Luna

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Abstract Online dating has emerged as one of the most extensive and still-growing online industries, but user experience remains poor due to two main deficiencies in currently available platforms. The first deficiency lies in the current game theoretic tactics, the rules to which users must adhere in order to achieve dating success: bad incentives have left the dating game with a severe attention imbalance and have resulted in issues such as poor messaging behavior, fake accounts, and misuse of personal data. The second deficiency lies in poor user-matching algorithms, which result in low levels of success in finding and connecting with a potential partner.

The Luna platform introduces an entirely new approach to online dating to address these issues. Through the introduction of attention economics, Luna delivers an online dating platform which solves the attention imbalance, thereby relieving pressure on all users. Luna also introduces an innovative use of machine learning compatibility calculations to achieve superior matches between users.

To efficiently deliver this new economic mechanism, Luna employs a queueing system built upon distributed ledger technology and includes novel features to maximize user trust. This document sets out in detail both the current issues faced by online dating platforms and Luna's solution, which includes its innovative system of incentives, its use of machine learning algorithms, and its use of blockchain to deliver a high level of user satisfaction.

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Foreword

by Vinay Gupta

Why it's Important That We Fix Online Dating

I'm a person who is usually known for chasing big, important problems: climate refugees, critical infrastructure, pandemic flu, environment and so on. Why, then, have I been lugging around an idea about how to fix online dating for a few years, talking about it, and trying to get people to see different ways of thinking about it?

The answer is because the best things in life are free. There's no significant economic or social cost to people being with the people who will, at any given time in their life, make them happiest. And this is essentially a search (and possibly scheduling) problem. Let's deal with the search part first.

Humans in traditional societies knew about inbreeding. They evolved elaborate ceremonies with and traditions for making sure that their kids married outside of the tribe, even if there were serious difficulties (like language barriers) in doing so. More than one agricultural society held no-holds-barred festivals in which you could arrive with who you liked, and leave with somebody else, and nobody was really allowed to give you a hard time about it.

This stuff didn't happen for no reason. It happened because getting the biological imperatives right mattered. Presumably the cultures which didn't have these kinds of mechanism for keeping the gene pool stirred died out, or perhaps human instincts always settle on some kind of solution. But, one way or another, complex social arrangements around ensuring exogamy have always been the norm. Even in arranged marriage cultures like my own (about half of my cousins had arranged marriages) people would go hundreds of miles for a match in many cases.

A lot of time and effort went into these things. Dating wasn't just a case of whipping out an app, or heading down to the local bar district and hoping that common sense wasn't picking up the phone tonight. No, it was a case of long journeys and adaptation to a foreign culture and diplomatic relations with the neighboring tribes, and all the rest of it. These things involved serious effort.

But now the general model is to make everything as easy as possible: birth control and barrier contraception, no social pressure to make relationships lasting until quite late in life (or ever), and in some lucky countries social care systems so good that single parents don't have lives any harder than married parents all contribute to a general sense that sex and relationships are driven by convenience rather than being in some sense the centre of life. We have basically de-labored the process, and the results don't seem to be making people happy. I'm not comparing that level of happiness with some imaginary "good old days" — just noting that, on average, the entire thing is filled with angst.

So why do I think the blockchain can help?

The answer is twofold. Firstly, there is the agency problem. If you are on a dating site that gets paid when you see advertising as you search profiles, you are going to see a lot of profiles. They might withhold useful search features or pair you with a lot of people you won't like, but who aren't quite so obnoxious that you put the site down, and just feed you a smattering of great people to keep you interested. Or they might have seas of appealing bots whose job is to keep you

clicking, while delightful real people are just out of reach, tucked away in a corner of the database their algorithms just won't quite allow you to see. And then there's the actual performance of these systems — you'll find a lot more analysis about this in the whitepaper, but the results are quite discouraging. The bottom line is that these sites don't work directly for the best interests of their users — there's always a split motive, and this particular aspect of our lives is too important to let the agency problem interfere with our happiness. If there is to be machine help for people to find partners, the machines have to be working strictly on behalf of the people they are connecting, not hiding their algorithmic intentions behind complex veils made to sell advertising.

The second problem is more subtle.

Dating sites bake in all kinds of hidden assumptions. Take age: does it really matter, past the age of legal consent? Hard to know. For a very long time, asking people their age was considered impolite. Now, it's right up there, front and centre. Does that make for more or less successful relationships? How could we know? How could we watch? How could we measure?

Same thing for photographs. Of course looks matter, but are we selecting for nice looking people, or good photographers? Maybe dating people who are really good at selfies does genuinely result in better relationships — or maybe not! The bottom line is that we can't really tell, because all of this useful data is locked away inside of the matching engines of the data sites. OkCupid's blog series on what they'd learned from their data is absolutely fascinating, but it leaves me wanting more: much more! How could we design matching engines which genuinely produced human happiness? The answer would require data: both big, and open, and we would need to know something about the long term outcomes of various matches made, sometimes decades before. An algorithm which produces 5 brilliant years, then a string of massive ugly divorces might be suboptimal for reasons we can't possibly guess right now — and if that seems like an improbable outcome, let's remember that computers can recognize images better than people now. Maybe they can recognize compatibility too.

But for us to ever find out, we are going to require an open data ecosystem around computer dating. Blockchain is an integral part of that — it's what pays the bills to do the science and, in the case of Luna, it nicely and accurately solves one of the key problems in the computer dating arena: cut-and-paste messages spammed over huge numbers of people, resulting in an ever-lower number of good quality genuinely interested messages, hidden in an ever larger sea of dating spam. Just getting rid of that dynamic once and for all would be a great result, but I think that Luna offers far, far more.

By establishing the decentralized paradigm in dating, Luna helps to remake dating culture. Luna is not a service or a place, like Tinder or a bar. Luna is a method, and a method which can be continually improved using techniques like A/B testing, until it is genuinely producing better lives for people. Because blockchain techniques allow for sophisticated tools to be developed to align economic interests between (say) search algorithm designers and individual users, or between users and other users who don't like spam (i.e. everybody), the possibility exists to not only solve the questionable agency of the current generation of dating app providers, but to

create positive agency to do something really, really new.

We could pay the best people in the world to design algorithms to match other people, and make them happy.

Luna doesn't start with algorithm markets. Designing the necessary markets and mechanisms to genuinely reward people for doing the necessary science to get more optimal online matching is an uphill job, and the Luna team know that. So they're starting small: a token economy for dating.

What does this token do? It streamlines attention: messages sit in an inbox, and the messages that people paid most to send sit at the top of the inbox, with some modifiers which will be A/B tested along the way. That doesn't seem like a big deal, but it is. Once that flow of value is established — that these messages matter, that they are indeed precious cargo — economic incentive mechanisms can be designed to help people better target their search. Once the option of just spamming messages over half the site is gone, once you can't right swipe on everybody, the market exists for the design of algorithms which help you spend your time and energy talking to the people who are most likely to find you the person they wanted to meet.

We can't climb that hill towards genuinely better matching without an underlying tokenized economy to pay for the research, and we can't get better results without that research.

So, phase one, tokenize all the things, and use the simple brute force method of charging fees for communication to prune spam. To keep the system fair, the fees go to the person you're communicating with (minus a fee). Then, later, offer ways to take commission on introducing people using a variety of matching algorithms, ideally in a competitive array, and use that mechanism not just to prune the bad messages, but to actively steer and guide people towards each other based on criteria they might never consciously be able to articulate, but that sophisticated machine learning algorithms may able to sense. This is a big, bold, long term vision, but it's a good one.

If computers are good at anything, it is search. We aim to establish a market which sets up the right conditions to train them to do something important and something new: to train them to search for love.

1 Introduction

Luna is designed to mitigate the underlying inequality in the attention economy of online dating. It addresses the two main deficiencies that can be observed in existing dating websites and apps which cause low user satisfaction, namely the imbalance in messaging traffic and the misalignment of incentives and rewards. According to the MIT Technology Review, online dating is changing the nature of society. "People who meet online tend to be complete strangers... And when people meet in this way, it sets up social links that were previously nonexistent."[1] Luna employs blockchain to normalize the attention distribution which streamlines interactions between Luna users and helps to avoid users wasting their own and each other's time sending messages which will never be read, or reading messages which will never be replied to. This wasted effort and time can be reclaimed by incentivizing productive behaviors on behalf of both the senders and readers of dating messages.

2 Market Context and Problems

Since its inception in the 1990s the online dating industry has steadily grown, both in online sites and mobile apps. Today, online dating is the second most common way for heterosexual couples to meet; for homosexual couples, it is by far the most popular (Figure 1). In 2015, 50 million users of online dating sites and apps were registered in the US alone [2] and over 91 million worldwide [3]; the number of online dating users among young adults tripled from 2013 to 2016 [5]. The industry thus commands a considerable share of the online market: the top grossing app on iOS, Tinder, is valued at 3 billion dollars, with a paying user rate as high as 24% of its total of 50 million users [2, 6].

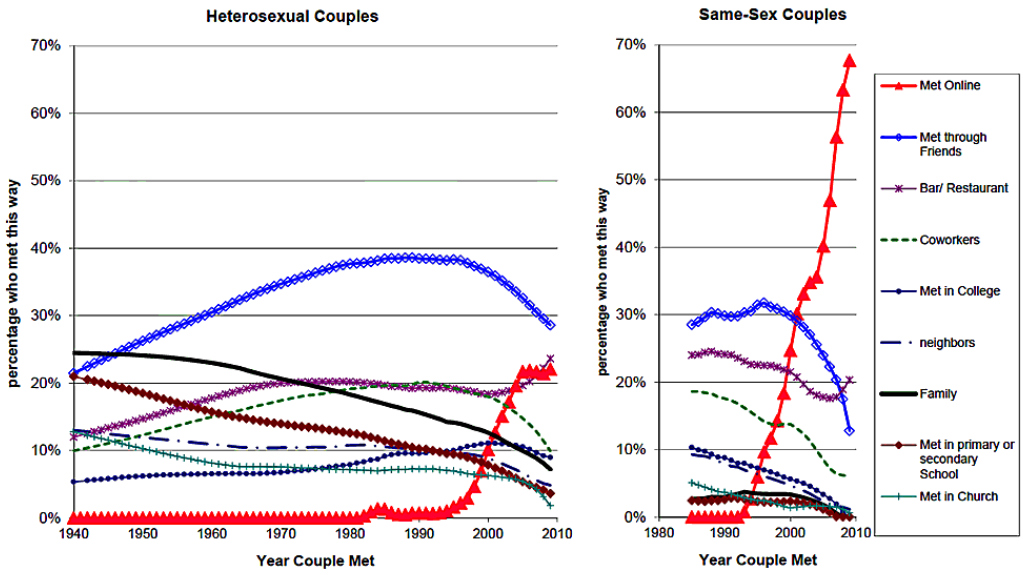

Figure 1: The way people meet their partners has changed dramatically in recent years [7].

Despite the scope and popularity of online dating platforms, most of the available services suffer from fundamental challenges that compromise user experience and deter would-be users. The primary challenge is that of message imbalances resulting from attention inequality between users of varying attractiveness. Many users thus have a negative experience of receiving either far too many messages (if they are considered to be at the top end of the attractiveness scale), or far too few (if they are perceived to be lower down the scale). On the online dating website OkCupid, some users at the higher end of the scale receive over 28 times as many messages as someone on the lower end of the spectrum [8]. In an experiment conducted by British data journalist Jon Millward, fictitious female users with profile pictures at the top end of the attractiveness scale received 120–230 messages per week, 17 times as many as fictitious male users, and also 17 times as many as fictitious female users at the lower end of the attractiveness scale [9]. On Tinder, a male user considered to be of only average attractiveness can expect to be swiped left (i.e. ignored) by over 99% of women [7].

Figure 2 illustrates this imbalance through Tinder's ranking of male and female "income inequality" (with "income" in this case correlating to the number of "likes") as compared to that of the world's leading nations — the higher the Gini coefficient, the higher the inequality.

Unsurprisingly, male users considerably outnumber female users on all common dating sites and apps. OkCupid has 1.5 male users registered for every female user on the site [11], and a recent study by GlobalWebIndex found that nearly two thirds of users on all location-based dating apps were male [12]. In addition there is a marked discrepancy in attention and perseverance between the genders, as a result of which female users are 2.5 times more likely to report dating site harassment than male users [13].

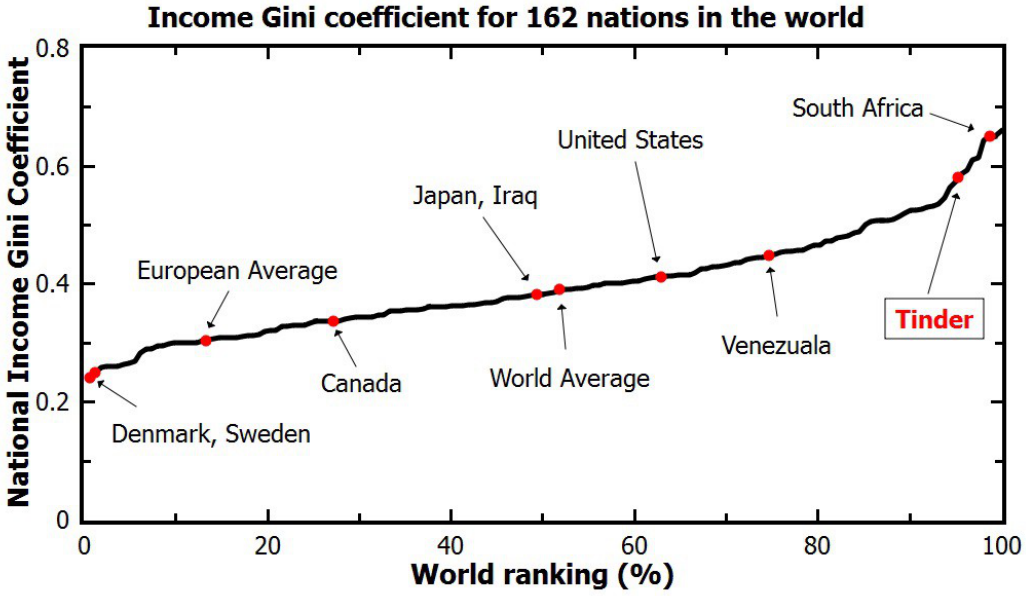

Figure 2: The Tinder economy has a higher Gini coefficient than 95.1% of the countries in the world [7].

The resulting problem creates a negative feedback loop — a small population of popular (mainly female) users, and a large population of unpopular (mainly male) users results in low response rates. These incentivize messaging strategies characterized by a proliferation of low-quality, low-investment messages sent to a high number of users in the hope of eliciting a response, which in turn exacerbates the messaging imbalance. In addition, these messages tend to be depersonalized, often cut-and-paste, and as a result alienate their recipients. A recent poll initiated by Luna on Twitter found that as many as 45% of users who had quit a dating app reported doing so due to this messaging imbalance [14].

The online dating industry has responded to this known issue with a number of different systems launched through sites such as Coffee Meets Bagel (2012) or Bumble (2014), though none of them with a perfect solution: presenting limited matches can be frustrating and encourages fake profiles [15], and requiring women to initiate contact limits dynamics preferred by passive women and active men [16]. Some platforms have sought a solution by providing spinoff apps available only to those who reach specific criteria, such as celebrity status, high income, or high intelligence, but these apps release only a little of the pressure, and have in addition the effect of designating the average user as subpar in comparison [17].

As a result, the demand for a better experience remains high among the vast majority of online dating site users. By correctly managing the imbalances of attention and interest between users, Luna can achieve a better experience for everyone.

3 Luna's Strategy

The online dating app Luna addresses these challenges by means of a system that acknowledges the attention inequality that informs user behavior specifically with regard to messaging: it makes use of economic theories and behaviors by introducing a system of incentives, and generates revenue in line with this system (§ 4.2). The token essentially acts as an invisible hand within an information-rich marketplace.

Luna's fuel is its QRC-20 token, the Star. Stars are the means for all in-app transactions between users. Luna endeavors to provide new users the ability to purchase tokens in several different ways, such as in-app credit card transactions with a licensed third-party API, on secondary exchanges, or by earning them through their interactions on and with the Luna app. Luna's reserve pool is used to provide liquidity and rewards to users, for example for verifying real-world encounters or providing compatibility feedback. A portion of funds raised may be used to ensure Stars are listed on exchanges.

Luna thus has the ability to encourage growth of the ecosystem. Tokens also provide greater user control: users do not require Luna's authorization to buy or sell, or withdraw tokens to an exchange. Furthermore, the token system allows for an exchange or secondary market to form, allowing users be compensated fairly for their efforts and attention by a price determined by the market, not by Luna. Luna anticipates a regular return of Stars through a small fee installed in the case of successful communication (§ 4.2), and intends to burn a percentage of these tokens in order to stabilize the value of tokens within the ecosystem [19].

Luna's users are able to limit the number of messages they receive per day, with

additional messages entering a queue. Stars allow for the initiation of conversations with users who have hit their limit by bumping messages up the queue to the recipient's inbox. These Stars then transfer to the message recipient's account. Users can thus earn Stars by reading, in a timely fashion, incoming conversation starter messages with attached Stars. This ability to earn tokens provides a strong incentive for new users to join Luna, and for existing users to remain active on the network.

The use of Stars also decreases the amount of competition users face when sending messages. Platforms such as OkCupid have no barrier to initiating contact, and the ensuing result is that of mass, low-quality messaging. Introducing a small barrier—a requirement to attach Stars—discourages mass messaging, so that popular users are far less overwhelmed by spam messages. The introduction of tokens as a liquid, platform-discrete asset thus succeeds in addressing the issue of inequality in the attention economy that fundamentally compromises the conventional online dating experience. Moreover, the base of popular, responsive users created will increase the value of the platform and aid in overcoming the network effect (§ 5.4).

§ 3.1 below provides a detailed description of Luna's messaging system and the use of Stars, as well as further details about user data acquisition and the function of the app beyond messaging.

3.1 Messaging

To clarify the system of using Stars, the following example involves two fictitious Luna users, "Alice" and "Bob."

3.1.1 Receiving

When Alice initially joins Luna, she can either earn some initial Stars by completing her user profile in detail (§ 3.2.2), or she might choose to buy Stars from an exchange. At sign-up she is prompted to select a daily inbox limit, and chooses to receive only three conversation starter messages per day. Alice will now receive a maximum of three first conversation starter messages from new contacts each day. If Alice receives fewer than three of these messages each day, her inbox functions like a basic inbox in that she immediately receives incoming messages. If more than three new contacts message Alice on any given day, the surplus messages are held in a queue, and each subsequent day Alice receives the first three messages in the queue. However, Alice may choose to "push through" additional messages from her queue at any time. She may select the number of messages she wishes to push, and receives the tokens attached to those messages.

3.1.2 Sending

Bob wants to send Alice a conversation starter message. If Alice has no queue in her inbox, Bob's message gets delivered to Alice instantly. However, if her daily inbox limit of three messages has already been reached and there are thus messages waiting in the queue, Bob's message would join the queue at the end and might not be delivered for a day or longer. At this point Bob is presented with the option to attach Stars to his message — the more Stars he attaches, the further the message

moves up in Alice's queue. If Luna has determined a high rate of compatibility between Alice and Bob, so that Alice is likely to reply to Bob's message, Bob receives a discounted rate, so needs to attach fewer Stars to push the message to the front of the queue than someone with a low compatibility rate.

In addition, when choosing to attach Stars to his message, Bob should receive information such as the number of unread messages in Alice's queue, an internally calculated reply quality indicator, and confirmation on whether Alice's account is verified.

3.1.3 Replying and Follow Up

If Alice opens Bob's message within 36 hours of receiving it in her inbox, the attached Stars are deposited into her account. Alice can use these Stars to bump her own messages to another user, or she can cash them out. She also has the option of donating them without friction to a partnered charity of her choice, for which she can earn a badge that will display on her profile.

Stars are only required to bump up initial conversation starter messages — if Alice chooses to respond to Bob's message, this message is free, and neither Alice nor Bob require any Stars to continue their conversation.

Figure 3 below illustrates how the system functions in the two possible situations explored above.

3.1.4 Mutual Messaging

There will be circumstances where one user wishes to message a user who has already messaged them. For example, Bob messages Alice, and his message waits in her queue. Alice browses through users and comes upon Bob. Luna lists an indication on his profile that he has a sent message currently in her queue. If she wishes to start a conversation, she may immediately receive his message. This happens regardless of whether Bob also has a queue for his inbox. We intend to design the platform in a way that obscures, to Alice, the number of tokens attached to Bob's message. This may be done by delaying the token deposits into Alice's account, so that all tokens earned during the delay are deposited in bulk.

3.2 Data Processing

Many of the most popular dating sites, including OkCupid, Tinder, and Coffee Meets Bagel, provide a limited search ability, and ask users to pay to unlock the ability to search by more specific criteria. This means that in the pursuit of profit these platforms are actively restricting their users' ability to find good matches. Even if a user should find a good match, their match might not be real — a study conducted by Sift Science on over 8 million user profiles on online dating platforms concluded that as many as 10% of all newly created dating profiles were fake [18].

Luna intends to provide a superior experience compared to industry standards, aided by the use of Stars to reward user engagement and encourage submission of better data. It is our novel data gathering approach that should enable us to train algorithms better than anyone in the industry: we are closing the feedback loop by tying back precise post-date satisfaction data to the search algorithms. This steers

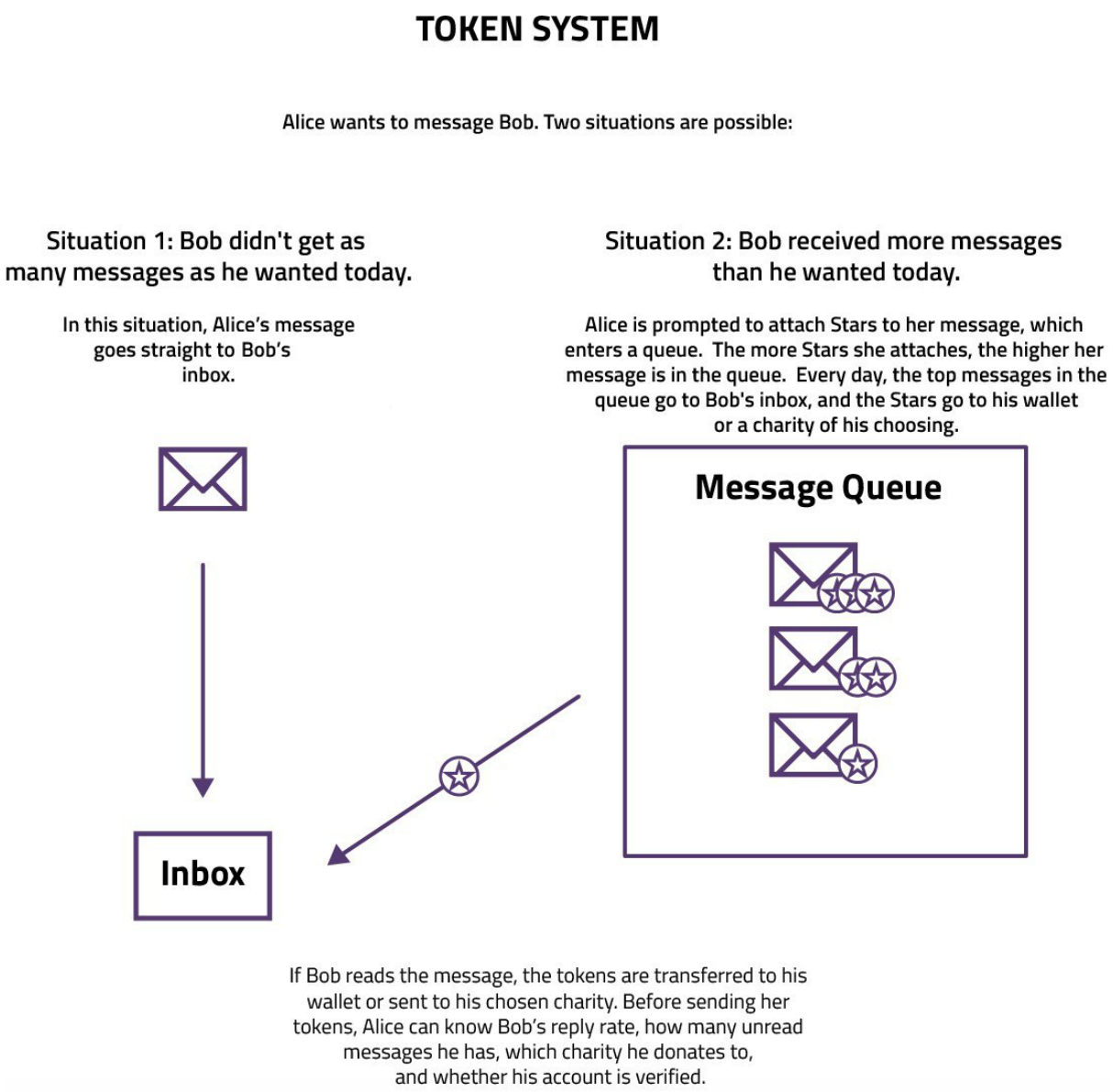

Figure 3: Luna's token system and messaging.

away from the 'pay to play' model and allows users to freely access all controls available at all times. In addition, a system of identity verification mechanisms for both online and in-person meetings avoids the problem of users creating fake accounts.

3.2.1 Sorting

When searching for new contacts, Luna users can set initial filters such as age, gender, interests, distance, and tags (§ 3.2.2), weighed by their relative importance (tf-idf). Profiles of other users are then presented as ranked by compatibility, and can be sorted by swiping them into "pass" or "message now" folders, which can be easily accessed later. A compatibility score is presented as a visible percentage rate on all presented profiles — the compatibility calculations are discussed in further detail in § 5 below.

3.2.2 Profiling

Upon signup, Luna requires users to supply some basic data including first name, gender, sexual orientation, location and phone number, and to provide a picture of themselves. In the alpha version, users may also provide additional information such as the nature of the desired relationship (casual, serious, etc.), a preference for monogamous or nonmonogamous relationship type, and education level. Users may be able to select tags to apply to their profile, which are keywords to aid in searching, such as "dancing" or "blockchain". Providing this information is optional; however, users can earn an initial fund of Stars by completing all details of their profile. We are enthused to explore digital footprint-based recommendations and psychometric profiling. Additional profiling features and mechanisms currently in development will be revealed upon launch. While users are free to search for matches globally, Luna will not allow user to set their location to a place where they are not.

3.2.3 Identity Verification and Moderation

Luna offers users several ways of verifying their identity to increase trust and help guard against scammers, bots, and catfishing. Through optional real ID verification, users may earn a verified ID status clearly visible through a badge on their profile. Users may also privately upload to Luna a unique photo or video demonstrating compliance to a small request such as holding up a number of fingers or reciting a number sequence, to be reviewed and approved within 24 hours. As an additional safeguard, SMS verification is used to ensure all are legitimate human users.

All users will have the ability to report any message or profile for harassing, abusive, or obscene content. The use of ID verification in connection with machine learning (§ 5.1) is expected to drastically reduce the number of rule violations; those that do occur will be handled by an outsourced moderation team, to be expanded as needed. Luna will take its guidelines from jurisdictional obscenity laws, and will not permit users under 18 years of age.

3.2.4 Meeting

In conjunction with Luna's user ID verification, the in-person meeting verification and compatibility feedback polls are intended to work to form a verified trust network of Luna users. We endeavor to provide a method of co-verifying in-person meetings with near-field communication (NFC) by simply opening the Luna app and touching phones together. Once verification has been made, users are later invited to respond to a brief compatibility feedback poll. Data collected from the compatibility feedback poll is used to train Luna's machine learning algorithms (§ 5.1). In addition, should a user feel uncomfortable about another user's intentions during an in-person meeting, they will be able to report so in the compatibility feedback survey. Any user who receives too many such reports will be banned from the network. Policies regarding banned users are subject to change, however at this time we intend to allow banned users to access their accounts and withdraw their collected tokens to an exchange.

3.3 Financial Model

3.3.1 User Goals

Users who engage in online dating pursue a variety of different goals. Dating platforms claim to help users achieve those goals, but if a platform's financial incentives are not fully aligned with user goals, the result can be manipulation of user behavior by the platform: actions taken to maximize revenue are often at odds with the interests of the user.

At Luna, we intend to structure the token economy in such a way that our system is rewarded when users achieve their goals, thus aligning our own incentives with those of our users and ensuring that all data, AI, and machine learning technology will be used to actually connect people.

Users of online dating apps look for one or more of the several possible end-results:

	Not meeting		*Meeting*	
	Short term	*Long term*	*Short term*	*Long term*
Sexual	Sexting	Love letters	Hook-up	Romantic relationship
Non-sexual	Chatting	Pen pals	Social	Friendship

On most dating apps, after creating a profile, a user must go through most or all of the following stages to achieve one of their goals:

I. Browsing profiles

II. Identifying appealing profiles

III. Indicating bilateral interest

IV. Exchanging messages

V. Arranging a date

Only after reaching stage IV or V has the user managed to actually achieve one or more of their goals. Successful bilateral messaging will satisfy users whose interests lie in the results listed in the left half of the table above ("non-meeting" results), and a successful date can achieve goals listed in the right side of the table ("meeting" results). Any satisfaction derived from any of the other stages generally exists only because of the potential for advancement to stages IV or V.

There are a number of ways in which online dating platforms monetize user engagement at the different stages listed above:

1. *Third party advertisements*
    a) Showing advertisements to users at Stage I is a common practice to incentivize the platform.
2. *Paid user membership*
    a) Many platforms such as Match.com or Zoosk require a paid membership for users to engage at any Stage.
    b) Others like OkCupid and Tinder offer premium services for paying users to unlock extra features.
3. *Paid features*
    a) Additional filtering available to premium users, such as on OkCupid Premium. This increases the likelihood of optimizing for Stage II.
    b) Access to the list of users who have already expressed interest, such as on OkCupid Premium. This increases likelihood of optimizing for Stage III by narrowing the search, though it also potentially introduces bias.
    c) OkCupid and Tinder also offer one-time 'boosts', which increase the paying user's visibility to other users for a period of time. This increases the likelihood of achieving Stage III at the cost of introducing bias to the matchmaking.
    d) Payment for messaging matches may specifically increase likelihood of reaching Stage IV.

In most cases companies accrue revenue at Stages I, II or III, while users do not achieve their goals until Stages IV or V.

3.3.2 Approach and Revenue

Luna intends to use a different approach to monetization by eliminating the use of advertisers as third parties on the platform, as well as by avoiding the use of subscriptions or direct paid platform features.

The approach consists of two parts:

1. *Fees which comprise Luna's revenue only occur in the case of successful communication.*

    As described in § 3.1, when a user receives and reads a message boosted with Stars, they also receive the Stars used to boost that message. Luna intends to take a small fee for this transaction, but only if the recipient responds to the

message within a window of a number of days yet to be determined. If the recipient does not respond, or only responds after more than this number of days, this fee will be re-paid to the sender. The number of Stars transferred to the recipient, however, will remain the same, whether they respond to the message or not. In this way Luna's financial incentives will be aligned with users' goals at Stage IV in the exchanging of messages.

2. *Possibility of tipping in case of successful offline dates.*

   Another way to provide incentive for Luna to help achieve its users' goals is to allow users to tip the platform after the achievement of Stage V in the completion of a successful date. As described in § 3.2.4, we intend to make feedback polls available after dates. Once users have rated their experience, Luna will then allow them to choose whether to leave a tip of their choice in the form of Stars. As this is a voluntary option, it should have no effect on user feedback.

   Tipping a platform is an infeasible idea in the context of currently existing dating apps; however, the free and direct-to-user benefits of Luna may register to users as something more resembling the mechanisms of Wikipedia: a free, friendly, and user-contributed service, rather than a platform like Match.com, which can feel exploitative. A tipping option may thus encourage a feeling of alliance with Luna in the user.

In this way, rather than recreating disparities which exist between the goals of current dating platforms and their users, Luna's financial incentives and user goals will coincide in the same stages of successful messaging (Stage IV) and successful dating (Stage V).

We anticipate, during the future development of the platform, the potential addition of other instruments and tools that continue to use these key principles to align user and platform incentives at the core.

4 Luna's Technology

Compatibility information used by Luna is based on user profile information, in-app messaging behavior, and offline post-date feedback. Luna may adopt a collaborative filtering algorithm developed by Dr. Kang Zhao. In addition, Luna may use advanced NLP techniques in conjunction with IBM Watson to integrate additional information from the contents of messages sent in-app, as well as from social media sources such as Twitter, if users choose to provide that information.

4.1 Machine Learning

Despite significant technological advances in information processing, storage, and retrieval, online dating has yet to optimally integrate machine learning for the user's benefit. A typical ML task for online dating might be to predict the level of compatibility between two users from a given set of input data, thus predicting for example whether one user is likely to respond to another user's message. Such a calculation would be based on both the recipient's own message history and that

of other similar users as well as both users' profile information (income, hobbies, and personality). Assessing the relative importance of these different features, and deciding how they need to be combined and weighed against each other to best predict the match is a task likely to be performed automatically by an ML algorithm. Predicting compatibility in this way is an ideal use for ML, as it is a task that cannot be reduced to simple rules, but depends on the interaction of many factors that can only be identified by extracting information from large amounts of data. Looking back at the fictitious users Alice and Bob from § 3.1 above, we see that Luna's ML algorithm can be expected to make a prediction about whether Alice is going to be interested in Bob, and whether Bob would respond to a message from Alice. Successful predictions of compatibility will enable even more accurate future recommendations, and will also play into providing a more effective pricing mechanism in the messaging system.

Recent developments of collaborative filtering algorithms extensions with external features, and Luna may implement Dr. Zhao's algorithm to extend the technique of collaborative filtering (the most common recommender system technique) to the setting of online dating. In practice this means accounting for two ways in which online dating differs significantly from more typical recommender system settings. The first is that preference must be reciprocal; in Luna, both users have to like each other. (Such is not true in, for example, the area of movie recommendations.) The second is that there are certain external features which are vital; the recommender system needs to make sure that users are recommended only those matches which satisfy the bidirectional compatibility constraints of gender and sexual orientation.

Building an ML model for Luna consists of a supervised machine learning task, since the model has to be trained based on which pairs of users have emerged as good or poor matches. The match between two users such as Alice and Bob can be measured in two ways:

1. *The degree of messaging activity, especially reciprocated activity, between the two users.* This includes information like whether Alice sent an initial message to Bob and whether Bob responded to Alice's message. Later, the measure of Alice and Bob's compatibility can be improved by factoring in data such as the length of their resulting conversation, sentiment analysis of the conversation, and indications of interactions outside Luna (e.g. through text messages, whether to chat or schedule a date).
2. *Feedback after a verified offline date.* Compared to online messaging activities, feedback provided via the Luna app can offer much more accurate information on the level of compatibility, so that the ML model can be reinforced and updated.

Taking the above factors into account, Luna may form a virtuous cycle between its token system and its ML model: the ML model helps to make the token system more efficient, determining the price of messages according to compatibility and the reward for providing post-date feedback; the token system in turn helps to contribute more and higher-quality data to further improve the ML model.

The ML model will assign a higher match score to a pair of users who are predicted to be compatible in their tastes, and thus enjoy dates with each other. Initially

a baseline match will be determined solely by the personal profiles provided by users at sign-up. The selection and weight of different personal attributes will be underpinned by social psychology (e.g. the fact that people tend to date someone with a similar socioeconomic status). As more data on user behavior becomes available, the model will learn from it and constantly improve its predictions.

4.1.1 ML Features

In general, two types of data (features) will be used to help the ML model learn what constitutes a good match and how good matches differ from a bad ones, and therefore how to predict matches with a high probability of success:

1. *Personal profile and preference data provided by users,* such as: income, education, body type, hobbies, the number and type of pictures provided, their preference for number of future children, and the text of their own personal description. If a user provides their social media handles, more data on their personality can be inferred based on their social media activity.
2. *The behavioral history of users on Luna,* including: liking others' profiles, sending messages to others, replying to others' messages, and a user's popularity based e.g. on number of messages received or the number of tokens users are willing to pay to send messages to them. An analysis of these behaviors can provide even better data than personal profiles can to deduce a user's taste in potential partners and the user's attractiveness to others.

With both user profiles and behavior data as the input, and the level of compatibility between two users as the output, the ML model will automatically learn the importance of these features and how to best combine them to predict compatibility. The learning process can be implemented through different ML methods and optimization processes. Different ML methods, firstly those developed by Dr. Zhao, will be tested and evaluated before implementation.

4.1.2 ML Model Validation

In the first phase of the app launch we will optimize for a composite satisfaction metric which takes into account the following components:

1. Prediction of the likelihood of a reply by a user to an initial message. In later versions the accuracy of this can be improved by weighting the answer with factors such as the length of the resulting conversation, or sentiment analysis applied to the conversation.
2. Prediction of the likelihood of positive offline feedback, i.e. feedback obtained through the app after a verified in-person meeting.

These measures ensure that users will have a higher compatibility rating with those users they themselves are likely to respond to, and with whom they are likely to enjoy in-person meetings and dates. It is important to us that every algorithm we deploy contributes to the success of our users on the platform. We are building an experimental framework for comparing the effect of various discovery and matching

algorithms, and will continue to assess their success strictly from a user success angle, taking into account the needs of various user personas.

It is our strong belief that the mechanism to establish the popularity of the app and the success of Luna is, ultimately, long-term user satisfaction — any user who ceases to use the app not because of frustration with the messaging imbalance, but on the contrary because they have managed to find another user with whom to form a successful relationship, will help to encourage additional users in search of the same result.

4.2 Centralization vs. Decentralization

Current trends hail blockchain as a panacea; however, centralization remains the right choice for specific applications. Additionally, due to the immutability of blockchain and the unknown nature of the future of cryptography and code-breaking, it is irresponsible to publish any personal data on a blockchain. Luna users will therefore have control of their own private keys.

Though private servers are a specific failure point for any leak or breach, there exist best practices to secure against attacks. In the blockchain world, privacy is an ever-active area of research, with many inconvenient limits. For instance, zero-knowledge proofs still rely on a trusted protocol wherein masterkeys are created and destroyed. However, once state-channels and lightning networks are known to be field-tested and invulnerable, Luna aims to implement these to further its decentralization ethos.

In summary, in the initial app launch, user transactions and compatibility feedback gathering should be decentralized, while the storage and processing of user-data will be centralised for security and optimization.

4.3 Scalability

It is well understood that current blockchain infrastructure is not scalable, in that there is a limit to the amount of total usage any blockchain can handle. As for all blockchain-based projects, scaling is a notable concern on Luna's long-term technical roadmap, as it may generate an existential risk. It needs to be noted that scalability is a key feature for consensus network platforms, and as such the progression already present within the field is promising. QTUM's design, which was built with scalability in mind, incorporates PoS consensus, higher TPS than e.g. Ethereum, Bitcoin-style UTXO, and lower transaction fees than comparable platforms. In addition to QTUM's own design, numerous projects dedicated to the task of scalability, from sidechains to completely new consensus ideas. Considering this mass effort, it is anticipated that a solution will likely be forthcoming in the near future.

However, in the case a scalable solution is not found to accommodate Luna's growth, a backup strategy has been put into place by building the Luna platform in a network-agnostic manner. Should Luna approach mass adoption without a QTUM-compatible scaling solution in sight, it will be possible to rapidly switch the blockchain integration layer to use a private network which does compromise online scalability. Plans to future-proof the Luna platform to the maximum possible

extent are in place. This will also prove useful in the case that Ethereum ceases to be viable for any other unforeseeable reason.

While Luna is currently built on QTUM, it is chain agnostic, and reserves the right to shift blockchains if the technology demands it. Should this be the case, users in possession of Star tokens will receive an equivalent number of Stars on the new chain.

4.4 Network Effect

In the Luna network, we expect a long tail degree distribution to occur, meaning that a relatively small number of users will attract most of the attention. Via our token mechanics these high-value users will be incentivized to spread the word and to become 'cheerleaders' of the Luna platform, which is a structural advantage in addressing the network effect. High-value users are key to generating a reputation for reliability and quality, and are significantly more effective in the spread of word-of-mouth awareness than lower-value users. As the only online dating app to date designed to selectively reward popular users, Luna anticipates little difficulty in attracting a large number of influential high-value users. In addition, Luna's growth strategy aims to leverage the most well-connected individuals and their direct influencers (in line with the Barabasi paradox).

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