Recommendation System for Assisting the Management of Information Technology

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***Abstract*—Management of the problems occurred in environments that make use of the Information Technology (IT), together with the need for the quick response from the support teams area, a challenge for today. With this, organizations require systems to manage these incidents, as a Service Desk to centralize these records. The objective of this work is to integrate a system of Mobile Service Desk to a recommendation system that stores past interactions and automatically suggests as a possible solution for new similar incidents in the managed environment. As a contribution of this work, an algorithm was compared for similarity analysis and it has been integrated to the tool that showed the best results.**

Keywords–Mobile Service Desk; Recommendation System; Similarity Analysis Algorithms

I. Introduction

The increasing dependence of organizations on the use of Information Technology (IT) is making the management of IT services within these environments an increasingly important activity [1]. In case of any problem in these managed local places (e.g., computer, printer, software, networks, or any device that causes abnormal functioning of IT services), the expectation is that the user has a quick response of the team support, so the damage can be minimized [2].

The concept of service to users of IT service, which was originally named Help Desk [3], was created; this way, the problems could be centralized and subsequently solved by technicians responsible for these tasks. However, today, this area has absorbed other services and proceeded to call up of Service Desk, in the case of an extended version of the Help Desk and offering a greater amount of services [4].

A challenge that reaches those responsible technicians for these management environments is that, in many organizations, there is a high turnover of human resources. In 2010, according to the Research Institute Gartner [5], the turnover of IT personnel around the world was only 3%. In 2011, it jumped to 5%. Thus, the departure of an employee is a loss of human capital and generates a replacement cost (i.e., recruitment, selection, hiring and training) which can be high. In addition, there is the difficulty of transferring knowledge and experience among employees of this area [6].

A possible alternative to the problem of turnover is the integration of a Service Desk tool to a recommendation system, where the technical solutions applied in previous situations are retained in the database system, and when a new calling with similar features occurs, they are presented as a possible solution to the incident.

This work is part of a project that aims to design and implement a Service Desk tool mobile, called Mobile Service Desk, which has features of context awareness (e.g., geographical position, expertise and time), and it equipes this tool with a recommendation system. Thus, the intellectual capital generated through the services performed by the support staff which is retained in the system and it is recommended as a possible solution for new similar callings. This paper outlines the design and validation of the recommendation system integrated into the tool.

The paper is structured as follows: Section 2 presents the related work in the field of Service Desk. Section 3 explains the concepts of Service Desk, recommendation systems and pre-processing text. Section 4 discusses the proposal for the relationship between calls, which serves as a basis for recommendation system. Section 5 presents the methodology employed in the development of this work. Section 6 treats the implementation of the recommendation system integrated into the Service Desk. Section 7 presents the results obtained with the work. Finally, Section 8 contains final considerations of this paper and future work.

II. Bibliographical Revision

This section is a literature review of the terms related to this research and also serves as a basis for the development of this work, such as Service Desk systems, pre-processing techniques and algorithms analysis of similarity, that provides support to the system that recommends similar calls.

A. *Service Desk Systems*

With the increasing business demand and globalization, more and more organizations need to ensure the quality of services performed to obtain better chances on the market. Thus, the goal of a Service Desk is to provide IT users with a Single Point of Contact (SPOC), vital to the realization of effective communication between users and teams that manage IT in an organization [7].

Its primary mission is to restore the normal operation of services of the users the fastest as possible, minimizing the business impact caused by IT failures [8]. In addition to it, the customer service keeps users informed about progress in solving incidents, changes and related events [4].

Operation of a Service Desk system occurs through the opening of calls or tickets. From this point on, whenever there is an open call, it is managed to be serviced. Moreover, these systems can also be based on some practical methodology for maintaining IT services, for example, the Information Technology Infrastructure Library (ITIL) [9].

B. Recommender Systems

A recommendation system combines computational techniques to select custom items based on users' interests and as the context in which they live. According to Adomavicius and Tuzhilin [10], this issue has become an important area of research from the early work on collaborative filtering emerged in the 90s. According to the authors, the interest in this area remains high, because it has a large number of research problems and also for the abundance of applications that help users deal with information overload and provide recommendations, customized content and services to them.

Based on how the recommendations are made, these systems are generally classified as follows: (i) content-based, which seeks to recommend items similar to those that have been an interest to the user, (ii) collaborative filtering, which operates identifying users with similar preferences to present and recommend items that were of interest of that similar user, and (iii) hybrid-approach, resulting from the combination of collaborative and content-based methods [11].

The method based on content (i) calculates the utility of an item s for user c, based on the utility of "similar" items to the same user c. The calculation of similarity between items is performed through the use of a set of attributes that characterize each item [10]. To enable this type of recommendation it is necessary to find associations between these items [12].

The goal of collaborative filtering (ii) is to recommend new items or predict the utility of an item for a given user, based on the data from the similar users to it. Thus, the user will receive recommendations for items that people with similar preferences to it, preferred in the past. This method is divided into two categories: the first is called memory-based, and the second is called model-based. The calculation of the value of an item *s* in relation to a user *c* is made from the utility of the same item for other users *c*, similar to the user *c* [10].

The hybrid method (iii) is defined as a method that combines both strategies based on content recommendation, as for the collaboration-based strategies [11]. The advantage of an approach that unifies the others is to significantly increase the chances of getting correct answers on their recommendations and to eliminate the limitation of both approaches.

C. Pre-Processing Text

Text mining techniques, which can also be found in the literature as text data mining or knowledge discovery of textual data bases, in general, refer to the process of discovering knowledge in unstructured text documents. This technique can be seen as an extension of data mining or knowledge discovery in a structured databases [13].

In a Service Desk system, text mining techniques can be applied in the description of open calls by the user, in order to perform a pre-processing of texts to later analyze the similarity between them and identify similar cases of past interactions stored in database. This can be accomplished by using some text mining techniques, for example, by removing stopwords, and stemming algorithms for the similarity analysis.

A set of strings that compose a document consists of a few words (tokens) that have no semantic value, being useful only for the text that can be understood in general. In a system of data mining, such as words that are considered stopwords and belong to a stoplist. With a well organized stoplist is possible to eliminate up to 50% of the total words in a text [14].

An example can be seen through the phrase "I have problem in my printer."; by applying the technique of removing stopwords results in "Printer problem" resulting in around 66% of the words that compose the phrase being removed.

Stemming aims to reduce each word until its radical is obtained by removing suffixes that indicate variation in form of the word as plural, verb tense, adverbs, gender and accentuation. According to Krovetz [15], the use of stemming improved in 35% the recovery of information in some datasets.

Radicalization is a process that involves different algorithms according to the language in question, as there are differences in how words are formed, so that the application of a specific technique can produce mixed results according to the language of the texts [16].

According to Viera and Virgil [16], the approach that is best known for the Portuguese language is that of Orengo and Huyck [17]. There is also the algorithm of Porter [18], for the Portuguese, following the same rules developed by the same author for the English language.

1) Orengo Algorithm: The algorithm Orengo and Huyck is developed specifically for the Portuguese [17]. This algorithm consists of a series of eight steps, performed in accordance with a predefined order by the algorithm, such as the longest suffix that must be removed first. This algorithm was developed based on the most common suffixes found in Portuguese [19].

The Orengo algorithm presents eight steps that are as follows: (i) reduction in the plural, that removes the end *s* indicative of plural words that do not constitute exceptions to the rule, making modifications as necessary; (ii) reduction of the female, that removes the final *a* of female words based on the most common suffixes; (iii) reduction adverbial, that removes the final *minded* of words that do not constitute exception; (iv) reduction in grade, removes most common indicators of augmentative and diminutive; (v) nominal reduction, which are removed 61 suffixes for nouns and adjectives; (vi) verbal reduction, which reduces the number of verbal forms to their radicals; (vii) removing vowels, where it is removed the vowels a, e, o, of the words which were not addressed by the previous two steps; (viii) removal of accents, which are removed the diacritical signs of the words.

2) Porter Algorithm: Porter's algorithm, originally proposed for English, is based on the idea that the suffixes in

English are mainly composed of a combination of smaller and simpler suffixes [18]. The algorithm consists of a series of five steps, in which some rules are applied to remove suffixes in each step. If a suffix combines with the word, the suffix is removed if the rules that were defined for that step are applicable [19].

In consonance with Viera and Virgil (2007), Porter's algorithm adapted to the Portuguese language is also based on rules. Five steps are performed by him: removal of suffixes; removal of verb suffixes, if that first step is not carried out there isn't any changes; removing the suffix (i) if it is preceded by (c); removal of residual suffixes *os, a, i, o, á, í, ó*; removal of suffixes (and), (is) and treatment of cedilla; after all, the nasalized vowels should be return to its original shape [16].

D. Similarity Algorithms between Strings

In literature, there are several techniques for calculating the similarity between strings, such as the inverted index model, Levenshtein Distance algorithm, natural language processing, algorithms of Boyer-Moore, Karp-Rabin, Jaro-Winkler, among other techniques that can be seen in [13][14][17][20]. In the next sections, some of these algorithms are presented.

III. Relations Between Tickets: Proposal

One of the features of Service Desk proposed in this paper is that it presents solutions of past problems for the new incidents that the support will have to answer, in order to find a way to solve this new incident by applying a method already used in another similar call.

Thus, the technical support team can have at your fingertips a possible solution to the problems that need to answer. For this to be done, when a user opens a call in Service Desk system, the system should automatically relate it with other previous records in the system that have already been solved.

In this work, five stages that compose the pre-processing text are applied, as proposed by Avila [21], which serve as an initial step for further analysis of similarity between strings.

The first is the removal of invalid characters, such as quotation marks, brackets, parenthesis, among others, that need to be removed. After this, the replacement of accented character is performed, which is substituted by the respective non-accented character. The third step is the exclusion of repeated words, to avoid unnecessary comparison of a duplicate word several times. Also, a lowercase is applied, to prevent words with the same meaning that start with uppercase characters, will be differentiated from a similar word starting with lowercase characters.

The fourth step is the removal of stopwords, to prevent words like articles, adverbs, pronouns, prepositions, among others that have no semantic value, being only useful for text that can be understood, in general; Finally, stemming algorithm from Orengo and Huyck [17] is applied; this was chosen because it has been developed specially for the Portuguese language, to reduce morphological variants of the words, as singular forms, plural, verb conjugations, for its root or radical, by removing suffixes and prefixes.

After the execution of the steps for pre-processing in the opening text of the call, there will remain a set of strings that will be analyzed with previous case in order to determine the similarity between calls. For this, the *similar_text()* algorithm was used; the justification of using this algorithm is detailed in Section VI, which presents the comparative analysis of the algorithms for similarity between strings.

With the determination of similarity between calls, the system recommends possible solutions to a new incident. Thus, at the time the technician will accomplish its service, the system must have the knowledge of solved cases where the opening text of the call has similarity to the current incident. This paper proposes a method for content-based recommendation system, where the contents and characteristics of the calls are analyzed in order to determine what level of similarity they have and then recommend cases already solved to a similar that has not been answered.

Figure 1 shows in flow chart form the operation of the recommendation system of solutions proposed in this work.

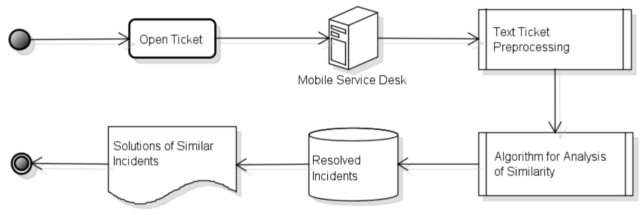

Open Ticket
Mobile Service Desk
Text Ticket Preprocessing
Algorithm for Analysis of Similarity
Resolved Incidents
Solutions of Similar Incidents

Figure 1. Operation of Recommendation Solution System

Then, the techniques of preprocessing text, as addressed in Section 4, are applied. These techniques analyze the similarity of the resulting text with cases already solved in order to obtain a possible solution to the incident and submit it to the technician at the time that it is to serve you.

Figure 2 shows the operation flow of the proposed system. From the opening of a call by the user, the system automatically links this with previous calls; with it, it is possible to suggest the support team possible solutions related to the call opened. To connect the calls, the use of text preprocessing algorithms and similarity analysis have been proposed.

User opens a call in the systemafter and the system searches if there are similar calls. If there is any information relating to that call, it will be displayed by the system. Otherwise, it transforms this new information in context to the system and writes the solution of the problem to be used in the future.

IV. Methodology

The recommendation concerns the use of mobile devices and systems research in order to propose a system for Service Desk were stimulated by the observation of the behavior of the User Service Center (USC) of a federal university. During the observation period (i.e., between October and December 2012), an informal interview each month, with some technical supervisors and the USC was performed.

Through interviews, some questions were raised, such as: (i) operation of the current system of USC as the opening of a call; (ii) the existence of some kind of prioritization and classification of calls; (iii) the existence of a division of the technicians as to their knowledge; (iv) how is the distribution

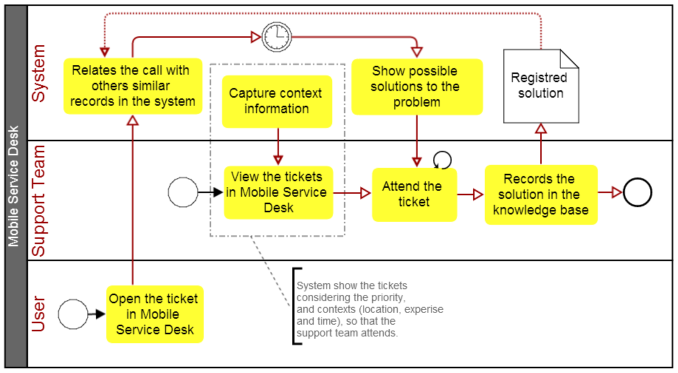

Mobile Service Desk
System
Support Team
User
Relates the call with others similar records in the system
Capture context information
Show possible solutions to the problem
Registred solution
View the tickets in Mobile Service Desk
Attend the ticket
Records the solution in the knowledge base
Open the ticket in Mobile Service Desk
System show the tickets considering the priority, and contexts (location, experise and time), so that the support team attends.

Figure 2. Operation of Mobile Service Desk

of the distance calls that the technicians need go to solve; (v) whether the solutions of the incidents are stored; (vi) number of technicians who work.

Besides these questions, along with USC, a dataset containing real calls of the system was fetched, in order to use them to compare the algorithms for similarity analysis. The dateset is useful to evaluate the time it takes to process a comparison of similarity with other records and evaluate the quality of the results obtained by each algorithm. There were more than thirty-five thousand records of calls imported into the system, which comprise the calls opened during the period between March 13, 2009 and November 20, 2012.

Four algorithms that calculate the similarity were compared: (i) Jaro-Winkler Algorithm [22], (ii) Levenshtein Distance Algorithm [23], (iii) String Similarity Algorithm, which is a class used to calculate the similarity between two text strings, created from the "diff" algorithm, that compares the difference between files under GNU (GNU Operating System) [24], and (iv) The *similar_text()* function, that is native from PHP for calculating the similarity [25].

For system modeling the Unified Modeling Language (UML) was used, which allows to represent application objects through a standardized graphical notation and diagrams. For creating UML diagrams, the software Astah Community [26] version 6.6 was used, which is a free UML modeling tool.

The database was modeled with the support of DBDesigner software, in version 4, which is a free program that integrates creation and graphical modeling of data [27]. The database used for data persistence was MySQL [28], and the tool used to access and maintain the database was HeidiSQL [29], which is also free.

The module recommendation of the Mobile Service Desk solution has been implemented in NetBeans, a free software, which is an Integrated Development Environment (IDE), and can be used with different programming languages, such as Java, PHP, HTML, JavaScript, C/C++, etc. [30].

To validate the proposal, a free programming language that has features such as ease of handling strings and Web programming was sought. Beyond the initial requirements, the PHP Hypertext Preprocessor (PHP) was also chosen for having the following characteristics: (i) server-side language, which performs multi-functions, (ii) compatible with MySQL, (iii) cross-platform, (iv) functions available for use, and (v) documentation.

To work on many mobile devices, the system has a unified user interface, i.e., an unique implementation for all mobile devices and operating systems. Thus, to provide this unified interface, the jQuery Mobile framework was used, which it is based on HyperText Markup Language 5 (HTML 5), and has libraries as the jQuery and jQuery UI, and has as characteristic to be optimized for touch interactions [31].

Finally, the Mobile Service Desk was installed on a server with the operating system Ubuntu, version 12:04, Long Term Support (LTS), using 32-bit architecture. In this, MySQL 5.5 database and Apache 2.2 web server, with support for PHP 5.3 programming language, were installed and configured.

V. Mobile Service Desk Integrated at the Recommendation System

Faced with the high use of mobile devices, such as smartphones and tablet, it was decided to study ways to use these technologies to apply in IT management. The idea of using the location information of the technician is to speed up the service of the tickets which is already expressed in the work of Lobo [2], who also considered that not only the location was important, but also the definition of a mechanism that utilizes the experience and practice of technicians to decrease the occurrence of a second service.

In this work, these practices were maintained and improved in order to consider not only the latitude and longitude of the technical but also their altitude at the time of setting a priority of service. Since the cases where the building is composed of several floors may occur. Thus, the question of the altitude is an essential factor to set the distance from one point to another.

Furthermore, other problems found in these IT environments, such as the issue of staff turnover, led to the study of the techniques for storing the solutions and later on the treatment of these data, so for those new team members can get suggestions for possible solutions to similar problems that have already been resolved. In order to have suggestions of similar solutions could be aggregated to the tool, the study of techniques in the area of recommender systems was necessary.

The Mobile Service desk is a system that has specific functional features, such as run on a variety of mobile devices, treat context sensitivity, and keep a history of the solutions of the problems so that later this solution may be suggested to some other similar ticket through of a system of recommendation.

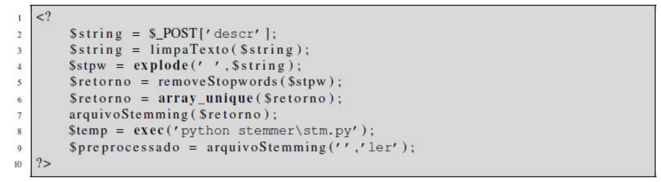
To perform the service of tickets, from the moment when a “Support” level user accesses the system, the open tickets are listed. At the moment in which informs that will start attending to the incident, the system will list the solutions of similar cases to the current problem, so that a solution can be reused. Even at the time the technician will attend some ticket, theses cases are related to the current treatment are presented. For this, the relationship of tickets was implanted, as addressed in Sections V-A and V-B.

The implementation of the relationship of tickets, to be further suggested as a possible solution of a problem to be treated, is divided into two stages: (i) pre-processing text; (ii) similarity analysis.

A. *Pre-Processing Text*

In this step, to each opening text of ticket, the following actions are applied: (i) removal of invalid characters, (ii) application of lowercase, (iii) removing stop words, (iv) exclusion of repeated words, and (v) application of stemming algorithm.

In the second line of Figure 3, the variable call "string" receives off a POST method, the value of the text to be processed; in "limpaTexto()" function the text is passed to lower case and accents and other punctuation characters, dashes, quotation marks, brackets, among others are removed. The fourth line is responsible for mounting an array with all the words that compose the text.



```
1  <?
2      $string = $_POST['descr'];
3      $string = limpaTexto($string);
4      $stpw = explode(' ',$string);
5      $retorno = removeStopwords($stpw);
6      $retorno = array_unique($retorno);
7      arquivoStemming($retorno);
8      $temp = exec('python stemmer\stm.py');
9      $preprocessado = arquivoStemming('','ler');
10 ?>
```

Figure 3. Algorithm Code of Pre-Processing Text

The “removeStopwords()” function in line 5 is responsible for the removal of the stopwords of the text, in turn, the “array_unique()” function has the task of removing the terms duplicated. In the line 7, the “arquivoStemming()” function generates the text file with the key words of the text, so that in line 8 to run the Python script, which applies the technique of stemming in Portuguese on the file previously generated. This, the result at 9, is stored in the "preprocessado" (pre-processed in English) variable.

Other information to be highlighted about the pre-processing text step is regarding to the stemming; Ptstemmer script [32] was used because it possesses both the algorithms presented in [17] and [18], implemented for the Portuguese language. In this work, we opted to use the Orengo and Huyck [17] algorithm, because its rules were specifically created for the Portuguese language; in turn, the Porter algorithm is an adaptation of another language to Portuguese. In case the opening of ticket is performed in another different language than the Portuguese, a specific stemming technique for the language should be applied to the system.

B. *Similarity Analysis*

To verify the similarity between the text of the ticket to be attended to and the texts stored in the system relating to, the comparing strings and returns the percentage of similarity between them was applied. This algorithm was chosen due to its superior performance in relation to the other algorithms tested. The complete comparison between the similarity algorithms is presented in the Section VI.

VI. RESULTS

In this section, the validation of the suggestion system integrated at the Mobile Service Desk with the test plan and results obtained through the evaluation of the analysis of similarity algorithms is described.

The tests of the similarity analysis algorithms were performed using real data captured from the database of User Service Center (USC) containing the tickets opened between January and November 2012, in a total of 7033 tickets. To test the running time of the algorithms as well as the quality of the results were opened several tickets in the system; however, some of them will not be shown in this paper; the others can be seen in Table I.

TABLE I. TEXTS TO TEST THE SIMILARITY ANALYSIS ALGORITHMS

Nº	Texto do Chamado
1	Meu computador está extremamente lento. Desconfio que seja algum vírus
2	Ocorre erro de spooler na impressão!!!

After pre-processing of texts opening tickets was obtained the results presented in Table II. This resulting text was used to compare the similarity between them and the USC tickets imported to the system.

TABLE II. RESULT OF PREPROCESSING TEXT (IN PORTUGUESE)

Nº	Preprocessed Text
1	comput extrem lent desconfi viru
2	ocorr err spool impressa

The results referring to the five cases with highest similarity obtained when running the test related to the first open ticket in the system "Meu computador está extremamente lento. Desconfio que seja algum vírus" ("My computer is extremely slow. There must be a virus" in English) are shown in Tables III, IV, V and VI.

In these tables, the first column shows the opening text for the ticket similar to how it was in the database of the USC (i.e., without spelling corrections or abbreviations), the second column is the percentage of similarity between these records and the case that has been verified.

Analyzing the data from the first test of similarity algorithms, it is possible to conclude that the five records with greater similarity captured by Jaro-Winkler algorithm are somewhat related to the problem of "computador lento" ("slow computer" in English). In the Levenshtein distance algorithm, two of the results are unrelated to the problem, since one it is just a slowness in browser and another is without network access. In the String Similarity, the result "Computador e retro-projetor desconfigurado" ("Deconfigured Computer and multimedia projector" in English) is unrelated to the problem. Finally, in *similar_text()* the top five results are related to the problem.

This way, it is possible to conclude that, in the first test, the Levenshtein distance and String Similarity algorithms do not return a good result, by seeing how these similar cases that were unrelated to the problem.

The second test was carried out by way of the so-called "Ocorre erro de spooler na impressão!!!", ("There are error of spooler at the printing!!!" in English); after the execution of the similarity algorithms, the results achieved are shown in Tables VII, VIII, IX and X.

Analyzing the data from the second test of the similarity algorithms, it is possible to conclude that the Jaro-Winkler algorithm does not obtain good results, given that the first

TABLE III. TEST OF TICKET 1 FOR JARO-WINKLER ALGORITHM

Text of Ticket	Preprocessed Text	Similarity
Computador extremamente lento e, eventualmente travando.	comput extrem lent event trav	89,75 %
Computador necessita ser formatado, pois está com excesso de vírus.	comput necessit format excess viru	88,83 %
Computador não liga normalmente, infectado por virus.	comput lig norm infect viru	88,28 %
Computador extremamente lento e trancando. Veio um técnico mas parece que ficou pior.	comput extrem lent tranc vei tecn fic pi	87,94 %
Computador lento e configurar a impressora	comput lent configur impress	87,25 %

TABLE IV. TEST OF TICKET 1 FOR LEVENSHTEIN DISTANCE ALGORITHM

Text of Ticket	Preprocessed Text	Similarity
O computador está muito lento, e alguns arquivos da área de trabalho sumiram. Desconfiamos que esteja com vírus.	comput lent arqu are trabalh sum desconfi estej viru	79,17 %
Computador extremamente lento e trancando. Veio um técnico mas parece que ficou pior.	comput extrem lent tranc vei tecn fic pi	78,41 %
Computador extremamente lento para entrar na internet. As vezes tem que ser reiniciado e mesmo assim não consegue entrar na internet. Demora para abrir os e-mails e não consegue enviar a resposta do e-mail.	comput extrem lent entr internet vez reinici assim conse dem abr email envi respost email	76,71 %
Computador não está entrando na internet e nem no SIE. Está sem rede. Após configurar impressora em rede.	comput entr internet sie red configur impress	73,65 %
Computador extremamente lento e, eventualmente travando.	comput extrem lent event trav	71,25 %

TABLE V. TEST OF TICKET 1 FOR STRING SIMILARITY ALGORITHM

Text of Ticket	Preprocessed Text	Similarity
Computador extremamente lento e, eventualmente travando.	comput extrem lent event trav	77,96 %
Computador lento e escaner.	comput lent escan	72,34 %
Computador extremamente lento e trancando. Veio um técnico mas parece que ficou pior.	comput extrem lent tranc vei tecn fic pi	71,42 %
Computador e retro-projetor desconfigurado	comput retroproje desconfigur	71,18 %
Computadores com sistema muito lento	comput sistem lent	66,66 %

TABLE VI. TEST OF TICKET 1 FOR *SIMILAR_TEXT()* ALGORITHM

Text of Ticket	Preprocessed Text	Similarity
Computador extremamente lento e, eventualmente travando.	comput extrem lent event trav	74,19 %
Computador extremamente lento e trancando. Veio um técnico mas parece que ficou pior.	comput extrem lent tranc vei tecn fic pi	71,23 %
computador lento, possível vírus	comput lent possi viru	68 %
Computador muito lento...deve ter virus....	comput lentodev viru	67,92 %

TABLE VII. TEST OF TICKET 2 FOR JARO-WINKLER ALGORITHM

Text of Ticket	Preprocessed Text	Similarity
Ocorreu um problema na galeria da página do centro de Educação, solicito pessoal especializado em Páginas. OBR. Aguardo.	ocorr problem gal pag centr educaca solicit especi pag obr aguard	75,45 %
Esta ocorrendo enceramento dos programas, tanto do oficce quanto de páginas de internet. Em algumas vezes aparece a mensagem de memória insuficiente ou que ocorreu falha no sistema e em outras vezes os programas são simplesmente finalizados.	ocorr encer programas tant oficc pag internet vez aparec mens memor insufici ocorr falh sistem simples final	73,85 %
Não ocorre a inicialização. A fonte está funcionando normalmente.	ocorr inicializaca font funcion norm	73,15 %
Está ocorrendo um erro na inicialização do computador. Já ocorreu a visita do técnico do CPD o qual informou que está ocorrendo um erro em virtude da própria atualização do computador e que provavelmente terá que ser formatado.	ocorr err inicializaca comput ocorr visit tecn cpd inform virtud atualizaca prova format	72,81 %
Não consigo imprimir, erro na impressão.	consig imprim err impressa	72,65 %

four records more similar that he found have no relation with the problem. Levenshtein distance, String Similarity and *similar_text()* algorithms, all the results has to do with printing problems, moreover bring a result related to the spooler problem.

To measure the execution time of each algorithm, the timestamp server was detected at the start of processing and, at the end, this value it was subtracted from the current

TABLE VIII. TEST OF TICKET 2 FOR LEVENSHTEIN DISTANCE ALGORITHM

Text of Ticket	Preprocessed Text	Similarity
Impressora configurada e não responde às solicitações de impressão.	impress configur respond solicitaco impressa	75,47 %
Computador formatado ontem precisa ser colocado em rede. Inatalar impressora.	comput format ont precis coloc red inatal impress	74,06 %
Reinstalar e configurar na rede serpro uma impressora matricial Epson fx 2180 .Obs. para impressão de relatórios contínuos.	reinstal configur red serpr impress matric epson fx ob impressa relato continu	73,33 %
Instalar serviço de spooler, impressoras desativadas	instal serv spool impress desativ	72 %
Peço para retirar de uma sala e instalar em outra um computador e colocar em rede o mesmo com a impressora.	pec retir sal instal comput coloc red impress	70,99 %

TABLE IX. TEST OF TICKET 2 FOR ALGORITHM STRING SIMILARITY

Text of Ticket	Preprocessed Text	Similarity
Instalar serviço de spooler, impressoras desativadas	instal serv spool impress desativ	57,14 %
Não consigo imprimir, erro na impressão.	consig imprim err impressa	57,14 %
Solucionar problema com impressora	soluc problem impress	54,90 %
Solucionar problema com impressora	soluc problem impress	54,90 %
Demora p/ impressão.	dem p impressa	54,54 %

TABLE X. TEST OF TICKET 2 FOR ALGORITHM *SIMILAR_TEXT()*

Text of Ticket	Preprocessed Text	Similarity
Não consigo imprimir, erro na impressão.	consig imprim err impressa	62,74 %
Instalar serviço de spooler, impressoras desativadas	instal serv spool impress desativ	62,06 %
porblemas de impressão.	porblemas impressa	60,46 %
Não dá a ordem para impressão	ord impressa	59,45 %
Reinstalar impressora..	reinstal impress	58,53 %

timestamp. This way, the runtime in microseconds that was converted to the right measure in seconds was obtained and presented in the form of average between all the tests.

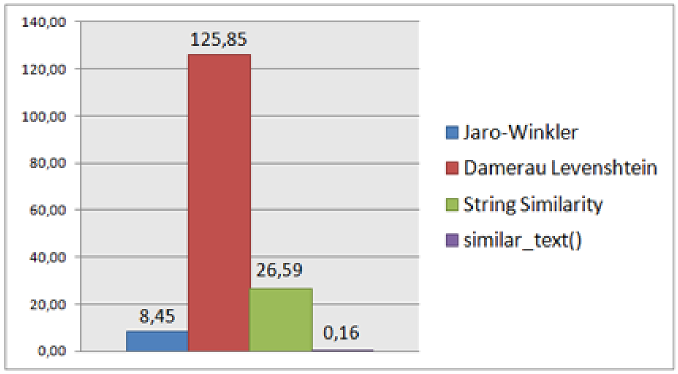


Figure 4. Performance Analysis of Algorithms Similarity (in seconds)

Comparing each of the opening texts of tickets with each record in the database system, the similarity analysis algorithms had very different performances. The lowest average time to perform all the calculations, as the graph shown in Figure 4, it was obtained by the similar_text() function algorithm with an average of 0.16 seconds. The Levenshtein Distance algorithm shown the worst performance, taking an average of 125.85 seconds to accomplish the task. In turn, Jaro-Winkler (8.45 seconds) and String Similarity (26.59 seconds) algorithms had intermediate performance.

VII. Conclusion and Future Work

The function of a Service Desk is to perform the process of incident management, dealing with all incidents of an organization linked to the IT area, such as software and hardware failures, communication networks or any device that causes the abnormal functioning of the IT services. The main objective of incident management is to restore the operation of the service as quickly as possible.

In addition, the Service Desk provides for IT users an IT SPOC, vital for an effective communication between users and teams that manage IT in an organization [7]. This helps managers, since it is not necessary to visualize numerous tools to access information concerning incidents of IT environment.

The results obtained by this research indicate that the similarity analysis algorithms and pre-processing text can be part of an integrated Service Desk to recommendation system solutions which, as seen in the Section VI, in the majority of cases return results referring to the problem in question. With these similar problems, it is possible that the solution adopted in the previous one should be reused by a technician in the new problem that needs to be solved; this way, by means of indications of the possible solutions, the system of recommendation may speed up to solve the incident.

Thus, the main contributions of this study are: (i) modeling of a recommendation system aggregate to the Service Desk tool; (ii) validation of the proposed solution by testing using several similarity analysis algorithms and using the algorithm with the best performance in the recommendation system.

In the light of the results, it can be considered that the use of recommendation for possible solutions might help the technicians of the teams of assistance, especially for those that joined the team recently. It is further considered that these improvements also help to reduce the determining and resolution cost of incidents, which for Song [33] represent more than half of the operating IT costs.

REFERENCES

[1] I. L. Magalhaes and W. B. Pinheiro, IT Service Management in Practice: An approach based on ITIL. São Paulo: Novatec, 2007.

[2] J. Lobo, “Expertise location and context influencing the management of it,” Master’s thesis, Universidade Federal de Santa Maria (UFSM), 2011.

[3] G. Cavalari and H. Costa, “Modeling and development of a help desk system for the municipality of lavras,” RESI - Revista Eletrônica de Sistemas de Informação, vol. 4, no. 2, 2005, pp. 1–18.

[4] M. Jantti and J. Kalliokoski, “Identifying knowledge management challenges in a service desk: A case study,” in Proceedings of the 2010 Second International Conference on Information, Process, and Knowledge Management, ser. EKNOW ’10. Washington, DC, USA: IEEE Computer Society, pp. 100–105.

[5] GARTNER, “Cio alert: U.s. it staff turnover trends and analyses,” [Online]. Available from: http://envisat.esa.int/, retrieved: May, 2014.

[6] D. Wang, T. Li, S. Zhu, and Y. Gong, “ihelp: An intelligent online helpdesk system,” Systems, Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions on, vol. 41, no. 1, Feb. 2011, pp. 173 –182.

[7] OCG, Office of Government Commerce, ITIL Service Transition. UK: The Stationary Office, 2007.

[8] R. Cohen, Help Desk and Service Desk Management. NOVATEC, 2011.

[9] ITIL, “Information technology infrastructure library,” [Online]. Available from: http://www.itil.org/, retrieved: Jun., 2014.

[10] G. Adomavicius and A. Tuzhilin, “Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions,” IEEE Trans. on Knowl. and Data Eng., vol. 17, no. 6, Jun 2005, pp. 734–749.

[11] M. Balabanović and Y. Shoham, “Fab: content-based, collaborative recommendation,” Commun. ACM, vol. 40, no. 3, Mar 1997, pp. 66–72.

[12] E. B. Reategui and S. C. Cazella, “Recommendation systems,” XXV Congresso da Sociedade Brasileira da Computação - V ENIA, vol. 17, 2005, pp. 306–348.

[13] C. Aranha and E. Passos, “Technology of text mining,” RESI - Revista Eletrônica de Sistemas de Informação, 2006, pp. p.v. 2, p. 2.

[14] J. R. Junior, “Developing a methodology,” Master’s thesis, PUC-Rio, 2007.

[15] R. Krovetz, “Viewing morphology as an inference process,” in Proceedings of the 16th annual international ACM SIGIR conference on Research and development in information retrieval, ser. SIGIR ’93. New York, NY, USA: ACM, 1993, pp. 191–202.

[16] A. F. G. Viera and J. Virgil, “A review of algorithms radicalization in portuguese,” [Online]. Available from: http://InformationR.net/ir/12-3/paper315.html, retrieved: Jun., 2014.

[17] V. Orengo and C. Huyck, “A stemming algorithm for the portuguese language,” in String Processing and Information Retrieval, 2001. SPIRE 2001. Proceedings. Eighth International Symposium on, Nov 2001, pp. 186 – 193.

[18] M. F. Porter, Readings in information retrieval. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., 1997, ch. "An algorithm for suffix stripping", pp. 313–316.

[19] M. V. B. Soares, R. Prati, and C. Monard, “Wci 02 improvements on the porter’s stemming algorithm for portuguese,” Latin America Transactions, IEEE (Revista IEEE America Latina), vol. 7, no. 4, Aug 2009, pp. 472 –477.

[20] M. Bendersky and B. Croft, “Finding text reuse on the web,” in Proceedings of the Second ACM International Conference on Web Search and Data Mining, ser. WSDM ’09. New York, NY, USA: ACM, 2009, pp. 262–271.

[21] R. de Avila and J. Soares, “The design of the correction of essay questions based on the adaptation of algorithms comparison and text search techniques combined with pre-word processing tool,” RENOTE - Revista Novas Tecnologias, vol. 10, no. 3, Dez 2012.

[22] W. E. Winkler, “String comparator metrics and enhanced decision rules in the fellegi-sunter model of record linkage,” in Proceedings of the Section on Survey Research, 1990, pp. 354–359.

[23] V. I. Levenshtein, “Binary coors capable or ‘correcting deletions, insertions, and reversals,” in Soviet Physics-Doklady, vol. 10, no. 8, 1966.

[24] GNU, “Binary files and forcing text comparisons,” [Online]. Available from: http://www.gnu.org/software/diffutils/manual/html_node/Binary.html, retrieved: Jun., 2014.

[25] PHP, “Php similar_text manual,” [Online]. Available from: http://php.net/manual/pt_BR/function.similar-text.php, retrieved: Jul., 2014.

[26] Astah, “Astah community,” [Online]. Available from: http://www.astah.net/, retrieved: Jul., 2014.

[27] DbDesigner, “Dbdesigner,” [Online]. Available from: http://fabforce.net/dbdesigner4/, retrieved: Jul., 2014.

[28] MySQL, “Mysql,” [Online]. Available from: http://www.mysql.com/, retrieved: Jun., 2014.

[29] HeidiSQL, “Heidisql,” [Online]. Available from: http://www.heidisql.com/, retrieved: Jul., 2014.

[30] NetBeans, “Netbeans,” [Online]. Available from: http://netbeans.org/, retrieved: Jul., 2014.

[31] M. S. Silva, jQuery Mobile - Develop web applications for mobile devices with HTML5, CSS3, AJAX, jQuery and jQuery UI. Novatec, 2011.

[32] PTStemmer, “Ptstemmer - a stemming toolkit for the portuguese language,” [Online]. Available from: http://code.google.com/p/ptstemmer/, retrieved: May, 2014.

[33] Y. Song, A. Sailer, and H. Shaikh, “Problem classification method to enhance the itil incident and problem,” in Integrated Network Management, 2009. IM ’09. IFIP/IEEE International Symposium on, Jun 2009, pp. 295 –298.