Web-Based Monitoring and Evaluation

Research Activity Assessment Case Study

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Abstract— **The work is devoted to issues of monitoring and evaluation system development. It is suggested to use the web as the source of data for monitoring. The assessment of web-based indicators for monitoring is realized with the help of Rasch model. The application of suggested approach is illustrated by the case study of universities research activity assessment.**

Keywords- monitoring and evaluation; web mining; research activity; information system; Rasch model

I. INTRODUCTION

Nowadays any enterprise's functioning requires some control and audit activities. They provide management with information about success or failure of the development strategy. This can be achieved by continuous monitoring and evaluation (M&E) of enterprise's work.

This work is devoted to monitoring issues of research quality in higher education establishments (HEE). Generally the scope of our interest covers the usage of information technologies (IT) for quality management in HEE.

As everyone knows, HEE has many directions of its functioning. This includes the basic ones (educational process and scientific researches) and a number of supporting and organizational processes. In this work we consider research activities as those which define the place of HEE in the world scientific society. The results of researches are expressed in different ways. Scientists highlight the benefits of their results and experience participating in the conferences and workshops and publishing papers.

Nowadays to manage conferences and publications scientists often use web resources, since they make all up-to-minute information available for everybody. Therefore we suppose that HEE research activity can be estimated based on data located on the web.

The goal of our research is development of web-based monitoring IT. Such IT system must support the search of appropriate data on the web and its processing. Not only the HEE research activity is represented on the Internet, but the enterprises highlight their outcomes on the web as well. Therefore we suppose that the suggested approach may be useful not only for monitoring of HEE's academic and research activities, but also for enterprise functioning M&E.

The rest of the paper is organized in the following way. Section 2 describes the stages of M&E, methods of data collection and processing. Section 3 represents the reference model of web-based M&E. The case study of the suggested approach is given in section 4. The conclusions and future work directions are presented in section 5.

II. ISSUES OF MONITORING AND EVALUATION SYSTEM DEVELOPMENT

There are two basic types of M&E: implementation-focused and results-based [1]. In the given work we consider the second one. Results-based M&E is a powerful tool that management can use to measure outcomes and feed the obtained information back into the process of decision-making. We can distinguish the following common steps: readiness assessment, agreeing on goals and outcomes, selecting key indicators to monitor, determining baseline data on indicators, planning for improvement, monitoring and evaluation themselves, reporting and using findings. During readiness assessment we explore which existing resources can be used for establishing M&E system. The next step supposes that long-term goals, corresponding outcomes and short-term targets have to be defined. Key indicators must be monitorable, clear, relevant, economic and adequate. To determine baseline data collection methods are chosen and the current situation is evaluated. Planning for improvement provides us with target performance which is the baseline plus desired level of improvement. Monitoring means continuous collection of data on defined indicators. The gathered data must be reliable and valid. Evaluation provides data that explain managers why the goal has or has not been achieved.

Traditionally such data collection methods as official records review, interviews, observations and surveys are applied for M&E [2]. Most of the mentioned methods intend some kind of communication with enterprise's employees. To organize interviews and surveys the questionnaires must be prepared and some trained people must conduct them. Often special experts and organizations profiled on sociological researches are involved in this process. To support review of official records analyst's facilities become necessary. In all cases this requires human resources, time, and financial expenses.

Monitoring activities provide a large amount of data that are usually processed with the help of statistical methods. Different types of statistical analysis allow defining central moments and parameters of distribution laws for collected data.

This includes factor, correlation, variance, discriminant analyses [3].

There are some problems in organization of M&E system. Often the outcomes of some enterprise's policy are reflected in some implicit data that can't be observed directly. To analyze such data special techniques have to be applied. Methods of data collection have some constraints, therefore they should be improved. Generally M&E requires automation, for this purpose M&E information system (IS) must be elaborated.

III. Web-Based Monitoring and Evaluation Reference Model

The traditional sources of data for M&E include the administrative data, results of interviews, direct observations and surveys. Generally all data sources can be classified into external and internal for the targeted system, primary and secondary, quantitative and qualitative, discrete and continuous, structured and unstructured. In this work we suggest to use the Internet as the external source of heterogeneous data which continuously change (are included, updated or removed from the web) and are stored in a structured or unstructured form depending on the particular web page. First of all it can be noticed that traditional sources are already presented on the web. The results of surveys, some administrative data are published on special web sites. And on the other hand the Internet stores huge amount of information that implicitly reflects the outcomes of enterprise's work. So the outcomes are evinced on the web in different forms. The implicit data stored on the Internet can be used to construct the indicators of outcomes. To gather such data web mining techniques are applied. Web content mining implies extraction of useful data, information and knowledge from web page contents.

We suggest the following reference model of the web-based monitoring and evaluation (fig. 1).

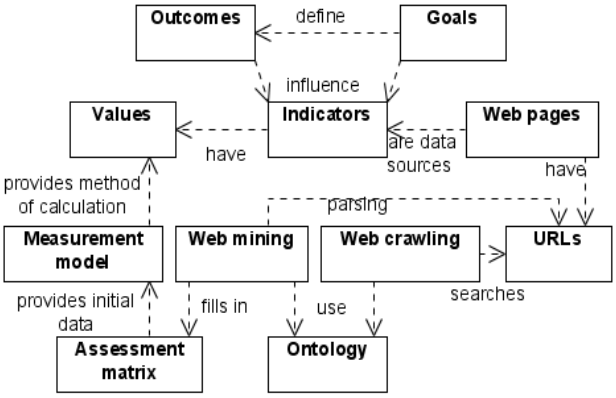

Figure 1. Reference model of web-based M&E

Based on goals and outcomes of system functioning the indicators of its progress are defined. Since we are talking about web-based M&E, the sources of data are web pages. The result of web crawling is the collection of all URLs where necessary information may be located. To extract that information web mining is used. It provides methods and algorithms for searching particular words and phrases on the web pages. The ontology defines the direction of search. The results of web mining techniques application are assessment matrices which reflect the presence of definite terms on particular web pages. The values of indicators are calculated based on the obtained assessment matrices and measurement model.

To find the web pages web crawling is applied. When the seed is processed, it takes one web page from the frontier and the process is repeated recursively (fig. 2). The order in which a web crawler visits pages from the frontier is defined by the crawling algorithm. In our work we use the breadth-first algorithm [4]. The next step is indexing of stored content. The result of indexing is term-by-document matrix.

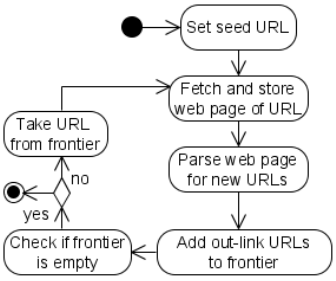

Figure 2. Web crawling activity

When the relevant pages are determined, we can extract the necessary data from them to fill in the indicators with values. The indicators' values form the initial data for evaluation.

We suggest the following framework for estimation of indicators. We assume that the indicators are latent and can't be observed explicitly. Ontology can be helpful when there is a need to define a common vocabulary of terms in investigated domain. We suppose that the probability of appearance of terms on web pages is connected with indicator's value. Therefore to estimate indicators we suggest to use Rasch model [5].

In the beginning we need to form the assessment matrix $N \times M$ with elements $x_{ij} = \{0,1\}$, where $i \in \overline{1,N}$ is the term from the ontology and $j \in \overline{1,M}$ is the targeted web page. x_{ij} is equal to 1, if the i-th term is present on j-th web page, otherwise it equals 0. The indicator's value is defined from the following dependency:

$$P(x_{ij}=1 \mid \theta_i, \beta_j) = \frac{\exp(\theta_i - \beta_j)}{1+\exp(\theta_i - \beta_j)},$$

where $P(x_{ij})$ is probability of presence of i-th term at j-th web page; θ_i is a value of i-th indicator associated with i-th term; β_j is difficulty of j-th web page.

Both parameters of Rasch model are measured in logits [5]. Initial estimates are calculated by PROX algorithm for Rasch model parameters estimation [6]. The final estimates are obtained by adjusting initial ones with the help of maximum likelihood estimation procedure. The reliability of obtained estimates is confirmed by KR20 reliability coefficient [6].

IV. CASE STUDY

In the given work we consider monitoring and evaluation in HEE. In different HEEs M&E are organized in different ways. The accounting activities are common to any university. HEEs collect data about its students and their progress in studies, about the staff and their results of work and much more data on financial operations. For today all modern universities have IS that support administrative data collection, analysis and either centralized or distributed storage [7]. Such IS may totally cover all activities in HEE or support the work of particular departments and offices.

Another kind of M&E is HEEs ratings. Many non-governmental and non-profit organizations make ratings of the universities worldwide [8]. Such ratings consider all aspects of HEE's work. The following criteria are often used to evaluate HEE: teaching and research quality, level of graduates employment, resources and infrastructure quality, international cooperation and knowledge transfer, etc. The problem is to estimate these criteria. Since they have different nature, different methods are applied for this purpose. For example, calculation of citation indexes (which is statistical processing of data from bibliographic databases like Scopus) requires the high quality of input data, including its availability, timeliness and reliability. Employers community surveys concerning HEE reputation and students surveys about their satisfaction also use statistical data processing and in this case the main problems are the sample volume, uncertainty measurement and reliability estimation. Some criteria are estimated via expert methods which obvious disadvantages are experts' subjectivity, competency level and efficient organization of the work of experts' group in the case of collective methods. When the values of all criteria are known the final step is to obtain the comprehensive university's score – a single number which defines its place in the rating. The most common method is to use weighted means. The problem here is to define weight coefficients. And again usually experts methods are used which disadvantages were mentioned above.

Public organizations and universities by themselves often conduct different polls and questionnaire surveys for students and staff [9]. The obtained estimates are used by HEE management to improve the program, policy and strategy.

In this work we consider the web as the source of data for M&E in HEE. The data that characterize the outcomes of HEE work are presented in the ratings, news, blogs, job offer and CVs web sites, corporative web sites, social networks and so on.

We pay attention to research activity monitoring in HEE. We consider the part of research activities connected with conferences carrying out. In this case the indicators of high research quality may be the following: the number of persons from particular HEE who participate in the conference, who are present in the organization committees and technical program committees, the number of conferences in which HEE members take part, the level of those conferences according to the ratings. These indicators can be considered dynamically from year to year.

As an example we consider the assessment of indicator called Level of Activity in Conferences Organization (LACO). Usually each conference on its web site has some web pages devoted to organization, technical program, workshops, tutorial and other committees. There are the lists of persons who are the chairs and the members of the committee. As a rule the person's name is followed by the affiliation and the country. So we can find out names of HEEs which take an active part in conferences organization.

To extract data about conference's committee's members we implement the web crawler which has to perform in the following way. The seed web page is the page with the list of conferences. With the help of querying we define the presence of web pages where we can find conference name, words "program committee", "technical program committee", "organization committee" and the name of HEE. If such page exists, we can make a conclusion that the HEE takes part in conference organization.

In the given work we take top 50 universities in computer sciences according to world rating [10]. The list of conferences includes top 25 conferences in computer sciences according to rating [11]. We form the assessment matrix in which x_{ij} is equal to 1, if the name of i-th HEE is mentioned at least once in any committee of j-th conference, and 0 – otherwise. The frequency histogram of HEEs scores is represented on fig. 3.

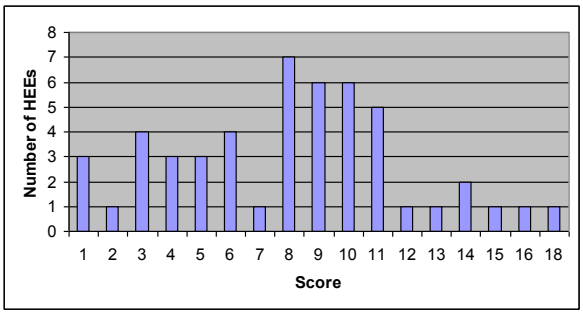

Figure 3. HEEs scores frequency

According to Rasch model the LACO estimates of 50 HEEs were calculated. The total score, presence rate, initial and final LACO estimates and standard errors (SE) for the first 10 universities are given in Table 1. Maximal, minimal and mean values of LACO, its variance (Var), standard diviation (SD) and mean standard error are presented in Table 2.

Reliability of the obtained results is shown in Table 3. Separation indexes and separation reliability for HEEs (PSI and PSR) and conferences (ISI and ISR) are presented there.

The domain of definition of LACO varies from -5 to 5 logits according to Rasch model. Generally we can see that universities internationally recognized as leaders in computer sciences demonstrate high results in research activity. The current research shows the difference in arrangement of HEEs because the official rating includes different criteria for estimation, not only research quality. We consider only activity in conferences organization which may be one particular indicator of the research quality.

TABLE I. LACO ESTIMATION (FRAGMENT)

HEE	Score	Presence rate	Initial θ, logits	Final θ, logits	SE
Massachusetts Institute of Technology	14	0.56	0,24	0.27	0.44
Stanford University	14	0.56	0,24	0.27	0.44
Carnegie Mellon University	16	0.64	0,57	0.68	0.46
University of California, Berkeley	9	0.36	-0,57	-0.7	0.45
Harvard University	6	0.24	-1,15	-1.36	0.5
University of Oxford	8	0.32	-0,75	-0.9	0.46
University of Cambridge	9	0.36	-0,57	-0.7	0.45
ETH Zurich	10	0.4	-0,41	-0.5	0.44
National University of Singapore	11	0.44	-0,24	-0.3	0.44
Princeton University	5	0.2	-1,39	-1.63	0.53

TABLE II. ANALYSIS OF LACO ESTIMATION

Max θ, logits	Min θ, logits	Mean θ, logits	Var θ	SE θ	Mean SE
1,12	-3,56	-1,04	1,08	1,04	0,52

TABLE III. RELIABILITY ESTIMATION

PSI	PSR	ISI	ISR
1,53	0,7	2,33	0,84

V. CONCLUSIONS AND FUTURE WORK

The given work provides the idea of introduction of web mining techniques into traditional M&E activities that are already organized in universities worldwide. Since the Internet is a huge and open source of data of different sort, we suggest to extract the useful data and based on it make analysis of some indicators. To start with we propose to estimate research activity of HEEs. Obviously data about achievements of scientists from different universities are presented on the Internet. In particular the lists of members of conferences committees are usually available in the full or cut form. To mine these data we need a web crawler which searches for targeted web pages and makes their indexing. To process the data obtained from the web we use Rasch model.

The obtained estimates of research activity express only one aspect of HEE's research quality connected with efforts in conferences organization. They can be used in M&E to assess the university's policy concerning science promotion. These estimates are the values of research activity indicator which should be considered together with the set of indicators that characterize research quality. Data on these indicators must be collected within HEE's M&E information system. Also the indicator of such kind may be used in universities ratings construction as one of possible criteria for assessment.

As the extension of the introduced idea we suggest to investigate the variation of research activity estimates in time. Often we can find the data about the previous conferences of the last up to ten years on the conferences' web sites. So it is possible to screen how the university's activity changes over time. Based on this the conclusions about success of HEE's strategy can be made. Another proposal is to research the activity of authors from specified university by analyzing the presence of their works in the collection of abstracts of some conference, which also may be available on the conference web site.

Generally by the presence of university's name in different ratings, news and articles on the Internet we may infer about the quality of the provided education and research work. Such kind of research requires more complex web mining techniques to analyze web content. Exactly this can be specified as one of the future directions of our work.

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