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모바일앱 추천시스템과 블록체인 기술

Blockchain Technology for Mobile Applications Recommendation Systems

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초 록

블록체인기술에 대한 관심은 지속적으로 증가되고 많은 분야에 활용되고 있다. 블록체인 기술은 타인이 함부로 데이터와 거래를 제어할 수 없게 하는 분산 환경을 제공한다. 모바일앱 추천은 모바일 사용자에게 적당한 앱을 추천하는데 사용된다. 예를 들어, 사용자의 선호도 및 모바일 환경에 따라 서로 다른 모바일앱을 추천하는 복수의 안드로이드기반 추천앱이 개발되어왔다. 앱 추천은 사용자가 다른 사용자의 경험을 참조하여 앱을 발견하는 데 도움을 준다. 수집된 많은 양의 데이터 및 사용자 정보는 외부 공격에 대한 취약성과 사용자 개인 정보 보호 문제를 내포한다. 이 문제를 해결하는 방법으로 암호화 안전을 보장하는 블록체인 기술을 적용할 수 있다. 본 서베이 논문에서는 모바일앱 추천 기술과 전자상거래 기술 동향을 살펴본다. 개인화된 앱 추천에 대한 사용자의 개인 정보 선호 중요성 측면에서, 블록체인기술과 협업필터링 기술의 접목이 사용자에게 안전한 데이터 환경을 제공할 수 있는지도 살펴본다.

ABSTRACT

The interest in the blockchain technology has been increasing since its inception and it has been applied to many fields and sectors. The blockchain technology creates a decentralized environment where no third party controls the data and transaction. Mobile apps recommendation has been extensively used to recommend apps to mobile users. For example, Android-based recommendation applications have been developed to recommend other mobile apps for download depending on user's preferences and mobile context. These recommendations help users discover apps by referring to the experiences of other users. Due to the collection of a large amount of data and user information, there is a problem of insecurity and user's privacy that are prone to be attacked. To address this issue the blockchain technology can be incorporated to assure cryptographic safety. In this paper, we present a survey of the on-going mobile app recommendations and e-commerce technology trend to address how the blockchain can be incorporated into the collaborative filtering recommendation systems to enable the users to set up a secured data, which implies the importance of user privacy preference on personalized app recommendations.

키워드 : 모바일앱, 추천시스템, 블록체인, 협업필터링
Mobile Apps, Recommendation Systems, Blockchain, Collaborative Filtering

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This paper is based on the first author's master thesis [26], and a preliminary short version of this paper appeared in 2017 Fall Conference of KISM&SEBS [25]. This paper is a fully extended version that features mobile application recommender systems, evaluation measures, and challenges to apply the blockchain technology into recommender systems.

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1. Introduction

Blockchain is new trend in digital technology which provides a strong cyber security result and high level of privacy protection. It is a distributed ledger technology by allowing digital information to be distributed but not copied. It is used in the crypto currency Bitcoin, data and virtually everything of value. The main key attributes of using the blockchain technology are its decentralized, consensus based shared ledger, transparency, smart contract and privacy. It does not need a third party as a go-between or authority for verification or any other reasons but used in constructing a secure anonymous, immutable and transparent service [31]. A blockchain can be used by mobile applications recommendation systems to promote interaction, security and privacy in recommendation systems.

Recommendation system is an effective way to reduce information overload and also provides personalized recommendation. It is a software tool and technique that provides suggestions for items or information that are of use or interest to a user [19]. Recommender systems create recommendation using different type of knowledge and data about the users, attainable items, and earlier transactions stored in database. Then the users can browse and make a decision of their choice.

Due to the rapid development of internet, mobile devices, and smart phones, millions of mobile apps emerge to take over of every aspect of mobile user activities. As a result of the huge number of mobile Apps, it will be difficult for users to find important and interesting Apps. At this point, recommender systems are used to help users find a suitable applications and suggestion in an online app markets. The suggestion predicted to the user depends on users which share similar preference and taste.

Moreover, there are some problems encountered when computing similarities between user's profile, attributes, behavior etc. due to insecurity in data privacy. To prevent this occurrence the blockchain technology is used to allow the jointly nodes information to transact and prevent fraud [11,33]. In this paper, we propose an approach to combining this technology and recommendation systems with little effect of revealing user's personal data. This approach indeed requires building specialized distribution mechanism to solidify recommendation system.

2. Overview of Blockchain Technologies

Blockchain is a peer-to-peer distributed ledger technology which enables records to be sorted and stored into blocks and are linked and secured using cryptography. Blockchain exploits Distributed Ledger Technology (DLT). Distributed ledger technology is a digital system for recording the transaction of assets in

which the transactions and their details are recorded in multiple places at the same time. Blockchain can be used for any form of transactions without going through a mediator. It also supports other functions like smart contracts, Ethereum, or etc. Blockchain may operate in three forms; public, private or hybrid. A public blockchain like Bitcoin is an open blockchain whereby anyone can participate by reading or sending transactions or by joining the agreement process (proof of work, proof of stake, etc.) by means of unknown node. The public blockchain is also called permissionless ledgers which allow anyone to contribute data to the ledger with all participants having an identical copy of the ledger since there is no particular owner of the ledger. While the private blockchain is sometimes called permissioned ledgers which allow for distributed identical copies of a ledger, but only to a limited amount of trusted participants only since the network may have an owner(s). The hybrid blockchain possesses a combination of public and private blockchain characteristics. Its network members or governing body can determine which transactions can remain public, and which must be restricted to a smaller group of members. Actually, a blockchain is a chain of blocks of information that register Bitcoin transaction. The process of computation basis of creating, insertion and using the blocks are called blockchain technology. The main characteristics of blockchain technology are trust evoking and decentralized nature [23].

Blockchain technology documents online transaction while ensuring that those transactions are secure. It also offers a way to securely and efficiently create a tamper-proof log of sensitive activity. A global network of computers uses blockchain technology to jointly manage the database that records Bitcoin transactions. Blockchain impact the way mobile telecommunications and wireless networks interact and operate.

2.1 Mechanism

Blockchain technology is applicable to any digital asset transaction done online and the transaction is a digital block that needs to be verified before it enters the system. The proof of existence enables the users to pay a transaction fee and upload a file to have a cryptographic proof of it contained on the bitcoin blockchain. After anonymously uploading the document and paying the network fee, a hash of the document (or any other type of digital file) is generated as part of the transaction. Then the proof of existence website shows recently uploaded files that have hashes on the blockchain. This uses the public and ledger like nature of the blockchain to store the proof of your file, which can later be verified and issue of authorship or dating ensued. Essentially, by inserting the cryptographic hash of the document in a transaction, when that transaction is mined into a block, the block timestamp becomes the record's timestamp [1]. The block-

chain creates a protected data point where you encrypt only the information that you want important people to know at certain times.

2.2 Blockchain Applications

Blockchain technology has huge variety of applications and uses beyond just Bitcoin, which includes as follows:

- Financial services and banking: It can be used to transform, create secure and suitable options to time consuming and expensive banking/financial processes. Financial/banking services are using this system to initiate innovation like smart bonds and smart contracts. The example of blockchain financial/banking services can be found in the areas of payment, asset management, and insurance etc, where the service would be provided faster, cheaper, and in more secure and transparent manner. The application of blockchain in finance in the future is through crypto currencies, specifically Bitcoin.
- Business and recommendation: Using blockchain tech offers services in healthcare, academia, real estate, energy and media. The blockchain can also be applied toward making business accounting and recommendation more transparent.
- Government: Blockchain application in government helps in record management, identity management, voting, taxes, etc.
- Other industries: Blockchain can also be applying in other industries like in data storage and verification, cyber security, internet of things.

2.3 Benefits and Limitation of Blockchain Technology

- Decentralization: It means the dispersal of nodes, data, miners and developers. There is no need for a third party or intermediary to support transactions alternatively a consensus technique is used to agree on the validity of transactions and removes costs.
- Transparency and trust: As blockchains are shared and everyone can see what is on the blockchain, this allows the system to be transparent and as a result trust is established.
- Security: Every transaction is verified within the network using independently verified complex cryptography, the authenticity of the information can be assured. All information is encrypted, which adds security by its own.
- Tracking: As nothing can be changed and the ledger is present across multiple nodes, blockchain is easier to track. It won't come as a surprise that blockchain is often used for asset tracking as a consequence.

The blockchain technology also has the limi-

tations which may include as follows.

- Performance: Due to the nature of blockchain, that is peer-to-peer distribution. Blockchain transaction can only complete when all parties update their different ledger and it might take a long time. It will be slower than the centralized database.
- Large energy consumption: The blockchain technology consumes a lot of energy. Blockchain network's miners are attempting 450 thousand trillion solutions per second in efforts to validate transaction, using substantial amounts of computer power.
- Interoperability: the ability of computer systems or software to exchange and make use of information.
- Cost: blockchain offers huge savings in transaction costs and time but the high initial capital costs could be discouraging

3. Recommender Systems and Challenges

Recommender systems are techniques that provide user with personalized information that may be of interest to the user. Some important techniques for recommendation systems are:

- Collaborative filtering [15]: It provides feedback information based on the user that rate the items. Collaborative filtering can recommend items with different content, which other users have shown interest. There are two main types of collaborative filtering [12] - Neighborhood (memory based) and model-based method.
- Content based filtering [20]: It depends on item description and characteristics. This creates a profile for all the users.
- Hybrid filtering [27]: It is the combination of all other filtering approaches.

Some major challenges in recommender systems may include the followings.

- Cold start - it is very hard to give new user recommendation since his profile is empty. Item too can equally have a cold start when there are new and have not gotten any rating.
- Data sparsity - when there are many users and items like online shop there are always users that rates the items.
- Scalability - when the increase of users and items are still capable to change in size or scale with the purpose of the user with the same tastes and description.
- Privacy - It is the state of ensuring that the user data is kept private and secure. Privacy has been the most encountered problem.

3.1 Privacy and Security Issues

The accuracy of recommendation depends on how many users' feedback on their prefer-

ence on items they received. And the feedback information and personal data collected from the users need privacy protection and it's has to be protected against intruder. In order to prevent and maintain reliability, security and confidentially the privacy policy is introducing to reduce the risk and shows transparency.

4. Mobile Application Recommender Systems

Mobile applications (also known as mobile apps) are software programs developed for mobile devices such as smart phones, tablet and watch. Nowadays mobile devices usage is outstripping that of desktop computers and laptops. As a result of that many developers have shifted to "mobile first" approach [18] which cause an explosive growth in a mobile apps development. The three major players in the mobile apps supply are Google play for Android devices, Apple's app store for iPads and iPhones and Amazon Appstore for Amazon fire devices. The numbers of mobile apps are widely increasing, and this becomes a big challenge for users to find an interesting apps. As a result of this, recommender systems used online app markets to help provide users with app suggestions. The mobile apps are widely known by the number of downloads, active users or the usage frequency.

Here we review some facts on mobile computing, mobile service and technology.

Mobility: Mobile information system in recommend systems can be characterized in three perspectives: User mobility which refers that the user can access a mobile information system in different locations. Device Portability refers to the fact that the device used to access the information system is mobile. Wireless connectivity refers to the facts that the device used to access the recommender system is networked by means of a wireless technology such as Wi-Fi.

Mobile Services: Mobile service as information services for mobile users also stresses the mobility dimension rather than the wireless one.

Mobile Devices: These days, there are many mobile devices and different types are daily introduced in the market. There are two major classes of devices; Sensor and radio frequency identification - these are simple wireless devices set to accomplish few simple functions [7].

5. Recommendation Based on Collaborative Filtering

Collaborative filtering is widely used technique in recommender systems. It is a method of filtering or evaluating items though the ideas of other people. It also recommends items based on similarity measures between users and

items. Two types of collaborative filtering are: Neighborhood-based (memory-based) and Model - based collaborative filtering.

5.1 Neighborhood-based Collaborative Filtering

The examples of neighborhood based collaborative filtering include user-based approaches and item-based approaches [21]. User-based recommendation works by recommending items that are liked by the like-minded users, it focuses on the similarity between two users. In the user-based approach, the users perform the main role. <Table 1> shows an example of an user ratings database for Eric and other users.

〈Table 1〉 Example of users' Ratings Database〔26〕

users	item 1	item 2	item 3	item 4	item 5
Eric	5	3	4	4	Null
user 1	3	2	1	3	3
user 2	3	3	4	1	5
user 3	4	3	2	5	4

The standard collaborative filtering approach takes an user input matrix with ratings as the only input and produces a prediction value indicating similarities to other users. Recommendations are given to user based on evaluation of items by other users from the same group, which share common preferences.

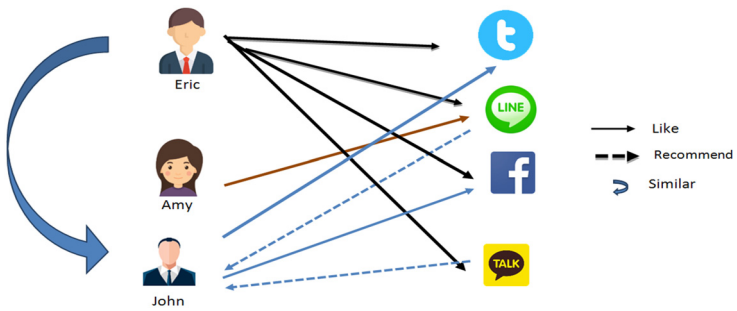
Some common similarity measures include cosine based, adjusted cosine and the Pearson correlation based similarity has been widely used. One challenge the user-based collaborative filtering has is the scalability problem.

5.2 Model-based Collaborative Filtering

In this approach, models are developed using different data mining, machine learning algorithms to predict users' rating of unrated items. There are many model-based CF algorithms: Bayesian networks, clustering models, latent semantic models such as singular value decomposition, matrix factorization-based algorithms, probabilistic latent semantic analysis, multiple multiplicative etc [29]. Based on these models, missing ratings can be predicted efficiently.

In this collaborative filtering, adequate information is required like user ratings and survey but when the information is lacking a problem known as Cold - Start problem is created [17]. It is, however, not easy to give new user or item recommendation due to lack of any previous history.

<Figure 1> illustrates an example of collaborative filtering recommendation. John is the one receiving recommendation but this time he likes Facebook and twitter. And if we search for the person with similar preference like him then we can see that Eri also likes Facebook and twitter. He is a user similar to John because



〈Figure 1〉 Collaborative Filtering Recommendations

he likes Line and Kakaotalk, and therefore both items are recommended to John.

5.3 Evaluation Measures

The most common CF evaluation measure for prediction accuracy is the mean absolute error (MAE) and root of the mean square error (RMSE). MAE is the most popular and commonly used; it is a measure of deviation of recommendation from user's set value. It is computed as follows [9]:

$$\mathrm{MAE} = \frac{1}{N}\Sigma_{U_j}|P_{u_i} - r_{u_i}|$$

where P_{ui} is the predicted rating for user u on item i, r_{ui} is the actual rating and N is the total number of ratings on the item set. The lower the MAE, the more accurately the recommendation engine predicts user ratings. Also, the Root Mean Square Error (RMSE) is given by Cotter et al. [10] as:

$$\mathrm{SE} = \sqrt{\frac{1}{n}\Sigma_{u,i}(P_{u_i} - r_{u_i})^2}$$

Other evaluation measures are precision, recall, and F1 measures [6].

5.4 Incorporating Blockchain Into Collaborative Filtering

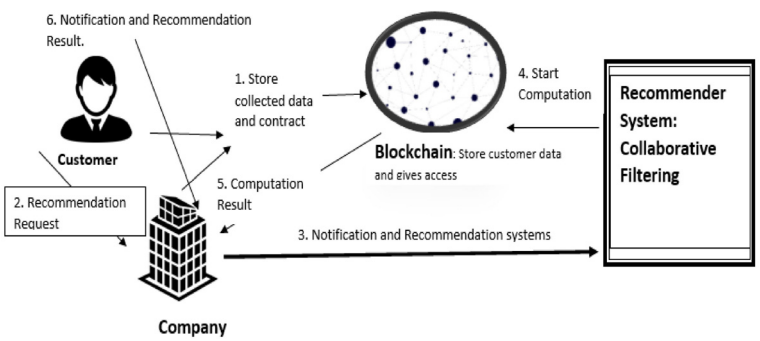
An increasing number of individual like install apps, watch movies or TV using mobile applications. Moreover, as the amount of information and online services increases, it becomes more and more difficult for users to find the right information that is needed to complete a particular task (e.g., choosing a movie, or planning a trip, download of Apps etc.). Specifically, users of e-commerce web sites usually find it difficult to locate their best products and services, due to the huge number of options to consider and the lack of effective system support in making decisions. Recommender systems are information filtering and decision support tools that help in addressing these problems, supply product and service recommendations personalized to the user's needs and preferences at each particular demand [13].

There have been a few previous works on Apps recommendation but these works depended on recommending the relevant Apps to the user without considering the user's privacy preference. Collaborative filtering recommender systems as a popular technique for recommendation focused only on filtering and recommendation disregarding user's privacy and security. To address this issue a recommendation system using the benefits of blockchain technology secure multiparty computation is incorporated. Blockchain technology potentially help to enable improve recommendation with assurance of security, integrity of data, accessibility and confidentiality. In this emergent technology, users are able to get personalized recommendation and still keep their data secure and private. Users can use the blockchain system to store personal data useful for recommendation systems for example, interested items, digital transaction, special needs, information, apps recommendation, etc. the data is encrypted and secure. The company also collects and store interesting data like e-commerce/e-shopping, credit card data etc. for recommender system in the blockchain system to avoid hacker's attacks and some other dangers. And the blockchain will make sure that the data is released way to the customer in a trust and encrypted fashion, which shows the proper and transparent data storage record between the company and the customer. The company equally uses the blockchain for data contract agreement processing [14] that gives the new and old customer access to agree and terminate the contract at any time.

5.5 Architecture

Blockchain is a decentralized ledger of all transactions across a peer to peer network. Using this technology, participants can confirm transactions or recommendations without the need for a central certifying authority.

In collaborative filtering recommender system, blockchain system is used to do computation in recommendation systems without revealing the input data. For instance, if a user



〈Figure 2〉 Example Scenario of Incorporating Blockchain in Collaborative Filtering [26]

request or wants to get recommendation for transaction or app recommendations. Firstly, the interested user will send a recommendation request to the company through peer-to-peer network consisting computers nodes. When the company received it, with many users' data it has already contracted with the network of nodes, collaborative filtering algorithm will use it as a set of values to get maximum recommendation. Moreover, the blockchain will do all the computation once verified the transaction or the app recommendation is combined with other transactions to create a new block of data for the ledger without the company direct involvement. The new block is then added to the previous existing blockchain, in a way that is stable and unchangeable. At last, when the transaction is completed, the company gets the result, and forwards it to the customer's address. Then the customer gets notification and recommendation result with a secure access and Privacy. In <Figure 2>, we illustrate how the customer, company and blockchain system interact each other.

6. Related Works

6.1 Mobile App Recommendation

Mobile app recommendation has been studied by some researchers. Woerndl et al. proposed an approach integrating users' locations [28], as different users might be interested in the same application when they are at the same location. Some mobile recommender systems may be as follows. Appjoy proposed by Yan et al. [30] automatically measures app usage patterns and recommends related apps based on a collaborative filtering method. AppsFire, AppBrain, and Appazaar have been developed, while other works [28-30] have also been presented. AppsFire [2] allows users to form friendships and share the apps they like. AppFire influence social network to allow users sharing and recommendation of mobile application among friends. AppBrain [3] recommend popular application with high volume of downloads. It observes the installation history of apps and provides recommendations in the same group. AppSpace [4] recommend the application the user might like based on the user installed application and rating. The main weak point of AppSpace is that the user has to clearly inform the system of his preference such as installed application. AppAware [16] help users in making discoveries of mobile application by using location to produce recommendations. Appazzar [5] is a recommender system for mobile applications in a form of a widget. It recommends apps that might be of interest to the user based on the current location.

6.2 Collaborative Filtering Recommender Systems

Collaborative filtering technique is the most mature and the most commonly implemented.

Collaborative filtering recommends items by identifying other users with similar taste; it uses their opinion to recommend items to the active user. Collaborative recommender systems have been implemented in different application areas. The collaborative filtering method was first used in the Tapestry project that was developed for the purpose of filtering e-mails. The purpose of the developed systems is decomposing the e-mails that were labeled by user based on specific criteria [22]. GroupLens is a news-based architecture which employed collaborative methods in assisting users to locate articles from massive news database [24]. This system makes personal recommendations using Usenet News.

Ringo is an online social information filtering system that uses collaborative filtering to build users profile based on their ratings on music albums [8].

Amazon uses topic diversification algorithms to improve its recommendation [32]. The system uses collaborative filtering method to overcome scalability issue by generating a table of similar items offline through the use of item-to-item matrix. The system then recommends other products which are similar online according to the users' purchase history.

7. Conclusion

In this paper, we focus on an outline on how to realize mobile app recommendation for mobile users and to deal with user's personal data right and privacy. Blockchain can be incorporated in collaborative filtering of recommender system to bring a solution which portrays cryptographically guarantees user's privacy in recommender system. The system can prevent the fear of misuse of personal data and fraud which the user might encounter. This assurance will motivate people to share their information which will boost the recommendation system benefits in App recommendation, e-commerce and other sectors. This insinuates that it is important and better to consider user privacy preference on personalized App recommendations.

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