autonomous organizations that are decentralized (DAOs): Examine the use of DAOs to democratize loyalty program governance by enabling users to collectively decide on strategic goals, rules for the program, and how rewards are distributed. Create voting mechanisms and smart contracts inside DAO frameworks to allow for transparent and decentralized control of loyalty program operations, which will promote empowerment and community involvement.

Internet of Things (IoT) and Wearable Devices: Examine how wearable technologies and IoT devices can be integrated to improve the smooth communication between clients and NFT-based loyalty programs. Create Internet of Things (IoT)-enabled smart devices that can track consumer interactions and activities automatically, including restaurant visits, hotel stays, and purchases, to allow for real-time reward accrual and redemption. Utilize wearable technology to facilitate frictionless transactions at participating locations and provide customers easy access to their loyalty benefits.

Examine how augmented reality (AR) and virtual reality

(VR) can be used to give customers engaging and interactive loyalty experiences. Create augmented reality (AR) applications that superimpose virtual incentives and rewards over real-world settings, such as hotel rooms or restaurant tables, to raise the perceived value of loyalty club advantages. Examine VR-based loyalty programs that let users virtually peruse reward catalogues, redeem incentives in virtual settings, and interact creatively with branded material.

Blockchain Scalability Solutions: To handle a higher amount of transactions and users, address the scalability issues related to blockchain-based NFT systems. To improve NFT-based loyalty program throughput and efficiency, investigate and create scalable blockchain solutions, such as layer 2 protocols, sharding strategies, and consensus algorithm optimizations. Examine interoperability protocols that facilitate smooth asset transfers and interactions between various blockchain networks so that users can take use of their loyalty benefits in a variety of ecosystems. We may create new avenues for innovation and distinction in NFT-based loyalty programs by concentrating on their integration, which will eventually increase consumer happiness, retention, and brand loyalty.

REFERENCES

- [1] M. Dabbagh, M. Sookhak, and N. S. Safa, "The evolution of blockchain: A bibliometric study," *IEEE Access*, vol. 7, pp. 19212–19221, 2019.
- [2] V. Ali, A. A. Norman, and S. R. B. Azzuhri, "Characteristics of blockchain and its relationship with trust," *IEEE Access*, vol. 11, pp. 15364–15374, 2023.
- [3] R. Manzoor, B. S. Sahay, and S. K. Singh, "Blockchain technology in supply chain management: an organizational theoretic overview and research agenda," *Annals of Operations Research*, Nov 2022. [Online]. Available: <https://doi.org/10.1007/s10479-022-05069-5>
- [4] O. Jawabreh, A. Baadhem, B. Ali, A. Ahmad, A. Bani Atta, A. Ali, F. Fahmi, F. Al-Hosaini, and M. Allahham, "The influence of supply chain management strategies on organizational performance in hospitality industry," 09 2023.
- [5] M. Zrnić, "Study on the importance of food traceability in the tourism industry," 03 2021.
- [6] S. Al-Msallam, "Customer satisfaction and brand loyalty in the hotel industry," Feb 2016. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2738998
- [7] S. Kadam, R. Senta, R. K. Sah, A. Sawant, and S. Jain, "Blockchain revolution: A new horizon for supply chain management in hotel industry," *2024 International Conference on Emerging Smart Computing and Informatics (ESCI)*, pp. 1–8, 2024. [Online]. Available: <https://api.semanticscholar.org/CorpusID:269190816>
- [8] N. Safaie, A. Nazeri, and A. Mottakiani, "Supply chain management in hospitality and its impact on competitive advantage, hotel, and supply chain performance," *Industrial Engineering and Management*, vol. 7, pp. 166–185, 2020. [Online]. Available: <https://api.semanticscholar.org/CorpusID:231659752>

- [9] J. Schijns, C. Gelderman, and P. Daams, "The impact of loyalty programmes in a b-to-b context: Results of an experimental design," *Journal of Targeting, Measurement and Analysis for Marketing*, vol. 16, no. 4, pp. 274–284, 2008.
- [10] M. Hofman-Kohlmeyer, "Customer loyalty program as a tool of customer retention: Literature review," 2016.
- [11] M. J. Haverila, K. C. Haverila, C. McLaughlin, and H. H. Tran, "The impact of tangible and intangible rewards on online loyalty program, brand engagement, and attitudinal loyalty," *Journal of Marketing Analytics*, vol. 10, pp. 64–81, 2022. [Online]. Available: <https://api.semanticscholar.org/CorpusID:246384312>
- [12] A. Vuletić, D. Naletina, and A. Polić, "The impact of terrorism on the security and continuity of international business activities," 2016.
- [13] M. Garcia, "Securing customer data with blockchain: Implications for customer relationship management. journal of information security," *Journal of Information Security*, vol. 25, no. 4.
- [14] D. Dhvani, G. Gopalakrishnan, M. N. Guzman, N. Jureczek, H. Kim, and M. McDonald, "The benefit of blockchain loyalty programs," *Ideas for Leaders*, Sep 2022. [Online]. Available: <https://ideasforleaders.com/Ideas/the-benefit-of-blockchain-loyalty-programs/>
- [15] L. Steinhoff and R. W. Palmatier, "Commentary: Opportunities and challenges of technology in relationship marketing," *Australasian Marketing Journal (AMJ)*, 2020. [Online]. Available: <https://api.semanticscholar.org/CorpusID:220627898>
- [16] S. B. M. Situmorang and D. T. H. Aruan, "The role of customer brand engagement on brand loyalty in the usage of virtual hotel operator," in *Proceedings of the International Conference on Business and Engineering Management (ICONBEM 2021)*. Atlantis Press, 2021, pp. 101–109.
- [17] J. Choi, "Integrating the mobile game item and customer loyalty mileage in nft," *International Journal of Current Science Research and Review*, 2022. [Online]. Available: <https://api.semanticscholar.org/CorpusID:247069408>
- [18] D. Nissly, E. Soriano, and T. Sawyer, *LOYALTY NFT ENGAGEMENT SOLUTION*.
- [19] L. Wang, X. R. Luo, Y. Hua, and J. Wang, "Exploring how blockchain impacts loyalty program participation behaviors: An exploratory case study," in *Hawaii International Conference on System Sciences*, 2019.
- [20] Sulaiman and S. Musnadi, "Customer relationship management, customer satisfaction and its impact on customer loyalty," 2018.
- [21] C. Deventer, V. A. de Sousa, and L. Pirnay, "Nftbybrands: Value identification framework for analysis and design of nft initiatives," *Int. J. Electron. Commer.*, vol. 28, pp. 33–62, 2024. [Online]. Available: <https://api.semanticscholar.org/CorpusID:267119115>
- [22] H. Hosseinibeiki and M. Zaree, "A blockchain based solution to improve loyalty program with nft in agribusiness," *Journal of Smart Environments and Green Computing*, 2023. [Online]. Available: <https://api.semanticscholar.org/CorpusID:265201477>
- [23] C. E. Năstase, A. C. Niță, M. Vrăncianu, and C. I. Petrovan, "The decentralization of romanian tourism through blockchain and non-fungible tokens: A case study on stramosi nfts," in *Sustainable Approaches and Business Challenges in Times of Crisis*, A. L. Negruşa and M. M. Coroş, Eds. Cham: Springer Nature Switzerland, 2024, pp. 225–245.
- [24] A. Dalgıç, E. Yaşar, and A. Demircioğlu, "Do customers prefer hotels that use non-fungible tokens as a marketing tool? a study based on the value-attitude-behavior model," *Turizm Ekonomi ve İşletme Araştırmaları Dergisi*, vol. 5, no. 2, p. 148–164, 2023.
- [25] T. Ardavanis, *Membership NFTs Blockchain Technology, opportunities, and implementation of utility based Non-Fungible-Tokens*. Thesis, UAS, 2022.
- [26] V. K. P. Kuppa, R. Hegadi, K. Sajjan, K. D. Chowdary, M. S. R. Vanga, and P. Kumar, "Investopolis: Decentralized customer loyalty tokenization on the blockchain," in *2024 IEEE International Conference on Consumer Electronics (ICCE)*, 2024, pp. 1–5.
- [27] G. Yu, Q. Wang, C. Sun, L. D. Nguyen, H. M. N. D. Bandara, and S. Chen, "Maximizing NFT incentives: References make you rich," 2024.

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