Case based Reasoning as a Tool to Improve Microcredit

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Abstract: This paper will discuss the possibility to adopt the Case-Based Reasoning approach to improve microcredit initiatives. In particular, we will consider the Kiva microcredit system, which provides a characterisation (rating) of the risk associated to the field partner supporting the loan, but not of the specific borrower which would benefit from it. We will discuss how the combination of available historical data on loans and their outcomes (structured as a case base) and available knowledge on how to evaluate the risk associated to a loan request (exploited to actually rate past cases and therefore bootstrap the CBR system), can be used to provide the end-users with an indication of the risk rating associated to a loan request based on similar past situations. From this perspective, the case-base and the codified knowledge about how to evaluate risks associated to a loan represent two examples of knowledge IT artifacts.

1   INTRODUCTION

Microfinance and microcredit represent innovative and effective poverty alleviation instruments, recently conceived and implemented to support the creation of income-generating and sustainable activities in developing countries. Although these initiatives often require basic and relatively trivial interventions of digitization and automation of activities, the new scenario represents an interesting area of research for disciplines like economics but also for computer science. In particular, this paper discusses the possibility to adopt the Case-Based Reasoning approach (Aamodt and Plaza, 1994) to improve microcredit initiatives. More precisely, we will consider the Kiva microcredit system, which provides a characterisation (rating) of the risk associated to the field partner supporting the loan, but not of the specific borrower which would benefit from it. We will discuss how the combination of available historical data on loans and their outcomes (structured as a case base) and available knowledge on how to evaluate the risk associated to a loan request (exploited to actually rate past cases and therefore bootstrap the CBR system), can be used to provide the end-users with an indication of the risk rating associated to a loan request based on similar past situations. From this perspective, the case-base and the codified knowledge about how to evaluate

risks associated to a loan represent two examples of knowledge IT artifacts (Cabitza and Locoro, 2015); (Salazar et al., 2008). The paper breaks down as follows: the following sections will present a state of the art in microfinance and microcredit sectors, then Section 3 will introduce Kiva and its workflow, highlighting where and how the proposed system can be set. Section 4, finally, will describe the overall approach and the current state of development of the proposed system. Conclusions and future developments will end the paper.

2   MICROFINANCE

Microfinance is regarded as an innovative and effective poverty-alleviation tool to help the unbanked poor people, especially in developing countries, aiming to create income-generating activities (Milana and Ashta, 2012); (Hamada, 2010); (Amin, 2008). In developing countries, economic managers have been challenged by and continue to challenge issues like employment generation, poverty reduction and sustainable development that microfinance is dedicated to deliver. It still works as a critical approach against poverty and financial exclusion even facing some of its recent crises and the resulting criticism (Isa et al., 2011). Microfinance provides the underserved poor

access to financial services that help alleviate poverty through encouraging income-generating activities, empowering, and enhancing security which are the priority programs of World Bank proposed in a set of strategies for fighting against poverty in 2000 (*World Attacking Development*, 2000).

Since its beginning in the early 1970s, microfinance has remarkable performance with strong growth for which it has been positively acknowledged by the stakeholders from all corners of the world, and especially by the award in 2006 of the Nobel Peace Prize to Muhammad Yunus, the founder of microcredit modeled as Grameen Bank (Pompa et al., 2012). Traditionally, the need, small amount of loan without collateral, of the poor people is not served by the formal financial institutions. Also, such services are out of their reach due to the complicated application procedure, high interest rates, and long admission processing. Making the poor people access to financial services, especially microcredit, and sustaining the good repayment rate without collateral by designing an appropriate institutions are the significant contributions of microfinance. Some of the successful models of microcredit are Grameen Bank, BRAC, ASA in Bangladesh, SKS Microfinance Ltd. in India, Bank Rakyat Indonesia (BRI) in Indonesia. Current statistics of Grameen Bank (October 2014) show that it has 8.6 million borrowers, of which 97% are women for cumulative loan portfolio of $16.1 billion with outstanding balance for $1.1 billion and total deposit of $2.0 billion, of which 62% is borrower's deposit through 2,568 branches in 81,379 villages (2011), covering more than 97% of the total villages in Bangladesh employing 21,851 (2013) existing employees. Its repayment rate is 97.83%. Among over 3,500 Microfinance Institutions (MFIs) across the world, the latest data from the 1,252 financial services providers listed on MIX Market shows that, as of December 2012, they reached 91.4 million low income clients for an $81.5 billion portfolio. However, with 2.5 billion 'unbanked' people through greater financial inclusion -a new direction, the challenge of financial access remains.

Microfinance, in broader sense, is a provision of basic financial services accessible to poor people who are usually denied by traditional banking system. Such services are small loans, savings, insurance, and money transfer facilities (Wrenn, 2007); (Elahi and Rahman 2006). Self-help Group (SHG) and Joint Liability Group (Grameen model and its variants) are two common credit delivery models in microfinance (Nayak, 2010). Recently,

MFIs have been providing loans to individuals who need a larger size loan and who does not match with the other members in a group (Milana and Ashta, 2012); (Hamada, 2010). Such loans are provided especially for business and /or development purposes based on the personal creditworthiness and the capacity to produce any guarantee (like personal guarantor from friends/relatives, post-dated cheques, collateral security) of the microcredit borrower. In addition, MFIs also consider the borrower's technical skills in business and his/her reputation in peers and society. It is like conventional (quasi) lending but with flexible terms (Islam et al., 2012); (Nayak, 2010).

Microcredit in the early 1970s was the first revolution of microfinance targeted the unbanked rural people accessible to small loans without collateral. Such tiny amount of $100 loans was provided to the poor, especially women in the village who were denied by the traditional banking system. In this microcredit, the borrower's capacity and will to make regular savings and repay the loan with interest in a short time were the core issues to be successful. Non-profit based NGOs were the microcredit providers who argued that poverty is not a creation of any individual or social choices, but is the unwanted result of government or market failures depriving the poor of their rights to access financial services. The initial development was from the viewpoint of microcredit bank (supplier/lender's perspective) targeting reach out and searching for operational cases. Satisfactory repayment rate of microcredit program was very crucial to make it successful and sustainable. The important requirement of collateral was replaced by 'group formation' and 'mandatory savings' that worked as guarantee against default (Milana and Ashta, 2012). Eventually, such innovation became 'product-centered' services, rather than the required services centered on the real needs of the microcredit borrowers. Group lending with joint liability positively impacts on screening, monitoring, and state verification (Hermes and Lensink, 2007). It also helps reduce the problem of asymmetric information in borrower selection, loan monitoring, auditing, and enforcement (Ghatak and Guinnane, 1999); (Paal and Wiseman, 2011). Repayment in group lending is influenced by religious intensity (Al Azzam et al., 2012) as well as trust coming from social conformity and reciprocity (Attanasio et al., 2012). In addition to joint liability of the group lending model, there are some other good aspects like peer monitoring, auditing, and sequential lending which make this model elegant (Chowdhury,

2005). However, group lending works better than individual lending only if peer monitoring costs are lower than those of lender monitoring (Cason et al., 2012). Moreover, as individual members within the group grow at different rates and is penalized for default members, the one-size-fits-all standard loan will not work any longer, and individual lending will need to replace group lending (Besley and Coate, 1995). Such quasi conventional lending- individual lending with flexible terms are emerging in the direction of peer-to-peer online lending platform. In customer-centered finance, it has to start from financial services that customers really need. Such services like the provision of capital, credit, and insurance making a series of social intermediations create an organized social voice rendering demands to public institutions and policy makers, building self-confidence (Elahi and Rahman, 2006).

Capturing the whole movement of recent developments in microfinance is beyond the scope of this study, but our study tries to focus on the new direction of microfinance, web-based peer-to-peer microcredit (P2P microcredit model).

3 MICROCREDIT

One of the trends of today's microfinance operations is the adaptation and transformation of their business models from paper-based to digital or automation due to the continuous competitive pressure to balance between outreach and operational sustainability. Such trend is connecting the developed world to the developing countries in different dimensions making some parts of microfinance business easy and globally accessible in one hand, but throwing some challenges to the same market on the other hand. Peer-to-Peer (P2P) platforms are emerging with such challenges to them who are still employing paper-based workflows, but with the opportunities through web-based or the Internet models making this line of business more accessible and comfortable to all including individual lenders. Many P2P platforms have developed to spread the microcredit to individual lenders in the developed world aiming to link Western investors to the sector. Among the leading P2P platforms some of the most relevant are Kiva, MYC4, Zidisha, myELEN, Opportunity International, and the Microloan Foundation. Another web-based microlending model with unique features is United Prosperity that is non-profit platform uses its lending money to provide guarantee to local banks that provide microloans to

micro-entrepreneurs. Such guarantee from United Prosperity enables the banks greater leverage (usually loan amount is double of the guarantee) than traditional micro-credit. Also, this model unlike others facilitates the micro-credit borrowers to develop a relationship or a credit history with local banks by which the borrowers become independent in the long term. The prime advantages of these P2P models are lower operational costs, affordable interest burden to borrowers, easy access of Western individual lenders/investors who made the source of lending fund's portfolio well diversified, globally accessible platforms which are accessible by any poor borrowers specially from most of the developing countries. In 2009, US-based Zidisha became the first P2P microlending model to connect lenders and borrowers directly worldwide without local intermediaries. Based on wider coverage of both borrowers as well as lenders another US-based P2P model, Kiva has significant lending for more than $643 million from 1.2 million plus lenders in 84 different countries across the world. Although it is already mentioned about the benefits of such web-based models in microfinance activities, these P2P models have some problems like disclosure regarding borrower's or applicant's information, risk rating in borrower selection, methodologies for providing loans through local partners/ intermediaries and interest rate computation (use of flat rates), recovery of loans in case of default etc. Among them, the problem with the borrower/ loan applicant's information is critical to the web-based lenders to remain active in such platforms and to sustain them in the long term in the promotion of noble goal, reducing global poverty. Moreover, it is serious because no individual credit risk rating is provided directly or indirectly by the field partners or by such lending platforms resulting bearing the default risk lies absolutely with the lenders who ultimately refinance the field partners. To address this problem, we have chosen the leading model, Kiva to represent the borrower / loan applicant's profile in a scientific manner which is not only solve the problem of borrower's information in Kiva but also in other models that have the same problem in this sector.

4 Kiva AND ITS WORKFLOW

Kiva, founded in 2005, is a non-profit organization with the mission to connect people through lending to alleviate poverty. Its lending mechanism is different (Internet-based) from traditional lending

technology (group based brick-and-mortar model) and even from other web-based lending models in microfinance sector. It acts as an intermediary (online platform) to provide people with the opportunity to lend interest-free small amounts of money to underprivileged entrepreneurs via the Internet to microfinance organizations in the developing world. Kiva allows its users (lenders) to lend the money to borrowers (entrepreneurs) through its field partners (Microfinance Institutions-MFIs).
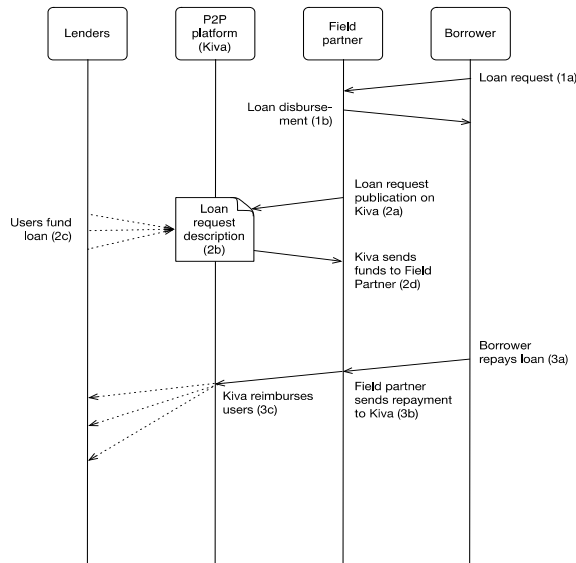

Figure 1: Overall Kiva workflow.

It follows, Figure 1, the following steps: (1a) the borrower meets with the Field Partner and requests a loan. The Field Partner, if certain criteria are met, disburses a loan to the borrower (1b). After loan disbursement, the Field Partner uploads the loan request to Kiva (2a), it's reviewed by a team of volunteer editors and translators and then published on Kiva.org (2b). Kiva lenders fund the loan request (2c), and Kiva sends the funds to the Field Partner (2d). The borrower, later on, makes repayments (3a) and the Field Partner sends funds owed to Kiva (3b). Kiva repays the principal amount to its lenders (3c). The lenders can make another loan, donate to Kiva, or withdraw the money to their PayPal account. Such loan can be made individually or in teams by the lenders (one to one, many to one, and many to many) (Choo et al., 2014).

As briefly discussed before, the users viewing loan request descriptions have an indication of the risk rating associated to the Field Partner, based on historical data of loans managed by that organization. However, no indication on the risk associated to the *specific* loan request is provided, as

shown in Figure 2. Selecting a borrower is a challenging task to online microcredit lenders as individual borrowers' profiles do not provide any risk rating on the site/platform except the microfinance intermediaries' aggregate risk indicators (depicted on the right bottom corner in Fig.2) based on the actual repayment of previous borrowers managed by the same field partner. This information can surely suggest good assessment and management capabilities of the field partner, but it is essentially unrelated to the current borrow request.
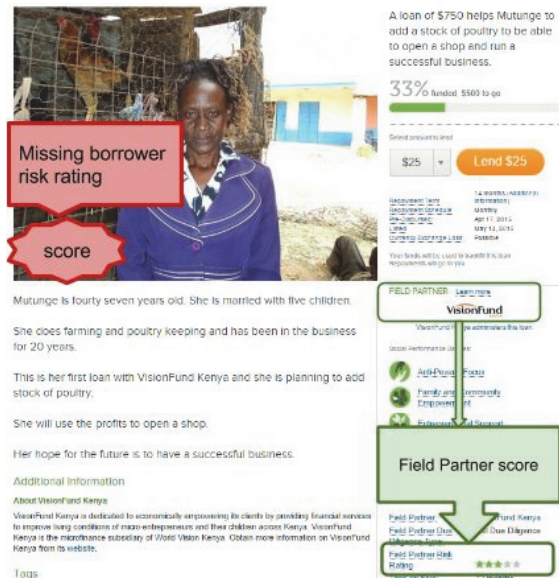

Figure 2: An example of Kiva loan request description.

Moreover, the sites merely keep typical advices for lenders/end users to diversify their portfolios through lending to more than one borrower via different field partners as well as in different countries and/or sectors. However, an indication of the borrower's risk, which is missing on the models (indicated in Fig.2), remains critical to the aggregate or individual lenders in the sites.

5 CBR FOR LOAN RISK RATING IN Kiva

The Case–Based Reasoning approach is based on the reasoning by analogy method (i.e. similar problems have similar solutions), summarized in the well known 4R's cycle by Aamodt and Plaza (1994) described in Figure 3: a description of the new problem is given, then it is compared to the description of similar problems already solved and

stored in the case base according to a similarity algorithm. The most similar problem description is then *retrieved* and its solution is *reused* as a first attempt to solve the new problem without starting from scratch. If the reused solution doesn't fit the problem a *revise* step can be applied to adapt it. Finally, the new problem description and its (possibly revised) solution are *retained* in the case base. Of course this approach requires the definition of (i) a case structure, comprising a *description* of the situation, an adopted *solution* and an *outcome*, and (ii) a proper similarity metric supporting the retrieval of cases that are relevant to the one at hand. This problem solving paradigm is suitable to deal with domains whose problem solving methods have not been fully understood and modelled, but in which experiential and episodic knowledge is instead present. In fact, within this paradigm it is not necessary to elicit and represent the knowledge required to *construct* a solution from the description of the current problem, but it is rather necessary to have an idea of how to *compare* two situations, two cases, and rate their degree of similarity.
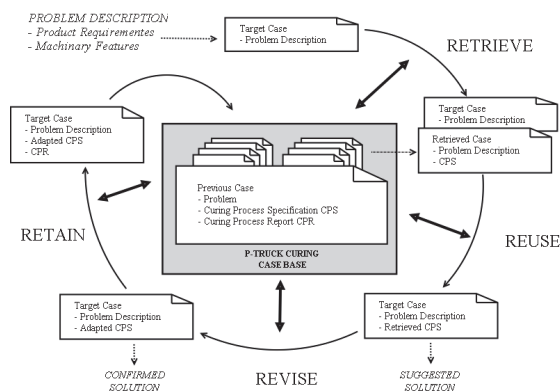

Figure 3: CBR Cycle.

Provided that the number of past cases is sufficiently covering the range of possibilities, it is plausible to think that the solution to a past situation sufficiently similar to the one at hand will be a useful support to the definition of a line of work for the current problem. Knowledge elicitation and representation phases in the definition, design and implementation of a CBR system are therefore focused on the definition of a proper structure for the case description (as suggested above, composed of a description, solution and outcome parts) and also of a proper similarity metric. The most knowledge intensive phase of the CBR cycle is about the *adaptation* of the past case solution to the present situation (Manzoni et al., 2007): it is not unusual that this phase is actually delegated to the human expert

(the so-called *null adaptation* approach) due to the lack of sufficient knowledge to systematically perform this kind of activity.

The main issue with the application of this approach to the present problem is certainly not the lack of data. In fact, Kiva makes available all the information associated to past loan requests and to the actual repayments made by the borrowers. All the information necessary to define a case description is available (for sake of space we just report an ER diagram of the defined schema in Figure 4: it contains information about the borrower, her location, the planned activity to be funded and the field partner), and also the final outcome is known. In particular, the information about the planned and actual repayments and their timing are present, where the comparison among the two types of records (planned and actual payment) provides useful indication on the fact that the borrower paid back in time (or even early), or he/she rather had problems in respecting the planned schedule. Of course no actual risk rating is present and therefore all cases would be missing the solution part. To solve this cold boot problem, we decided to adopt a strategy depicted in Figure 5: we chose to select a reasonable number of past loans that are sufficiently representative of all the countries, economical sectors for the funded activities, kind of borrowers, and actually rate them (filling thus the solution part of the case) employing expert rules for rating the risk associated to loan requests in developing countries, coded into a spreadsheet. This activity cannot, as of this moment, be completely automated due to the need to interpret elements of the borrower description written in natural language and not structured in fields of a database. Moreover, the above mentioned rules are not completely formalized and the experts sometimes actually manually modify the results of their direct application to define the risk rating. Expert rules are based on their opinion regarding objective assess-ment assessment of subjective judgement in order to arrive at the credit risk score for rating of borrower's risk. The obtained credit risk score will be required to be validated in holdout sample.

The knowledge elicitation activity carried out in order to define these rules was characterised by several interviews with experts in risk assessing in the microcredit context. These experts are actually proficient in the usage of spreadsheets and the interviewer was actually able to involve them in the creation of this support tool. From this perspective, this spreadsheet can be considered as a form of socially situated ITKA (Cabitza and Locoro, 2015),
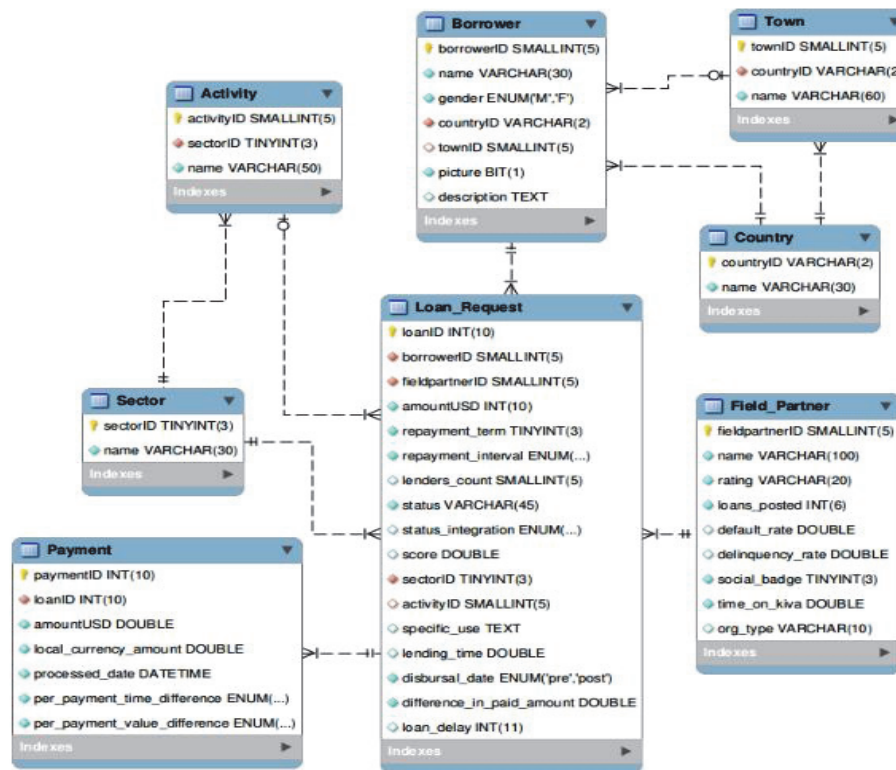
Figure 4: ER diagram of information related to a loan request as extracted by the Kiva XML data.

since it is aimed at providing a form of decision sup port but in the present form it is more an agile way to share and discuss rules and points of views on how to perform the risk-rating activities.

As a result of this activity, a proper case base is achieved and the actual CBR system can be used. The loan similarity metric was actually defined also exploiting the above mentioned rules for risk rating, that highlight what parts of a loan request description are most significant in determining the overall risk and that therefore are also more relevant for deciding about the similarity of cases. The similarity metric has been designed on the basis of profiling/characterizing attributes of borrower's success or failure in loan delinquency or not. This will be identified through the use of multiple discriminant analysis, which will allow to discriminate between success and failure or loan delinquency and not as far as possible minimizing the error of misspecification. Whereas the spreadsheet supporting manual risk-rating can be considered as a socially situated ITKA, the CBR system, in its final form, will instead be a typical example of representational ITKA (Cabitza and Locoro, 2015), since the knowledge structure, resulting from a careful information and knowledge modelling phase, will be mostly fixed, although the system will be provided with a form of incremental learning, inherited by the CBR approach. Although the system is characterised by a certain degree of flexibility, for instance in the weights and even the form of the similarity metric, changing the structure of the case would represent a problem for a potential inclusion of this system in Kiva's workflow. The experts involved in this study actually suggested that having the possibility to manage in a structured way information generally stored as text within the borrower description field would be actually useful for having a more refined similarity metric, but for the time being we decided to preserve the actual data structure adopted by Kiva's database and evaluate the achieved result before proposing such a problematic change.

Finally, it must be emphasized that the case base and even just the database of past loans actually represent objects of interest for researchers still involved in the study of microcredit but also in the perception of risk associated to loans. From this perspective, this does not represent an ITKA per se, but we are involved in research collaborations that might lead to the creation of a proper form of ITKA enclosing this database for collaborative research activities, in a socially situated ITKA perspective.
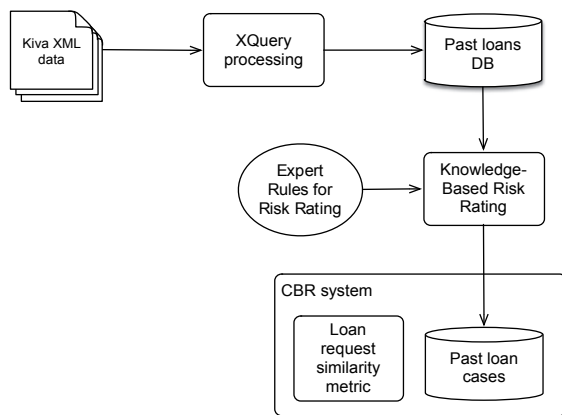
Figure 5: workflow for setting up the CBR system from initial Kiva data.

6 CONCLUSIONS

The paper has presented a CBR tool for improving microcredit system (Kiva), in particular for providing a loan request risk rating based on past loans that are most similar to the new one to be published on the microcredit web site. The system has been developed and a strategy to solve the cold boot problem has been devised and implemented: as of this moment, the case base is being populated to better cover the variety of the potential loan requests, and then we will proceed with a quantitative evaluation of the CBR system effectiveness.

This tool can be deployed to filed partners (1a in Fig.1) or alternatively to Kiva Systems (2b in Fig.1). The field partners can use this tool to assess/rate the new applicants (who will make loan requests to the field partners) and based on the rating they can also provide suggestions to the applicants for how to make their businesses more appealing, competitive for the loans and also, hopefully, more successful. In case of Kiva Systems, they can adopt/align this tool in their existing systems and thereby incorporate the rating in borrower's description space. Such kind of incorporation will definitely help the end users/lenders understand the risk category of the borrowers. As a result, the lenders will be able to diversify the lending risk of their lending portfolios.

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