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Journal evaluation based on bibliometric indicators and the CERIF data model

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Abstract. In this paper we propose an application of extended CERIF data model for storing journal impact factors and journal scientific fields and also propose a journal evaluation approach based on these data. The approach includes an algorithm for journal evaluation based on one metric for journals ranking that is also stored using the CERIF data model and that is in accordance with the rule book for evaluation of scientific-research results which is prescribed by the Republic of Serbia. The algorithm does not unambiguously evaluate journal, i.e. the algorithm suggests possibly journal categories according to the values of the metric, but final decision is made by commission. The proposed evaluation approach is implemented within CRIS UNS and verified on scientific-research results of researchers employed at Department of Mathematics and Informatics, University of Novi Sad. The complete evaluation approach proposed in this paper is based on the CERIF standard that allows an easy application of this evaluation approach in any CERIF-compatible CRIS system.

Keywords: CERIF; evaluation of scientific-research results; impact factor; CRIS UNS.

1. Introduction

Main output of scientific-research activity is scientific-research result: journal paper, monograph, etc. Evaluation of scientific-research results is important for research policy of state, region or institution. There are three approaches for evaluation of scientific-research results: creation of an experts group (a commission) that evaluates scientific-research results according to some rules, usage of bibliometric indicators (impact factor, h-Index, citation, etc.) and combination of previous two approaches, i.e., creation of commission which takes into account some bibliometric indicators for results evaluation.

Many research management systems have been developed in recent years. The central part of those systems is input of metadata about scientific-research results. Those metadata can be used for evaluation of scientific-research results of researchers in accordance with national, regional and international rule books. In order to do that, it is necessary to classify the results into appropriate categories defined by some rule book. Seljak and Bošnjak [1] present usage of SICRIS system for evaluation of researcher's results. Yi and Kang [2] present development of the evaluation system of the Electronics and Telecommunications Research Institute in Korea.

Standardization of data model used in those systems is necessary in order to enable researchers to find the desired data in various research management systems as well as to enable efficient data exchange between those systems. CERIF (*Common European Research Information Format* – http://www.eurocris.org/Index.php?page=CERIFintroduction&t=1) is a standard that defines data model of research management systems. A non-profit organisation euroCRIS (http://www.eurocris.org/) has been responsible for the development of CERIF since 2002. The European Union encourages the development of national research management systems in accordance with CERIF standard because the European Union wants to achieve maximum competitiveness of Europe at all levels of research activity. A research management system compatible with the CERIF data model is called CRIS (*Current Research Information System*).

The process of evaluation of scientific research is prescribed by law in the Republic of Serbia, i.e., there is the rule book which was issued by the Ministry of Education and Science of the Republic of Serbia. The Ministry uses the previously mentioned rule book for funding scientific projects and faculties and scientific institutions use the rule book for selection of teaching and scientific position. For those purposes, researchers have to evaluate their own scientific results according to the rule book and to submit their evaluation reports to competent institutions. After that, those evaluation reports are controlled by institutions' boards. The previously described evaluation approach, regardless to great effort made for controlling evaluation reports, still does not provide a consistent application of the rule book. There are some cases when same publication has been differently evaluated in a few final evaluation reports. In order to overcome those shortcomings a software system for evaluation of scientific results called CRIS UNS has been developed at University of Novi Sad since 2008. The first phase of CRIS UNS development covered implementation of a module for entering metadata about scientific-research results. The second phase of that system development is related to evaluation of those results. The main idea of using CRIS UNS for results evaluation is that researchers enter data about their scientific-research results by themselves and that some commission (group of experts) evaluates those results. The system is going to generate evaluation reports using metadata about scientific-research results entered by researchers and results evaluations entered by some commission. This approach does not require that researchers have to know the rule book for the evaluation and to apply it to their results, i.e., CRIS UNS improves procedure of evaluation of scientific-research results. The current rule book (which is published in 2008) prescribes that evaluation of a paper published in a journal depends on journal scientific field and journal value (category of journal), which means it is sufficient to evaluate journals (it is not necessary individual evaluation of all papers published in journals). The current rule book introduces three categories of journals based on value of the journal impact factor and scientific field (see Table 2). Therefore, it is necessary to enable storage of journals impact factors and scientific fields in the CRIS UNS data model. In that way, the CRIS UNS system could help commission members to evaluate journals. Due to the needs for increasing availability of scientific-research results, the CRIS UNS system is built on the CERIF data model that enables data exchange with other CERIF-compatible research management systems. Therefore, storage of the journals impact factors, scientific fields and the rule book in the CERIF compatible data model is necessary.

In this paper we propose an application of the CERIF model extension for storing previously mentioned data. This proposal includes algorithm for storing journals impact factors and scientific fields that does not require addition of new types of entities to existing data model, i.e., only instantiations of existing types of CERIF entities are required. This paper also proposes a journal evaluation method based on the journal impact factor (JIF) and journal scientific fields stored in the data model in previously described way. That method includes algorithm for journal evaluation based on one metric for journals ranking which takes into account the JIF and journal scientific fields. The metric for journals ranking is in accordance with the rule book prescribed by the Republic of Serbia and it is also stored in the CERIF data model. The proposed algorithm for evaluation does not unambiguously evaluate journal, i.e. the algorithm suggests possibly journal categories according to the values of the metric, but final decision is made by commission. The proposed evaluation approach is implemented within CRIS UNS and verified on scientific-research results of researchers employed at Department of Mathematics and Informatics, Faculty of Sciences, University of Novi Sad. Furthermore, the proposed approach allows simultaneously using different metrics for journals ranking that can be based on various bibliometric indicators. The complete evaluation approach proposed in this paper is based on the CERIF standard that allows an easy application of this evaluation approach in any CERIF-compatible CRIS system.

2. Background and related work

This section shows fundamental concepts and related work for the paper research area. Those concepts are basis for investigation presented in this paper. The section is divided into three subsections: Current Research Information Systems, Journal impact factor and Journal Citation Report and Rule books for evaluation of scientific-research results.

There are systems that evaluate scientific-research results. Seljak and Bošnjak [1] present evaluation of researcher's results stored in SICRIS system that is based on CERIF-compatible model, but this evaluation does not use bibliometrics indicators for evaluation unlike the evaluation approach presented in this paper that is based on bibliometrics indicators stored in the CERIF *cfMetrics* entity. Yi and Kang [2] present development of the evaluation system of the Electronics and Telecommunications Research Institute in Korea, but this system is not CERIF-compatible. The evaluation approach presented in this paper evaluates results stored in current research information systems that are interoperable with all CERIF-compatible systems. This interoperability increases accessibility of scientific-research results, i.e., enhances the further development of science.

2.1. Current Research Information Systems

Standardization of data model used in research management systems is necessary in order to enable data exchange between those systems. CERIF is a leading standard for data exchange between those systems and research management systems compatible with the CERIF data model are called CRIS (*Current Research Information Systems*).

CERIF (*the Common European Research Information Format*) defines a data model that contains information about people, projects, organizations, publications, patents, equipments, etc. The first version of CERIF was published in 1991 and the current version is the CERIF2008 v1.2 published in 2010. The CERIF data model has six groups of entities:

- Core entities,
- Result entities,
- 2nd level entities,
- Link entities,
- Semantic layer entities and
- Multilingual entities.

Entities *Project*, *Person* and *OrganizationUnit* are the CERIF *Core entities*. Entities *ResultPublication*, *ResultPatent* and *ResultProduct* belong to the CERIF *Result entities* and contain metadata about scientific-research results. Furthermore, the group *2nd level entities* contains entities dedicated to hold relevant data for scientific-research activity that do not belong to groups *Result entitites* and *Core entities*. The group contains the following entities: *cfCite, cfCountry, cfCurrency, cfCV, cfEAddr, cfEquip, cfEvent, cfExpSkills, cfFacil, cfFundProg, cfLang, cfMetrics, cfPAddr, cfPrize, cfQual, cfSrv*. Those entities are linked with the CERIF *Core entities* and *Result entities* through the CERIF *Link entities*. The *Link entities* hold references to the two related entities, time period in which relation between entities applied (attributes *startDate* and *endDate*) as well as the classification of relationship. The CERIF data model has the CERIF *Semantic layer entities* that enable classification of entities and relations between entities in accordance with some classification scheme. For example, classification of relations between the *Person* entity and the *ResultPublication* entity is: author of publication, editor of publication, lecturer. Examples of classification of the *ResultPublication* entity are: thesis, dissertation, paper published in journal, monograph, etc. In addition to the list of entities that belong to the *Semantic Layer entities*, CERIF prescribes values that those entities can hold (provides a list of possible classifications). The CERIF data model provides storage for certain data, such as title, abstract, keywords, research area in multiple languages. Those data are stored using the CERIF *Multilingual entities*.

Due to specific local or national requirements CRIS systems are built on different modifications of the CERIF data model. *Asserson, Jeffery and Lopatenko* [3] describe CERIF data model extensions that were created in order to satisfy requirements of a CRIS that was developed at the University of Bergen and a CRIS that was developed by "Science and Technology Facilities Council". Moreover, a CERIF data model extension that was created in order to satisfy requirements of the IST World portal is described in papers [4;5;6;7]. Furthermore, papers [8;9] describe a CERIF data model extension that uses the formalized Dublin Core for description of scientific-research results. *Ivanović, Surla and Konjović* [10] propose a CERIF-compatible data model based on the MARC 21 format (http://www.loc.gov/marc/). In that model, part of the CERIF data model related to scientific-research results is replaced with data model of the MARC 21 format. MARC 21 is a standard that prescribes a format for bibliographic data storing.

By 2011, there are many CRIS systems: IST World (http://www.ist-world.org/), HunCRIS (http://nkr.info.omikk.bme.hu/HunCRIS_eng.htm), SICRIS (http://sicris.izum.si/default.aspx?lang=eng), CRIStin (http://www.cristin.no/), Pure (http://www.atira.dk/en/pure/), CRIS UNS (http://cris.uns.ac.rs/), etc. IST World (*Information Society Technology World*) is a portal that provides access to scientific-research results from several countries. This portal was developed within a FP6 (*Sixth Framework Programme*) project. The data model created for the purpose of that system is a CERIF data model extension. HunCRIS and SICRIS are Hungarian and Slovenian national CRIS systems based on the CERIF data model. CRUStin is an information system used by scientific institutions in Norway. Pure is commercial software that can be installed and customized for the needs of scientific institutions. That software system is used by many universities such as the University of Helsinki and the University of Copenhagen.

CRIS UNS is a CERIF compatible research management system that has been being developed since 2008 at the University of Novi Sad in the Republic of Serbia. Experience gained from developing of the BISIS library information system (http://www.bisis.uns.ac.rs/) is used for developing CRIS UNS. The BISIS system has been being developed since 1993 at the University of Novi Sad. The current version 4 is based on XML technology. Within the version, an XML editor for cataloguing in the UNIMARC and MARC21 format [11;12] is developed. The first phase of CRIS UNS development covered implementation of a system for entering metadata about scientific-research results in the following forms: papers published in journals, papers published in conferences proceedings, monographs, papers published in monographs. The next phase of the system development is related to evaluation of those results. The system is built on the CERIF-compatible data model based on the MARC21 format presented in the paper [9]. The system implementation is described in the papers [13;14], and a module for automatic extraction of metadata from scientific papers in PDF format for CRIS UNS is described in the paper [15]. Scientific-research results from the system are available to anonymous user via Internet. The system is in accordance with CERIF and meets requirements prescribed by Ministry of Education and Science of the Republic of Serbia in the field of scientific-research results evaluation [16]. Moreover, the system is implemented as web application that enables authors to input metadata about their own research results without the knowledge of CERIF and MARC21. The system data model and architecture enable easy integration of the system with library information systems.

2.2. Journal impact factor and Journal Citation Report

One of bibliometric indicators is the journal impact factor (JIF). The JIF measures the importance of a journal. The JIF is a measure reflecting the average number of citations to articles published in science journals. *Glänzel and Moed* [17] discuss about advantages and disadvantages of using that indicator. Papers [18;19] explain the history and the proper uses of the JIF. *Bensman* [20] and *Bensman, Smolinsky and Pudovkin* [21] investigate the journals impact factors distribution. *Bordons, Fernández and Gómez* [22] discuss problems of using the JIF as measure in non-English speaking countries. *Van Leeuwen and Moed* [23] also discuss some shortcomings of the JIF and propose a new measure called *Journal to Field Impact Score* (JFIS). *Buela-Casal* [24] proposes to take into account the reputation of the publication from which the citation emanates. Moreover, *Bollen, Rodriguez and van de Sompel* [25] propose the measure of citations based on popularity (number of citations) and prestige (expert appreciation). *Sombatsompop, Markpin and Premkamolnetr* [26] propose the modification to the JIF from the point of citation period (half-life of the journal). *Frandsen and Rousseau* [27] generalize the definition of the JIF to allow different publications and citation periods. *van Leeuwen and Moed* [28] study the relationship between the JIF and other indicators. *Egghe* [29] compares the evaluation based on h-Index with evaluation based on the JIF. There are also other metrics for journals' scientific prestige such as Eigenfactor [30] and SCImago Journal Rank [31].,It is obvious that the JIF has weaknesses that researchers have been tried to eliminate by proposing some modifications of the JIF. Despite its weaknesses and existence of other metrics for journal ranking, journal impact factor is widely spread bibliometric indicator for evaluation of journals. Also, the JIF can be start point for measuring other aspects relevant for scientific-research activity. *Chinchilla-Rodriguez and colleagues* [32] propose an approach based on the JIF that visualize international scientific collaboration.

In a given year, the JIF is the average number of particular year citations received per paper published in that journal during some preceding period. If period of previous two years is used then it is two-year JIF, and if period of previous five years is used then it is five-year IF. Hereinafter, term JIF refers to two-year JIF (it is a common practice).

For instance, 131 papers in 2007 and 133 papers in 2008 were published in the journal *Scientometrics*. In other words, 264 papers were published in that journal in two-year period 2007-2008. Those papers were cited 572 times in all the papers published in 2009. The JIF for 2009 of *Scientometrics* is quotient of numbers 572 and 264, i.e., the JIF for 2009 is 2.167.

Journals impact factors are published in Journal Citation Report (JCR) every June for the previous year. The calculations are performed based on the situation in all three citations databases (SCIe(xpanded), SSCI, AHCI) on the first day of March.

JCR has two partly overlapped sections: *JCR Science Edition* and *JCR Social Science Edition*. Each journal can belong into several of 220 scientific fields and can have one annual impact factor. A journal position by the value of impact factor can be determined within each scientific field to which a journal belongs. **Table 1** presents the two-year impact factors of *Scientometrics* for the period 2001-2009. In the third and fourth row are positions of the journal within scientific fields. For example, within the scientific field *Computer Science, Interdisciplinary Applications* were 76 journals in 2001 and *Scientometrics* was on 25th place in a sorted list of journals. The list is sorted in decreasing order by value of JIF.

Table 1. Impact factors

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Two-year JIF	0.676	0.855	1.251	1.120	1.738	1.363	1.472	2.328	2.167
Scientific field: Computer Science, Interdisciplinary Applications	25/76	19/80	16/83	24/83	18/83	24/87	24/92	13/94	18/95
Scientific field: Information Science & Library Science	16/55	16/55	9/55	14/54	5/55	12/53	12/56	8/61	10/65

2.3. Rule books for evaluation of scientific-research results

Definition of different rule books for evaluation and quantitative expression of scientific-research results is possible. Those rule books contain types of results that can be evaluated (the elements of evaluation) and quantitative measures assigned to them. Types of results can be decomposed to several hierarchical levels. For example, the first level can be journal of international importance, journal of national importance, etc. The second level can be the type of publication in the journal: research article, review, etc. In general, it is possible to continue decomposition to arbitrary number of hierarchical levels (three, four, etc.). Different quantitative measures can be joined to same type results within different groups of sciences.

The paper [16] proposes an extension of the CERIF data model for storage of rule books using the following entities:

- The *RuleBook* entity contains name and description of a rule book, time period in which a rule book applies.
- The *ResultType* entity presents element of evaluation. Set of instances of the *ResultType* entity are connected to an instance of the *RuleBook* entity and a recursive relation defined for the *ResultType* entity enables that types of results can be decomposed to arbitrary number of hierarchical levels.
- The *SciencesGroup* entity represents model of group of sciences. This entity can be replaced with the CERIF entity *cfClass*.
- The *ResultTypeMeasure* entity represents model of quantitative measure of result type. This entity defines how many points researcher gets for result which belongs to some result type (relation between the *ResultTypeMeasure* entity and the *ResultType* entity) and belongs to some sciences group (relation between the *ResultTypeMeasure* entity and the *SciencesGroup* entity).

The extension proposed in the paper [16] is included in the CRIS UNS data model and that extension is used for description of the rule book for evaluation of scientific-research results prescribed by the Republic of Serbia. The rule book evaluates result depending on result type and group of sciences to which result belongs. Types of results are the followings: papers published in journals, papers published in conferences proceedings, monographs, papers published in monographs, etc. Three categories of journals depending on the value of JIF are introduced (**Table 2**).

Table 2. Journal categories

Journal category	Definition
Leading journal of international importance	Ranked among the top 30% in the JCR list of journals.
Outstanding journal of international importance	Ranked between the top 30% and 50% in the JCR list of journals.
journal of international importance	Exists on the JCR list of journals, but is not ranked among the top 50%.

Types and quantifications of results related to journals of international importance are presented in **Table 3**. There are three sciences groups: (1) *Mathematics and Natural Sciences*, (2) *Technical and Technological Sciences*, (3) *Social Sciences*. Within those sciences groups, types of results are quantified with numerical value, e.g., type of result *Paper published in journal of international importance* within sciences groups (1) and (2) is quantified with 3 points, and within sciences group (3) is quantified with 4 points.

Table 3. Types and quantifications of results related to journals

Result type	Code	Sciences group		
		(1)	(2)	(3)
Paper published in leading journal of international importance	M21	8	8	8
Paper published in outstanding journal of international importance	M22	5	5	5
Paper published in journal of international importance	M23	3	3	4
Paper published in journal of international importance verified by special decision	M24	3	3	4
Book review published in outstanding journal of international importance	M25	1,5	1,5	1,5
Book review published in journal of international importance	M26	1	1	1
Editor of outstanding journal of international importance	M27	3	3	3
Editor of journal of international importance	M28	2	2	2

Evaluation of scientific-research results using CRIS UNS requires:

- Input of results metadata,
- Input of a rule book for evaluation,
- Input of a commission categorization of journals, monographs and conferences and
- Generation of evaluation reports.

Evaluation of scientific-research paper published in a journal depending on group of sciences to which a researcher belongs: *Mathematics and Natural Sciences*, *Technical and Technological Sciences*, *Social Sciences*. The paper is evaluated using journal categories suggested by the CRIS UNS system. Calculation of suggested journal categories is based on positions by value of impact factor within each scientific field to which a journal belongs. For example:

- The journal belongs to the scientific fields Computer Science, Interdisciplinary Applications and Information Science & Library Science.
- Both scientific fields belong to the same sciences group: *Technical and Technological Sciences*.
- The researcher also belongs to the same sciences group. The system suggests journal categories using journal positions by value of impact factor in both scientific fields.
- The commission categorizes the journal (usually adopts one of the suggested categories).

Storage of impact factors and scientific fields of journals in the CRIS UNS data model enables CRIS UNS can suggest categorization of a journal that has an impact factor. A commission adopts or rejects suggested categorization. Also, the commission on the basis of their scientific competence evaluates papers published in scientific journals that do not have impact factors.

3. Findings

Evaluation and quantitative expression of scientific-research results using the rule book prescribed by the Republic of Serbia depends on results scientific fields. Result published in a journal can be evaluated on the basis of journal position by the value of impact factor within scientific field to which the journal belongs. Data about a journal IF, scientific fields and positions within scientific fields are necessary for previously described evaluation. On the basis of those data, some metric can be assigned to the journal. Those data storage in the CERIF data model is proposed in this section. The storage does not require addition of new types of entities as well as attributes to existing CERIF data model entities, i.e., only instantiations of existing types of entities are required.

Journals scientific fields can be stored using the CERIF group *Semantic layer entities* (**Figure 1**). That group contains the entities *cfClass* and *cfClassSheme* that describe classes and classification schemes, respectively. Relation between a class and a classification scheme can be established using the *cfClassSchemeId* attribute of the *cfClass* entity. A classification scheme is additionally described using the *cfClassSchemeDescription* entity that belongs to the CERIF group *Multilingual entities.* Furthermore, a class is additionally described using the entities *cfClassTerm* and *cfClassDescription* that also belong to the group *Multilingual entities*. A relation between two classes can be established using the *cfClass_Class* entity that belongs to the group *Link entities*. The attributes *cfClassSchemeId1* and *cfClassId2* hold foreign key values to the first, and the attributes *cfClassSchemeId2* and *cfClassId2* hold foreign key values to the second linked class. The attributes *cfClassSchemeId* and *cfClassId* classify the relation, i.e., those attributes hold foreign key values to a class that presents type of the relation. A relation between two classification schemes can be established using the *cfClassScheme_ClassScheme* entity that belongs to the group *Link entities*. Other entities of the CERIF data model are linked with semantic layer through the *cfClass* entity, e.g., the *cfResultPublication_Class* entity (**Figure 1**) links the entities *cfResultPublication* and *cfClass*. The *cfResultPublication_Class* entity defines results scientific fields (publication can present some scientific-research result) and the *cfResultPublication_ResultType* entity defines types of results by some rule book. The *cfCommission* entity is dedicated to hold basic information about commissions.

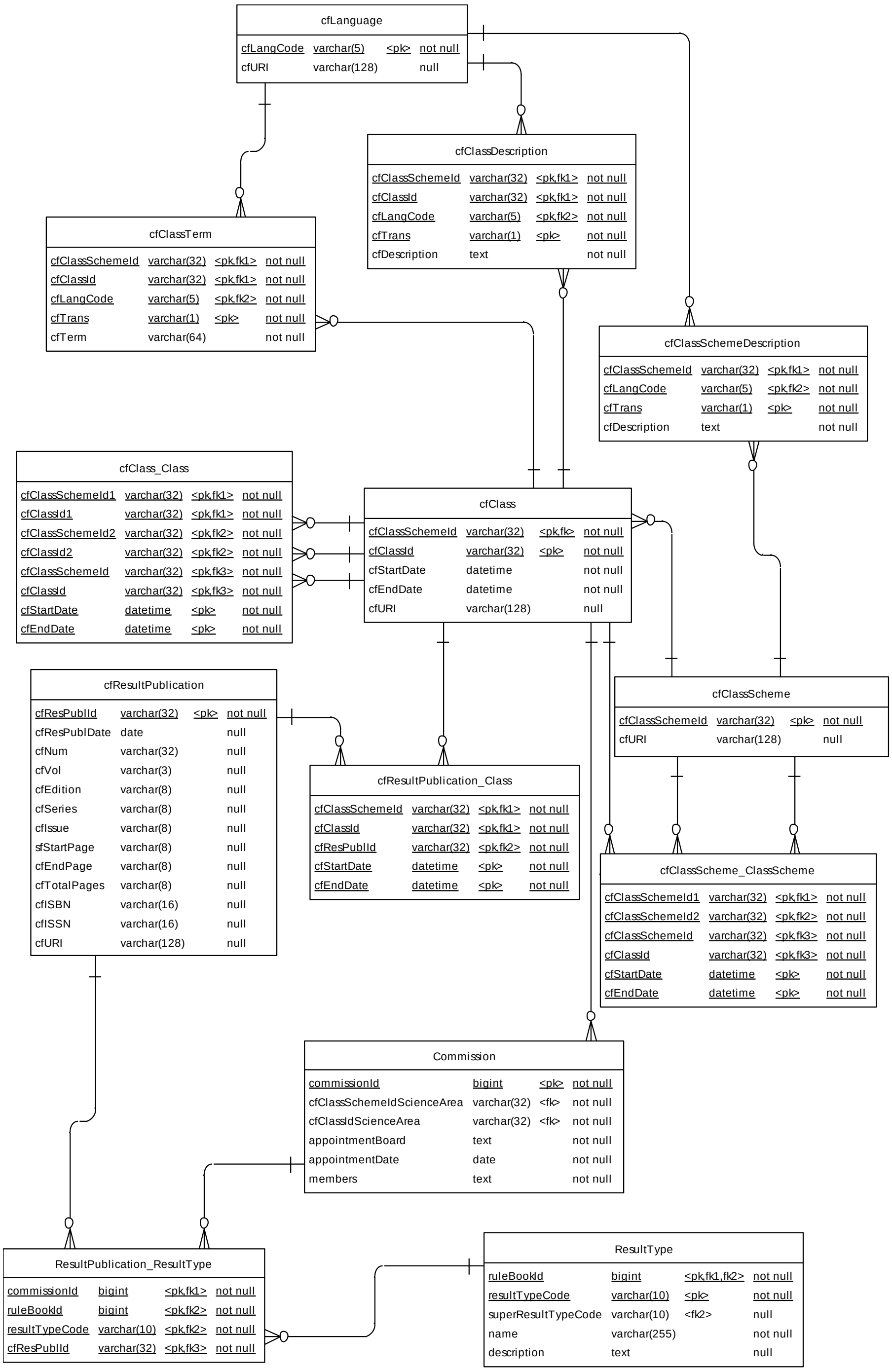

Figure 1. Journals and Semantic layer entities

In order to define scientific fields prescribed by JCR, the followings are necessary:

- Creation of an instance of the *cfClassScheme* entity with mnemonic name *scientific field*; and creation of 220 instances of the *cfClass* entity that are linked with the classification scheme *scientific field* and present scientific fields prescribed by JCR. In other words, the attribute *cfClassSchemeId* of those 220 instances holds the primary key value of the *cfClassScheme* entity instance with mnemonic name *scientific field*.
- Creation of an instance of the *cfClassScheme* entity with mnemonic name *section*; and creation of 2 instances of the *cfClass* entity that are linked with the classification scheme *section* and present the sections prescribed by JCR: *JCR Science Edition* and *JCR Social Science Edition*.
- Creation of an instance of the *cfClassScheme* entity with mnemonic name *scientific field – section - relation* as; and creation of an instance of the *cfClass* entity that is linked with the classification scheme *scientific field – section - relation* and has mnemonic name *scientific field belongs to section*.
- Creation of instances of the *cfClass_Class* entity for linking instances of the *cfClass* entity that represent scientific field (the attributes *cfClassSchemeId1* and *cfClassId1* of the *cfClass_Class* entity) and section (the attributes *cfClassSchemeId2* and *cfClassId2* of the *cfClass_Class* entity). Those instances of the *cfClass_Class* entity are classified using instance of the *cfClass* entity that has mnemonic name *scientific field belongs to section* (the attributes *cfClassSchemeId* and *cfClassId* of the *cfClass_Class* entity).

In order to link scientific fields and sciences groups prescribed by some rule book for evaluation, the followings are necessary:

- Creation of an instance of the *cfClassScheme* entity with mnemonic name *sciences group*; and creation of three instances of the *cfClass* entity that are linked with the classification scheme *sciences group* and have the following mnemonic names *Mathematics and Natural Sciences*, *Technical and Technological Sciences*, *Social Sciences*. Those three instances of the *cfClass* entity represent sciences group defined by the rule book for scientific-research results evaluation of the Republic of Serbia. As already mentioned, the CERIF extension for evaluation that is adopted for CRIS UNS replaces the *SciencesGroup* entity with the CERIF entity *cfClass*. Some rule book can have more groups of sciences. Within different groups of sciences same type results can be differently quantified.
- Creation of an instance of the *cfClassScheme* entity with mnemonic name *scientific field – sciences group - relation*; and creation of an instance of the *cfClass* entity that is linked with the

classification scheme *scientific field – sciences group - relation* and has mnemonic name *scientific field belongs to sciences group*.

- Creation of instances of the *cfClass_Class* entity for linking instances of the *cfClass* entity that represent scientific field and section, respectively. Those instances of the *cfClass_Class* entity are classified using instance of the *cfClass* entity that has mnemonic name *scientific field belongs to sciences group.*

In order to link a journal with result types and scientific fields, the followings are necessary:

- Creation of instances of the *cfResultPublication_ResultType* entity for linking an instance of the *cfResultPublication* entity that represents a journal and an instance of the *cfResultType* entity that represents a result type to which the journal belongs by some commission (the *commissionId* attribute of the *cfResultPublication_ResultType* entity).
- Creation of instances of the *cfResultPublication_Class* entity for linking an instance of the *cfResultPublication* entity that represents a journal and an instance of the *cfClass* entity that represents a scientific field to which the journal belongs. The attributes *cfStartDate* and *cfEndDate* define time period in which the journal belongs to some scientific field (journal can change scientific field over time).

The JIF is bibliometric indicator. The CERIF data model has the *cfMetrics* entity that is intended for storage of various metrics and this entity can be used for storage of the JIF. The *cfMetrics* entity and connected entities are shown in **Figure 2**. A metric name and description is stored using the multilingual entities *cfMetricsName* and *cfMetricsDescription*. A journal is stored using the *cfResultPublication* entity. That entity can be also used for storage of other publications, such as monographs, conference proceedings, etc. Those publications could be also linked with appropriate metrics. Multilingual entities linked with the *cfResultPublication* entity are not shown in **Figure 2** (*cfResultPublicationTitle*, *cfResultPublicationKeywords*, etc.). A value of metric in some year for some publication can be defined using the attributes *cfCount*, *cfFraction* and *cfYear* of the *cfResultPublication_Metrics* entity.

In order to store journals impact factors, the followings are necessary:

- Creation of instances of the *cfMetrics* entity with mnemonic names *two-year impact factor* and *five-year impact factor.*
- Creation of an instance of the *cfClassScheme* entity with mnemonic name *journal – impact factor - relation*; and creation of an instance of the *cfClass* entity that is linked with the classification scheme *journal – impact factor - relation* and has mnemonic name *value of impact factor.*
- Creation of instances of the *cfResultPublication_Metrics* entity for linking instances of the *cfResultPublication* entity that represent

journal and instances of the *cfMetrics* entity with mnemonic name *two-year impact factor*. Those instances of the *cfResultPublication_Metrics* entity are classified using the instances of the *cfClass* entity with the mnemonic name *value of impact factor.* There is an instance for each year. Year is stored using the *cfYear* attribute, and value of JIF is stored using the *cfCount* attribute of the *cfResultPublication_Metrics* entity.

- Creation of instances of the *cfResultPublication_Metrics* entity for linking instances of the *cfResultPublication* entity that represent journal and instances of the *cfMetrics* entity with mnemonic name *five-year impact factor*. Those instances of the *cfResultPublication_Metrics* entity are classified by the analogy to the classification described in the previous item.

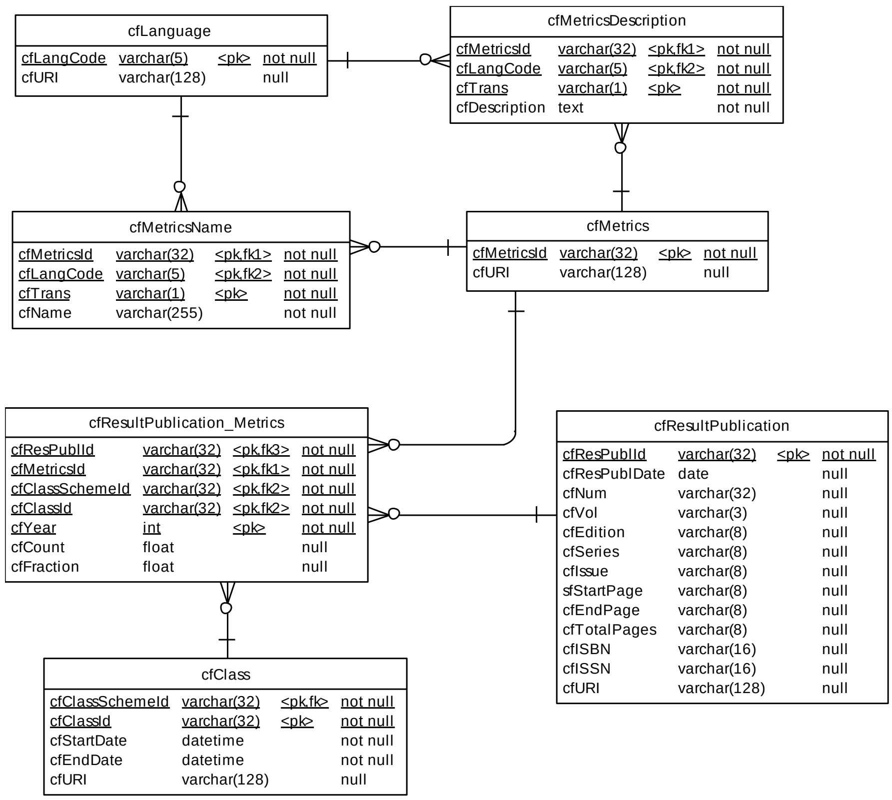

Figure 2. Metrics

By the rule book for scientific-research results evaluation of the Republic of Serbia, a paper published in a journal is evaluated on the basis of scientific fields and the journal category, which means categorization of the journal is sufficient, i.e., evaluation of each paper is not necessary. Category of journal referred in JCR within each scientific field is determined using a metric for journals ranking which is defined as quotient of *journal position in sorted list in decreasing order by value of JIF* and *total number of journals belonging to scientific field*. In order to store the metric for journals ranking, the following is necessary:

- Creation of instances of the *cfResultPublication_Metrics* entity for linking instances of the *cfResultPublication* entity that represent journal and instances of the *cfMetrics* entity with mnemonic name *two-year impact factor*. Those instances of the *cfResultPublication_Metrics* entity are classified using the instances of the *cfClass* entity that represent scientific fields to which a journal belongs. There is an instance for each year and each scientific field. Year is stored using the *cfYear* attribute, and position in sorted list of journals (in decreasing order by value of JIF) is stored using the *cfCount* attribute of the *cfResultPublication_Metrics* entity. The *cfFraction* attribute of the *cfResultPublication_Metrics* entity holds the metric for journals ranking. The metric for journals ranking holds a value from the interval (0, 1] and the value of metric establishes a category of journal according to the rule book. For example: A journal is a leading journal of international importance (**Table 2**) if value of its metric for ranking belongs to the interval (0, 0.3].

A scientific-research paper authorized by a researcher is evaluated in accordance with sciences group to which the researcher belongs: *Mathematics and Natural Sciences, Technical and Technological Sciences, Social Sciences*. The paper is evaluated on the basis of journal categorization (**Table 2**) within journal scientific fields which belong to the same sciences group like researcher. That journal categorization is done by a commission for evaluation. A CRIS can send queries to a database and provide values of the previously described metric to a commission. In that way, the CRIS provides help to the commission in journals categorization.

An example of such a query is shown in **Listing 1**. The query returns the value of the metric for *„Scientometrics“* for 2001 within the scientific fields that belong to the group of sciences „*Technical and Technological Sciences*“. The query is described using a meta-language that uses mnemonic names instead of the primary keys of entities. **Figures 1** and **2** shown in the previous section are necessary and sufficient for this query understanding. Those figures shows entities used in this query. Instances of the *cfClass_Class* entity link instances of the *cfClass* entity that represent scientific fields (the attributes *cfClassSchemeId1* and *cfClassId1* of the *cfClass_Class* entity) and instances of the *cfClass* entity that represent sciences groups (the attributes *cfClassSchemeId2* and *cfClassId2* of the *cfClass_Class* entity). Those instances of the *cfClass_Class* entity are classified using the instance of the *cfClass* entity with mnemonic name *scientific field belongs to sciences group* (the attributes *cfClassSchemeId* and *cfClassId* of the *cfClass_Class* entity).

```
select  journal_metric.cfFraction
        from    cfResultPublication journal, cfMetrics metric,
                cfResultPublication_Metrics journal_metric
        join    journal, metric, journal_metric
        where   journal is „Scientometrics“ and
                metric is „two-year impact factor“ and
                journal_metric.cfYear is „2001“ and
                (journal_metric.cfClassSchemeId, journal_metric.cfClassId) in
                        (select cfClassSchemeId1, cfClassId1
                            from cfClass_Class
                            where  mnemonicName(cfClassSchemeId, cfClassId) is
                                        „scientific field belongs to sciences group“ and
                                mnemonicName(cfClassSchemeId2, cfClassId2) is
                                        „Technical and Technological Sciences“)
```

Listing 1. Query

As already shown in **Table 2,** the journal *„Scientometrics“* in 2001 belonged to the scientific fields *„Computer Science, Interdisciplinary Applications“* and *„Information Science & Library Science“*. Both of those scientific fields belong to the group of sciences „*Technical and Technological Sciences*“. Within the first scientific field the metric for journals ranking has value 25/76 = 0.329, and within the second 16/55 = 0.291. Those two values are result of execution of query shown in **Listing 1.** Based on those values the journal can be categorized (**Table 2**) as *Outstanding journal of international importance* (value of the metric lies in interval (0.3, 0.5]) or as *Leading journal of international importance* (value of the metric lies in interval (0, 0.3]). A commission for evaluation has to make decision and categorize the journal.

4. Discussions

Previous section proves that journals impact factors and scientific fields can be stored in the CERIF data model. The CERIF semantic layer and the *cfMetrics* entity are used for that storage. The *cfMetrics* entity can be also used for storing other bibliometric indicators. On the basis of those data, evaluation of journals scientific-research results in accordance with some rule book is possible. A rule book can be stored using the extension of the CERIF data model presented in the paper [16].

The proposed evaluation approach is implemented within CRIS UNS and verified on scientific-research results of researchers employed at Department of Mathematics and Informatics, Faculty of Sciences, University of Novi Sad. Journals listed in JCR and their impact factors (see **Table 1**) are stored in the system database. The database contains only data related to journals that contain papers authorized by some researcher affiliated at the University of Novi Sad, i.e., all journals referred in JCR are not present in the system database. If the database contained all journals referred in JCR, the data supplied in the last two rows in **Table 1** could be derived. The department founded a commission for scientific-research results evaluation. The commission had to categorize all scientific journals in which at least one researcher employed at the department published some scientific-research result. In order to do that, the journal evaluation approach presented in this paper is used by the commission. As already mentioned, the approach uses a metric for journals ranking based on journals impact factors and journals scientific fields. The first encountered problem was the proposed metrics for different journal scientific fields can give different journal categorizations. The second encountered problem was missing JCR for some years. One possible approach to overcome these problems is evaluation of each journal for each year by the commission. The second approach that is applied in the CRIS system is based on rules for overcoming these problems created by the commission:

1. If a journal for a certain year has at least one of the scientific fields that belong to a sciences group in which the evaluation is done, then the best journal category within scientific fields belonging to the sciences group is adopted, otherwise the worst journal category within different scientific fields is adopted. Precondition for this rule is the journal has the impact factor for certain year.
2. If a journal for a certain year does not have impact factor, then the best journal categorization within a period of previous four years and next two years is adopted.
3. If a journal after applying the rule 1 and the rule 2 still does not have categorization for a certain year, then the journal is categorized as M53 (scientific journal) for the certain year.

Introducing of other rules defined by some other commission by which CRIS UNS automatically categorizes journals is also possible. However, a commission has to categorize journals that do not have JIF for any year. Journals categorizations are stored in data model as it is described in the paper [16].

Using of others metrics for journals categorizations is also possible:

- Value of JIF lies in some interval of values,
- Quartile score (http://researchassessment.fbk.eu/quartile_score),
- Eigenfactor (http://www.eigenfactor.org/),
- SCImago Journal Rank (http://www.scimagojr.com/),
- Position of a journal in a sorted list of journals by decreasing value of JIF within a scientific field (regardless to the total number of journals in the scientific field),
- etc.

Using the other metrics can be easy achieved in a way analogous to the proposed algorithm by creating new instances of the *cfMetrics* entity and new instances of *cfResultPublication_Metrics* entity that hold appropriate values.

The CERIF date model also enables storage of number of publication citations using the *cfCite* entity. This aspect of CERIF has not been considered in this paper because the rule book of the University of Novi Sad does not evaluate papers published in journals based on citations.

5. Conclusions

A proposal for evaluation of journal based on the JIF and journal scientific fields stored in a CERIF model extension is presented in this paper. The *cfMetrics* entity of the CERIF data model is used for storage of impact factors, and the CERIF semantic layer is used for storage of scientific fields. The storage does not require addition of new types of entities as well as attributes to existing CERIF data model entities, i.e., only instantiations of existing types of entities are required. Algorithm for journal evaluation presented in this paper is based on a metric for journals ranking that is in accordance with the rule book for evaluation of scientific-research results which is prescribed by the Republic of Serbia. The algorithm for evaluation does not unambiguously evaluate journal, i.e. the system suggests possibly journal categories which calculation is based on the metric, but final decision is made by commission.

On the basis of the categorized journals evaluation of all the scientific results published in journals can be done. A category assigned to a journal for a certain year can be used for evaluation of all results published in the journal in the certain year, or results can be evaluated using the best journal category for some period of time. The rule book for evaluation prescribed by the Republic of Serbia uses a period of three years (the result publication year and the previous two years).

CRIS UNS is CERIF-compatible research management system of the University of Novi Sad that stores journals impact factors and scientific fields as it is described in this paper and uses those data for evaluation of papers published in journals in accordance with the results evaluation rule book of the Republic of Serbia. The complete evaluation approach proposed in this paper is based on the standard CERIF that allows an easy application of this evaluation approach in any CERIF-compatible CRIS system.

This paper proves it is possible to create a research management system which:

- is interoperable with other systems based on the CERIF data model and
- can store bibliometric indicators about journals that can be used for evaluation of scientific-research results published in journals.

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