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CONTENT MANAGEMENT BY KEYWORDS: AN ANALYTICAL STUDY

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Various methods of content analysis are described here with special emphasis on keyword analysis. This study is based on an analytical study of 97 keywords extracted from titles and abstracts of 70 research articles, taking ten from each year starting from 2000 to 2006, in decreasing order of relevance, on the subject Fermi Liquid, which is a specific subject under the broad area of Condensed Matter Physics. The keywords beginning with the letters 'A' to 'F' only are considered for this study. The research articles have been collected from the bibliographic database of INSPEC. The keywords are indexed to critically examine its physical structure that is composed of three fundamental kernels, viz. keyphrase, modulator and qualifier. The keyphrase reflects the central concept, which is usually post-coordinated by the modulator to amend the central concept in accordance with the relevant context. The qualifier comes after the modulator to describe the particular state of the central concept and/or amended concept. The keywords are further classified in 36 classes on the basis of the 10 parameters, of which 4 parameters are intrinsic, i.e. Associativeness, chronological appearance, frequency of occurrence and category; and remaining 6 parameters are extrinsic, i.e. Clarity of meaning, type of meaning, scope of meaning, level of perception, mode of creation and area of occurrence. The number of classes under 4 intrinsic parameters is 16, while the same under 6 extrinsic parameters are 20. A new taxonomy of keywords has been proposed here that will enable to analyze research-trend of a subject and to identify potential research-areas under the scope of the same.

KEYWORD/DESCRIPTORS: Content management, Content analysis, Keyword cluster analysis, Keyword taxonomy, Condensed matter physics, Fermi liquid, Structure of keyword, Intrinsic criteria of keyword, Extrinsic criteria of keyword

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1 1 INTRODUCTION

Content analysis is a potential research method, which is extensively used in library and information science with varying aims and objectives. This methodology was first applied in the study of mass communications in the 1950s, which was based on a basic communications model of sender-message-receiver [1]. According to Kippendorf [2], 'Berelson's (1952) Content Analysis in Communications Research is considered the "first systematic presentation" of the conceptual and methodological elements of content analysis.' The researchers in almost all fields of Social Sciences, like anthropology, library and information science, management, political science, psychology, sociology et al use content analysis. This research method is applied in qualitative, quantitative, and sometimes mixed modes of research frameworks and employs a wide range of analytical techniques to generate findings and put them into context. The function

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of content analysis is a systematic and rigorous approach to analyze research papers obtained or generated in the course of research. The content of a subject is a time-dependent function, i.e. it changes with time. The method of content analysis should measure and reflect the variation in content of a subject from its research output to contemplate the unique needs of the research queries and strategies. The fundamental ingredients of the content of a subject are some keywords relevant to the same. An analytical study of keywords thus enables actual mapping of content. This needs categorization or grouping of keywords under some basic parameters. The predecessor of keyword analysis is textual analysis. The syntactic, syntagmatic, and pragmatic aspects of text have been considered while selecting keywords. There are so many procedures of content analysis in terms of both analytical goals and the means or processes developed to pursue them, which also include conversational analysis, discourse analysis, ethnographic analysis, universal pragmatics and rhetorical analysis. Let us present brief definition of each of them as presented in Wikipedia.

Conversation analysis (CA) is the study of talk in interaction (both verbal and non-verbal in situations of everyday life). CA generally attempts to describe the orderliness, structure and sequential patterns of interaction, whether institutional (in school, a doctor's surgery, court or elsewhere) or in casual conversation.

Discourse analysis (DA), or discourse studies, is a general term for a number of approaches to analyze written, spoken or signed language use. The objects of discourse analysis—discourse, writing, talk, conversation, communicative event, etc.—are variously defined in terms of coherent sequences of sentences, propositions, speech acts or turns-at-talk. Contrary to much of traditional linguistics, discourse analysts not only study language use 'beyond the sentence boundary', but also prefer to analyze 'naturally occurring' language use, and not invented examples. This is known as corpus linguistics.

According to Webster's Dictionary, ethnographic analysis is "the study and systematic recording of human cultures." Used in business, ethnographic research is the study of how people purchase and use goods and services. Ethnographic analysis examines how people use what they purchase in their environment—where consumers work, live or play. Unlike traditional research focus groups conducted in research facilities sitting around a table and being observed through a one-way mirror, ethnographic research studies how people interact with products and services in the environment in which the product is intended.

Universal pragmatics, more recently placed under the heading of formal pragmatics, is the philosophical study of the necessary conditions for reaching an understanding through communication. The philosopher Jürgen Habermas coined this term in his essay "What is Universal Pragmatics?" [3], where he suggests that human competition, conflict, and strategic action are attempts to achieve understanding that have failed because of modal confusions. The implication is that coming to terms with how people understand or misunderstand one another could lead to a reduction of social conflict.

Rhetorical analysis is the study that includes how authors attempt to persuade their audiences by looking at the various components that make up the art of persuasion.

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Although these approaches are almost alike in the context of research communication, they vary in the kinds of questions they address and in their functional methods. This paper presents a keyword-based model to apply the content analysis method in the micro-domain of a subject to encompass the variation in content over a stipulated time span. The traditional classification schemes were designed and developed to synchronize a systematic arrangement of books on the shelves in a logical sequence. The printed mass is summarily taking sharp turn towards electronic content today. The traditional role of libraries is also drastically shifting towards e-content management from inventory control. An inventory control or mere book keeping involves some recurring tasks that are effective for printed literature belonging upto certain limited number of subjects, but need continuous revision and updation with the increase in number of subjects, particularly multi and inter disciplinary subjects and also electronic content. As the universe of knowledge is continuously expanding, therefore new ideas are constantly sprouting and new subjects are consequently created. It is not possible for any classification scheme to provide absolutely all-possible subjects in the schedule. Therefore, inadequacies always remain in all classification schemes. Every new idea in the field of knowledge classification may be regarded as a new bud, which will blossom into a new flower in the next dawn to divulge some new colour resembling another fresh bit of knowledge. Such new colours make some new ways of knowledge evolution. Such ways are essentially different from those represented by the established traditional subject access tools like DDC or Sear's List or LCSH. U. Miller said [4], "The 'Library of Congress Subject Headings' was a nineteenth century solution to nineteenth-century problems. It is time to fundamentally rethink our approach to the whole issue of knowledge-management and controlled-vocabulary access systems and apply that new thinking to provide access to the Web".

Sparck Jones [5] pointed out that for information retrieval, theories of classification are inadequate and have not been sufficiently considered. She pointed out that a substantive theory of classification is needed but does not exist. Although many different approaches have been tried, this may still be the case in 2009. She focused on automatic methods for classification, but the issues addressed were fundamental for any general theory of classification, intellectual or automated. It is observed in many cases that the bottom-up approach of knowledge classification is more flexible and compatible with the ever-expanding universe of knowledge. This approach emphasizes on keywords, which is a significant way to organize e-content in a logical sequence. The hub of electronic information retrieval is focused on appropriate keywords only. At the moment of searching any topic either online or internet begins by recalling and typing a keyword in the browsing window. The heart of the traditional libraries was printed books and journals, and thus traditional classification schemes developed norms to arrange books. Today, the heart of the electronic libraries is electronic information resource in various forms, which needs new norms to organize e-resources. Since the retrieval feature of e-resource is shaped by suitable keyword, therefore we need some fundamental criteria for organizing keywords.

2 CONTENT ANALYSIS

There are so many definitions of content analysis chiefly based on its historical development. The notion of inference is especially important in content analysis. The researchers use analytical

constructs, or rules of inference, to move from the text to answer the research queries. The texts and the context define two domains, which are logically independent, and the researcher draws conclusions from one independent domain (the texts) to the other (the context). The context of the model discussed here highlights the study of the pattern of subject-content over a time span with the aid of the keywords. The keywords are reckoned as yardsticks to measure the subject-content and its temporal variation that is the crux of this model. The collective occurrence of keywords sketches the complete portrait of the subject from the fundamental level. In Library and Information studies the analytical constructs are not always explicit. The analytical constructs may be derived from (1) existing theories or practices; (2) the experience or knowledge of experts; and (3) previous research. In this model, the analytical construct has been derived from the experience only due to unavailability of both existing theory and previous research as well.

The content of a particular research paper published at a particular time is fixed, but as research papers represent ongoing trend of a subject; therefore the content of a collection of research paper over a stipulated time span gives a snapshot of the development of the subject concerned during the said time span. As far the content of the whole subject is concerned, it does not remain steady over the entire span but varies. This model describes the steps involved in content-variation analysis and differentiates between quantitative and qualitative analysis.

Content analysis by keywords is based upon the assumption that a paper's keywords constitute an adequate description of its content. The keywords also indicate the links a paper establishes between different subjects. Two different keywords co-occurring within the same paper are an indication of a link between the topics to which they refer [6]. The presence of many co-occurrences around the same word or pair of words points to a locus of strategic alliance within papers that may correspond to a research theme. Content analysis by keywords reveals patterns and trends in a specific discipline by measuring the association strengths of key terms representative of relevant publications produced in this area. The main feature of content analysis by keywords is that it visualizes the intellectual structure of one specific discipline into maps of the conceptual space of this field, and that a time-series of such maps traces the changes in this conceptual space.

Keywords are the most important research elements here, which can be extracted from journal articles, conference papers, reports or even chapters of books. The scope of this paper is restricted to the journal articles only. The keywords are culled out from keyword lists, title and abstract. Many journals, abstracting services and databases already provide such keywords. The resulting lists of keywords have been standardized to eliminate different spellings and variants of the same terms. Coulter et al. [7] selected keywords chosen by professional indexers. They believed that it is useful to study a fixed system that imposes a common nomenclature. Professional indexers' experiences assure standard application of that taxonomy. Looze and Lemarie [8] conducted co-word study based on the keywords proposed by the experts. Courtial [9] [10] and Law [11] downloaded keywords from online databases, which are added by database indexers and authors. Noyons and van Raan [12] [13] [14] [15] mapped the overall structure in the field of neural networks by using the co-occurrence of classification codes.

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This model deals with content-variation analysis not in all forms of textual analysis, but in the form of keyword-cluster analysis. This model emphasizes quantitative, rather than qualitative approaches to content analysis though both are used in information studies. Content analysis is a flexible research method that can be applied to many problems in information studies, either as a method by itself or in conjunction with other methods.

The selection of keywords from a text is a vital task, and there is another crucial step prior to this task, that is to understand the text for recognizing the central theme. Beaugrande and Dressler [16] suggested seven criteria for defining a text, which is the common form of data for content analysis:

1) Cohesion;
2) Coherence;
3) Intentionality;
4) Acceptability;
5) Informativity;
6) Situationality; and
7) Intertextuality.

In other words, text appropriate for content analysis is composed of linguistic elements arranged in a linear sequence that follows rules of grammar and uses devices like recurrence, anaphora and cataphora, ellipsis, and conjunctions to bring the elements together to create a message. This is the theme of cohesion. The text has meaning, often established through relationships that may not be linguistically evident, and draws on frameworks within the recipient for understanding. This is an interaction between the text's linguistic criteria and receiver's cognitive criteria. This phenomenon is known as coherence. The writer or speaker of the text intends for it to convey meaning related to his attitude and purpose. The receiver's biasness here is imposed on text. This phenomenon is known as intentionality. Conversely, recipients of the message understand the text as a message; they expect it to be useful or relevant, which is an inverse phenomenon of intentionality and is known as acceptability. The text may contain new or expected information, allowing for judgments about its quality of informing, which is known as informativity. The situation surrounding the text affects its production and determines what is appropriate for the situation and the culture, which is known as situationality. The text is often related to what precedes and follows it, as in a conversation (one interpretation of inter-textuality), or is related to other similar texts, for example, others within a genre, such as transcripts of chat sessions (another meaning of inter-textuality). This is just juggleries of interpretations in conversational stream, which is known as inter-textuality.

3 OBJECTIVES

The principal objectives of this article are summarized below:

1. To present a method of content analysis based on keywords;
2. To categorize keywords in different groups;
3. To describe physical forms of keywords, which includes structural aspects of the same; and

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4. To present details about intrinsic characteristics of the keywords through a sample collected from the journal-papers on Fermi-liquid.

4 SCOPE & METHODOLOGY

The titles and abstracts of 70 research articles belonging to the subject Fermi Liquid have been collected from the bibliographic database of INSPEC during the span of seven years, i.e. 2000-2006. The first ten articles have been selected in the decreasing order of relevance from each year's database. The method of systematic sampling is followed here. The keywords have been culled out from the titles and abstracts of said 70 articles. The keywords beginning with the letters 'A' to 'F' only are considered for this study. The notable feature is that only research articles have been taken for study out of the entirely available published literature. The other forms of outcomes like monographs, conference-proceedings, short communications, reviews, letters, reports etc. have been excluded from the considered domain of the present study as the largest contribution to the full set of published literature comes only from the research articles. The collected keywords are presented in Table 3. All categories are listed in Table 1 and the nature of keywords corresponding to each and every category is shown in Table 2.

In all, 97 keywords have been analyzed in detail, as presented in Table 3 and Table 4. The structural analysis of keywords is shown in Table 3; and the criteria-based categories of the keywords are shown in Table 4. All keywords are not collected from titles and abstracts for study, but some keywords, which are belonging to the following categories, have been rejected:

1. Too lengthy keyword (e.g. Low-temperature specific heat coefficient C/sub V//T, this keyword is selected after cutting off the last part);
2. Too common keyword (e.g. Physics);
3. Acronym (e.g. MFT) (Acronym is considered after expansion; e.g. Magnetic Field Tuning for MFT);
4. Too specific jargon (e.g. 1/[T ln/sup 4/(T/sub K//T)] divergence);
5. Keywords not directly related with central or allied theme of the subject concerned as manifested by the abstract (e.g. Local moments);
6. Symbol;
7. Formula (e.g. B ln/sup 2/(T/sub K//B)); and
8. Numerical figure.

5 KACOVA MODEL

The content analysis based on keywords emphasizes not only analysis of contents, but also the variation of contents over a stipulated time span. This is an important feature. The science and social science information are highly time-dependent. As information is manifested through keywords, the variation of information may also be traced through analysis of keywords over a particular time span. A keyword-based content analysis system involves a set of processes and techniques that support the evolutionary life cycle of the concerned subject information. Content analysis practices and goals vary with mission. News organizations, e-commerce websites and

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educational and research institutions all analyze their respective content, but in different ways. This leads to differences in categories of keywords that are presented in Table 1. The characteristics are shown here for research-based information on the subject of Fermi-Liquid.

A keyword-based content analysis consists of the following basic identification marks for categorizing the keywords:

- Source – the place of occurrence of keywords;
- User or receiver – the target audience for tuning the content message carried by the Keyword and the style of expression of the same; and
- Meaning – the meaning of the keywords to different users.

A critical aspect of content analysis is the ability to manage versions of content as it evolves with time. Another equally important aspect of content analysis involves the creation, maintenance, and application of review standards. A content analysis system involves a set of automated processes that supports the following features:

- Import and creation of sources of keywords;
- Identification of all keywords and their categories;
- The ability to assign target audience group belonging to each and every category; and
- The ability to track multiple versions of a particular keyword representing particular content.

The name given to this particular methodology of study incorporated to analyze temporal variation of content of a subject is, Keyword Associated COntent Variation Analysis or KACOVA [17]. This model involves a detailed abstraction and analysis of keywords. Any analytical study includes some of categorization of the subject of study. In accordance with this point of view, a systematic method of categorization of keywords has been presented here in the following Table 1. Before going through categorization, several steps are needed to follow. Those main steps involved in the KACOVA model are illustrated below (Fig. 1).

6 KEYWORD: STRUCTURAL ASPECT

The keywords are basically words or a collection of words. Sometimes a single word can be recognized as a keyword, while in many cases, a combination of two, three or even four words is regarded as a keyword. There is no hard and fast rule regarding the upper limit of the number of words maximally eligible to form a keyword. But usually there are maximum four or five words within a keyword. In this paper, 97 keywords (starting with the letter 'A' to 'F') have been structurally analyzed in details out of 335 keywords collected from 70 journal articles over a time span of seven years (Taking ten papers from each of the years from 2000 to 2007) belonging to the subject 'Fermi liquid'. The structural aspects of said 97 keywords are presented in Table 3. After thorough inspection, the keywords have been segmented in utmost three kernels, which comprise [18]:

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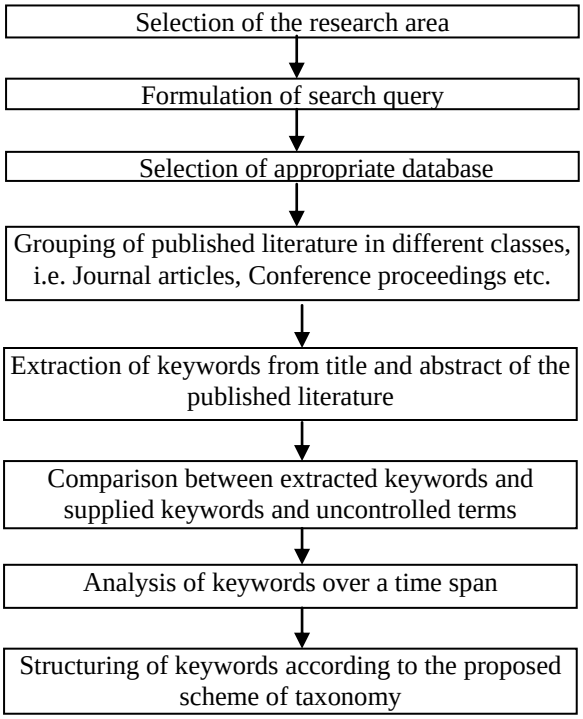

Figure 1: Steps involved in KACOVA model

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1) Keyphrase;
2) Modulator; and
3) Qualifier.

The keyphrase tells the central theme underlying behind the concept, the modulator amends the central theme in accordance with the relevant context. The modulator modulates the manifestation by the total spectrum of the central theme. The modulator polarizes the all-pervaded manifestation of the keyphrase in a specific orientation. The qualifier comes after the modulator to describe the particular state of the central concept and/or amended concept without disturbing the conceptual wholeness.

The notable point is that, there are differences between "Keyphrase" and "Keyword". For instance, the "Keyphrase" is just a part of a "Keyword", but not the entire keyword. A complete "Keyword" consists of all three above-mentioned components, i.e. Keyphrase, modulator and qualifier. There may be lot of keywords containing Keyphrase only, as evident from Table 3, but that is accidental. It is to be noted that all keywords studied here don't consist of all these three parts. The keyphrase is mandatory component of a keyword, i.e. each and every keyword must have a keyphrase, whereas other two components are optional, i.e. a keyword may or may not contain either a modulator or a qualifier or both. In this study, some keywords contain only

keyphrase, some other contains keyphrase and modulator, and a number of keywords contain keyphrase and qualifier; whereas the remaining keywords contain all these three kernels, viz. keyphrase, modulator and qualifier. The sequence of outcome of these three components is: Keyphrase ---------- Modulator ---------- Qualifier. The physical structure of a keyword thus takes the form as given below:

$$\text{Keyword} = (\underset{\text{Mandatory}}{\text{Keyphrase}} + \underset{\text{Optional}}{\text{Modulator}}), \quad \underset{\text{Optional}}{\text{Qualifier}}$$

The keyphrase is a subject-specific term/terms, the modulator may either be a subject-specific term/terms or a general word/words and the qualifier is a general word for majority of keywords. The qualifier hardly becomes a subject-specific term. Thus the keywords have been undergone through the following three phases after collection.

1) The three kernels of each keyword were identified at first
2) The kernels were arranged in the following order:
   Keyphrase ⟹ Modulator ⟹ Qualifier
3) The keywords were reorganized alphabetically in this order

7 KEYWORD: BASIC CRITERIA AND CATEGORIES

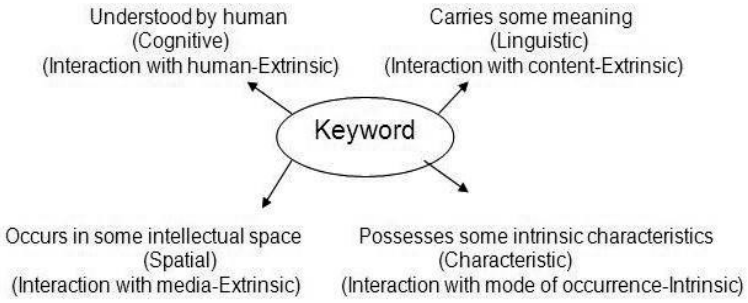

Fig. 2: Four Basic Criteria of a Keyword

In this study, the keywords have been categorized in four basic criteria. Each and every keyword carries some meaning that has been regarded as linguistic criteria. This criteria deal with the content expressed by the keyword and therefore this is a content-specific criterion. The keywords are always reckoned by human beings, also sometimes a particular keyword carries different meanings to different people. This has been regarded as cognitive criteria. This is a user-specific criterion. the keywords occur in some space, which may range from either journal article or books to even a popular magazine or newspaper. This is regarded as spatial criteria, which is a domain-specific criterion. lastly, all keywords possess some intrinsic characteristics, which are taken as characteristic criteria. the cognitive, linguistic and spatial criteria may jointly be regarded as extrinsic criteria, as these criteria evolves due to interaction of the keyword with some external agent like either human component, or media, or content. But the characteristic criteria evolve

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due to nature and property of the keyword and its different modes of occurrences. The characteristic criterion is thus (mode-of-occurrence)-specific criterion.

The specific orientations of these four criteria are given below:

Cognitive criteria → User-specific
Linguistic criteria → Content-specific } Extrinsic
Spatial criteria → Domain-specific
Characteristic criteria → (Mode-of-occurrence)-specific (INTRINSIC)

There exist some sub-criteria under each basic criterion. The Characteristic Criteria, also the only intrinsic one, consists of four sub-criteria that are exemplified in Table 2. All criteria and sub-criteria are listed in Table 1. Each sub-criterion consists of some specific keyword clusters, which are again classified in some more sub-classes. For instance, the sub-criterion, 'Associativeness with the Subject-Content (ASC)' consists of three sub-criteria named as 'Clustered', 'Twin' and 'Single' respectively. The representative notations of each sub-class are given in the last column of Table 1.

Table 1: Keyword categories based on four basic criteria

Nature of criteria	Basic criteria	Sub criteria	No. of classified keyword clusters	Name of each cluster		Representative Notation
Intrinsic	Characteristic Criteria	Associativeness with the Subject-Content (ASC)	3	Clustered		AK
				Twin		AW
				Single		AS
		Chronological Appearance (CAP)	4	Ephemeral		CE
				Non-Ephemeral (CF)	New	CJ
					Stable	CY
					Obsolete	CO
		Frequency of Occurrence (FOC)	3	Mono-frequent		FI
				Di-frequent		FD
				Multi-frequent		FU
				Action		TG

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Nature of criteria	Basic criteria	Sub criteria	No. of classified keyword clusters	Name of each cluster	Representative Notation
		Category (CAT)	6	Theory	TT
				Entity	TX
				Material	TM
				Property	TP
				Method	TH
Extrinsic	Linguistic Criteria	Clarity of Meaning (COM)	3	Clear	MC
				Jargon	MJ
				Ambiguous	MA
		Type of Meaning (TOM)	4	Factual	YF
				Analytic	YA
				Subjective	YS
				Objective	YO
		Scope of Meaning (SOM)	3	Common Word	SC
				Subject-generic	SG
				Subject-specific	SS
	Cognitive Criteria	Level of Perception (LOP)	3	Popular	LP
				Specific	LS
				Scholarly	LC
		Mode of Creation (MOC)	2	Fundamental	MF
				Derived	MD
	Spatial Criteria	Area of Occurrence (AOC)	5	Research Communication	RR
				Review Literature	RL
				General Information	RG
				Professional Information	RP
				General Recreation	RC

Table 1A: Ephemeral and non-ephemeral keywords (Definition)

Keyword-type \ Year		Y-2	Y-1	Y (Concerned Year)	Y+1	Y+2
Non-Ephemeral	New			A, B, C	A, C	A, B
	Steady	D, E, F	D, F	D, E, F	E, F	D, E
	Obsolete	G, H, I	H, I	G, H, I		
Ephemeral				J, K, L		

The alphabets A, B, C etc. represent keywords. The year under consideration is represented by Y. The ephemeral keywords for the year Y occur only in the year Y, whereas the non-ephemeral keywords occur in other years also. If any keyword occurs all other years except the year Y, then it will not be considered as the keyword of the year Y. The keywords A, C are New with respect to the year Y, because they appear for the first time in the year 'Y'; whereas Steady with respect to the year Y+1, because they appear in both preceding and following years of the year 'Y+1'. Similarly, the keywords H, I are Steady with respect to the year Y-1, but Obsolete with respect to the year Y, because they appear for the last time in the year 'Y'. The classifications New, Obsolete and Steady are thus temporal classifications, i.e. classifications based on time and hence change from year to year. If a keyword starts to occur from the year 2004, say, and continued till 2007, but disappeared after 2007, then the keyword would be considered as "New" in 2004; "Steady" in the year 2005 and 2006 and "Obsolete" in 2007.

Table 2: Nature of Keywords

Name of each cluster		Basic nature of keywords belonging to respective clusters
Clustered		A group of keywords containing a common keyphrase within a specific subject
Twin		Two keywords containing a common keyphrase within a specific subject
Single		A unique keyword within the particular domain of a specific subject
Ephemeral		A keyword belonging to a specific subject-domain appearing once only in the literature of the said subject over a stipulated span of time
Non-Ephemeral (CF)	New	A keyword belonging to a specific subject-domain appearing first in the literature of the said subject-domain at a particular year is considered 'New' in that year only
	Stable	A keyword belonging to a specific subject-domain appearing either second or third or any other higher time (But not last) in the literature of the said subject-domain at some year(s) is considered 'Stable' in those couple of year(s) only
	Obsolete	A keyword belonging to a specific subject-domain appearing last in the literature of the said subject-domain at a particular year is considered 'Obsolete' in that year only
Mono-frequent		A keyword occurs once only in the literature of the concerned subject over a stipulated time span
Di-frequent		A keyword occurs twice only in the literature of the concerned subject over a stipulated time span
Multi-frequent		A keyword occurs more than twice in the literature of the concerned subject over a stipulated time span
Action		Keyword(s) representing some sort of function(s) or activities
Theory		Keyword(s) representing some sort of theory or theoretical model
Entity		Keyword(s) representing some sort of idea(s) or concept(s)
Material		Keyword(s) representing some sort of concrete material(s)
Property		Keyword(s) representing some sort of attribute(s)
Method		Keyword(s) representing some sort of method(s) or technique(s)
Clear		Keyword(s) having an easily recognizable meaning by general audience

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Name of each cluster	Basic nature of keywords belonging to respective clusters
Jargon	Keyword(s) having a meaning, which is recognizable by the concerned subject or technical expert
Ambiguous	Keyword(s) having a fizzy meaning that is not clearly recognizable
Factual	Keyword(s) indicating some facts or phenomena
Analytic	Keyword(s) indicating some methodology or property
Subjective	Keyword(s) indicating some specific domain belonging to any subject
Objective	Keyword(s) indicating some specific object or data
Common Word	Keyword(s) belonging to superficial areas of a broad discipline
Subject-generic	Keyword(s) belonging to overall areas of any particular subject
Subject-specific	Keyword(s) belonging to specific area(s) of any particular subject
Popular	Keyword(s) for folk or common people
Specific	Keyword(s) for people belonging to specific communities
Scholarly	Keyword(s) for people belonging to learned or scholarly group(s)
Fundamental	Keyword(s) obtained from basic research, or classic text/scripture(s), or primary sources
Derived	Keyword(s) obtained from applied research, or fundamental keyword(s), or from secondary/tertiary sources
Research Communication	Keyword(s) occur in primary scholarly communication for learned societies
Review Literature	Keyword(s) occur in secondary review literature
General Information	Keyword(s) occur in mass media and general secondary sources for general public
Professional Information	Keyword(s) occur in technical communication for people belonging to some specific professional group(s)
General Recreation	Keyword(s) occur in recreational media for amusement of general public

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Table 3: Three kernels of keywords according to proposed structural analysis

KEYWORD = (KEYPHRASE + MODULATOR + QUALIFIER) **KEYPHRASE → ( ) MODULATOR → { }** **QUALIFIER → [ ]** (The symbol → stands for 'Is indicated by')	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Total**
(1/N-expansion)	1							1
(Absorption), [collisionless]						1		1
(Acoustic-wave) {propagation}				1				1
(Adsorption)					1			1

KEYWORD = (KEYPHRASE + MODULATOR + QUALIFIER) **KEYPHRASE → ( ) MODULATOR → { }** **QUALIFIER → [ ]** (The symbol → stands for 'Is indicated by')	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Total**
(Aluminium) {compound}		1						1
(Amplitude) {mode}				1				1
(Analytic-continuation)		1						1
(Anderson-model)	1		1					2
(Angular-momentum), [orbital]	1							1
(Anisotropic-large-dimension-limit)	1							1
(Anomalous-distribution-function)	1							1
(Anomalous-exponent)	1							1
(Anomalous-property)		1						1
(Antiferromagnet), [metallic]	1							1
(Antiferromagnetic-material)	1					1		2
(Antiferromagnetism)				1			1	2
(Antiferromagnetism), [itinerant]				1				1
(Anvil-apparatus), [cubic]							1	1
(Atomic-system)							1	1
(Band) {filling}, [conduction]					1			1
(Band) {model}, [magnetism]			2	1		1		4
(Band) {structure}	2						1	3
(Band), [highly-1d] [half-filled]							1	1
(Band), [parabolic]	1							1
(Band), [valence]					2			2
(Bethe-ansatz-solution)			1					1
(Bias-voltage)						1		1
(Binding-energy)					1			1
(Bogolubov-method)						1		1
(Boson), [Schwinger]				1				1
(Carbon-nanotube)		1		1	1			3
(Carbon-nanotube), [multi-walled]		1						1

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KEYWORD = (KEYPHRASE + MODULATOR + QUALIFIER) **KEYPHRASE → ( ) MODULATOR → { }** **QUALIFIER → [ ]** (The symbol → stands for 'Is indicated by')	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Total**
(Carbon-nanotube), [single-wall]					1			1
(Charge) {carrier mobility}		1						1
(Charge) {transfer}							1	1
(Charge) {transfer complex}, [organic]							1	1
(Charge-density-wave)				1				1
(Chemical-potential)	2							2
(Collective-mode)				1				1
(Conducting-material)						1		1
(Conductivity)			1					1
(Conductivity), [1d]		1						1
(Conductivity), [electrical]			1					1
(Contact-interaction)	1							1
(Core-level)					2			2
(Correlation-function), [density-density]	1							1
(Coulomb-interaction), [long-range]		1						1
(Coulomb-repulsion)						1		1
(Coupling-constant)					1			1
(Coupling-constant), [elementary-particle]					1			1
(Critical-fluctuation)			1					1
(Crossover-temperature)			1					1
(Current-voltage) {characteristics}						1		1
(Current-voltage) {characteristics}, [nonlinear]		1						1
(Cyclotron) {mode}, [high-order]						1		1
(Cyclotron) {resonance}						2		2
(Degenerate-level)							1	1
(Density-of-state)		1	1		2			4
(Density-of-state), [electronic]		1	1	1	2			5
(Dimensional-crossover)	1							1

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KEYWORD = (KEYPHRASE + MODULATOR + QUALIFIER) **KEYPHRASE → ( ) MODULATOR → { }** **QUALIFIER → [ ]** (The symbol → stands for 'Is indicated by')	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Total**
(Dispersion), [spatial]						1		1
(Dispersion-relation)		2						2
(Dispersion-relation), [strongly-anisotropic]						1		1
(Dopant-concentration), [low]					1			1
(Dyson-Schwinger-equation)					1			1
(Effective-mass)		2	2	1				5
(Electromagnetic-wave) {frequency}						1		1
(Electromagnetic-wave) {propagation}						2		2
(Electron)							1	1
(Electron) {correlation}	1							1
(Electron) {gas}, [2d]		2						2
(Electron) {metal}, [D]		1						1
(Electron), [conduction]				1			1	2
(Electron), [disordered] [itinerant]			1					1
(Electron), [localized]			1					1
(Electron), [exchange interaction]	2		1					3
(Electronic-state)	1							1
(Electron-system), [Graphene-based]		1						1
(Electron-system), [strongly-correlated]			1	1		2		4
(Energy-dependence)			1					1
(Energy-functional)	1							1
(Entropy)						2		2
(Fermi-energy)				1				1
(Fermi-level)				2	4			6
(Fermi-liquid)	7	6	5	4	6	8	4	40
(Fermi-liquid) {fixed-point}	1	1		1				3
(Fermi-liquid) {interaction}						1		1
(Fermi-liquid) {interaction}, [exchange]	1							1

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KEYWORD = (KEYPHRASE + MODULATOR + QUALIFIER) **KEYPHRASE → ( ) MODULATOR → { }** **QUALIFIER → [ ]** (The symbol → stands for 'Is indicated by')	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Total**
(Fermi-liquid) {system}, [marginal]						1		1
(Fermi-liquid) {theory}					1			1
(Fermi-liquid), [disordered]			1					1
(Fermi-liquid), [electronic] [nematic]				1				1
(Fermi-liquid), [Galilean-invariant]		1						1
(Fermi-liquid), [marginal]			1	1				2
(Fermi-liquid), [nematic]				1				1
(Fermi-liquid), [superfluid] [paramagnetic]	1							1
(Fermi-liquid-Luttinger-liquid-transition)		1						1

Table 4: Classification of keywords according to proposed scheme of taxonomy

KEYWORD = (KEYPHRASE + MODULATOR + QUALIFIER) **KEYPHRASE → ( )** **MODULATOR → { }** **QUALIFIER → [ ]** (The symbol → stands for 'Is indicated by')	**Intrinsic Criterion**				**Extrinsic Criterion**					
					Linguistic Criterion			**Cognitive Criterion**		**Spatial Criterion**
	ASC	**CAP**	**FOC**	**CAT**	**COM**	**TOM**	**SOM**	**LOP**	**MOC**	**AOC**
(1/N-expansion)	AS	CE	FI	TH	MJ	YA	SS	LC	MD	RR
(Absorption), [collisionless]	AS	CE	FI	TG	MC	YF	SG	LC	MD	RR
(Acoustic-wave) {propagation}	AS	CE	FI	TG	MC	YF	SG	LC	MD	RR
(Adsorption)	AS	CE	FI	TG	MC	YF	SG	LC	MF	RR
(Aluminium) {compound}	AS	CE	FI	TM	MC	YO	SC	LC	MF	RR
(Amplitude) {mode}	AS	CE	FI	TX	MJ	YS	SG	LC	MD	RR
(Analytic-continuation)	AS	CE	FI	TH	MJ	YA	SG	LC	MD	RR
(Anderson-model)	AS	CF	FD	TT	MJ	YA	SS	LC	MD	RR
(Angular-momentum), [orbital]	AS	CE	FI	TX	MC	YS	SG	LC	MF	RR
(Anisotropic-large-dimension-limit)	AS	CE	FI	TX	MJ	YA	SS	LC	MD	RR
(Anomalous-distribution-function)	AS	CE	FI	TT	MJ	YS	SS	LC	MD	RR

KEYWORD = (KEYPHRASE + MODULATOR + QUALIFIER) **KEYPHRASE → ( )** **MODULATOR → { }** **QUALIFIER → [ ]** (The symbol → stands for 'Is indicated by')	**Intrinsic Criterion**				**Extrinsic Criterion**					
					Linguistic Criterion			**Cognitive Criterion**		**Spatial Criterion**
	ASC	**CAP**	**FOC**	**CAT**	**COM**	**TOM**	**SOM**	**LOP**	**MOC**	**AOC**
(Anomalous-exponent)	AS	CE	FI	TX	MJ	YS	SG	LC	MF	RR
(Anomalous-property)	AS	CE	FI	TP	MJ	YA	SC	LC	MF	RR
(Antiferromagnet), [metallic]	AS	CE	FI	TM	MJ	YO	SG	LC	MF	RR
(Antiferromagnetic-material)	AS	CF	FD	TM	MJ	YO	SG	LC	MF	RR
(Antiferromagnetism)	AW	CF	FD	TX	MJ	YS	SG	LC	MF	RR
(Antiferromagnetism), [itinerant]	AW	CE	FI	TX	MJ	YS	SS	LC	MD	RR
(Anvil-apparatus), [cubic]	AS	CE	FI	TM	MJ	YO	SS	LC	MD	RR
(Atomic-system)	AS	CE	FI	TX	MC	YS	SG	LC	MF	RR
(Band) {filling}, [conduction]	AK	CE	FI	TG	MJ	YF	SS	LC	MD	RR
(Band) {model}, [magnetism]	AK	CF	FU	TT	MJ	YS	SS	LC	MD	RR
(Band) {structure}	AK	CF	FU	TX	MJ	YS	SG	LC	MF	RR
(Band), [highly-1d] [half-filled]	AK	CE	FI	TX	MJ	YS	SS	LC	MD	RR
(Band), [parabolic]	AK	CE	FI	TX	MJ	YS	SS	LC	MD	RR
(Band), [valence]	AK	CE	FD	TX	MJ	YS	SG	LC	MD	RR
(Bethe-ansatz-solution)	AS	CE	FI	TH	MJ	YA	SG	LC	MD	RR
(Bias-voltage)	AS	CE	FI	TX	MC	YS	SC	LC	MF	RR
(Binding-energy)	AS	CE	FI	TX	MJ	YS	SC	LC	MF	RR
(Bogolubov-method)	AS	CE	FI	TH	MJ	YA	SS	LC	MD	RR
(Boson), [Schwinger]	AS	CE	FI	TX	MJ	YS	SS	LC	MD	RR
(Carbon-nanotube)	AK	CF	FU	TX	MJ	YO	SG	LC	MD	RR
(Carbon-nanotube), [multi-walled]	AK	CE	FI	TX	MJ	YO	SG	LC	MD	RR
(Carbon-nanotube), [single-wall]	AK	CE	FI	TX	MJ	YO	SG	LC	MD	RR
(Charge) {carrier mobility}	AK	CE	FI	TX	MJ	YF	SG	LC	MD	RR
(Charge) {transfer}	AK	CE	FI	TG	MJ	YF	SC	LC	MF	RR
(Charge) {transfer complex}, [organic]	AK	CE	FI	TG	MJ	YF	SG	LC	MD	RR

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KEYWORD = (KEYPHRASE + MODULATOR + QUALIFIER) **KEYPHRASE → ( )** **MODULATOR → { }** **QUALIFIER → [ ]** (The symbol → stands for 'Is indicated by')	**Intrinsic Criterion**				**Extrinsic Criterion**					
					Linguistic Criterion			**Cognitive Criterion**		**Spatial Criterion**
	ASC	**CAP**	**FOC**	**CAT**	**COM**	**TOM**	**SOM**	**LOP**	**MOC**	**AOC**
(Charge-density-wave)	AS	CE	FI	TX	MJ	YF	SG	LC	MD	RR
(Chemical-potential)	AS	CE	FD	TX	MJ	YA	SG	LC	MD	RR
(Collective-mode)	AS	CE	FI	TX	MJ	YA	SC	LC	MF	RR
(Conducting-material)	AS	CE	FI	TM	MC	YO	SG	LC	MD	RR
(Conductivity)	AK	CE	FI	TX	MC	YS	SG	LC	MF	RR
(Conductivity), [1d]	AK	CE	FI	TX	MJ	YS	SG	LC	MD	RR
(Conductivity), [electrical]	AK	CE	FI	TX	MC	YS	SG	LC	MD	RR
(Contact-interaction)	AS	CE	FI	TG	MJ	YF	SS	LC	MD	RR
(Core-level)	AS	CE	FD	TX	MJ	YA	SC	LC	MF	RR
(Correlation-function), [density-density]	AS	CE	FI	TT	MJ	YS	SG	LC	MD	RR
(Coulomb-interaction), [long-range]	AS	CE	FI	TG	MJ	YF	SG	LC	MD	RR
(Coulomb-repulsion)	AS	CE	FI	TG	MJ	YF	SG	LC	MD	RR
(Coupling-constant)	AW	CE	FI	TX	MJ	YS	SG	LC	MD	RR
(Coupling-constant), [elementary-particle]	AW	CE	FI	TX	MJ	YS	SG	LC	MD	RR
(Critical-fluctuation)	AS	CE	FI	TG	MJ	YF	SG	LC	MF	RR
(Crossover-temperature)	AS	CE	FI	TX	MJ	YS	SG	LC	MD	RR
(Current-voltage) {characteristics}	AW	CE	FI	TX	MC	YS	SG	LC	MD	RR
(Current-voltage) {characteristics}, [nonlinear]	AW	CE	FI	TX	MJ	YS	SG	LC	MD	RR
(Cyclotron) {mode}, [high-order]	AW	CE	FI	TX	MJ	YA	SG	LC	MD	RR
(Cyclotron) {resonance}	AW	CE	FD	TX	MJ	YA	SG	LC	MD	RR
(Degenerate-level)	AS	CE	FI	TX	MJ	YA	SG	LC	MF	RR
(Density-of-state)	AW	CF	FU	TX	MJ	YS	SG	LC	MF	RR
(Density-of-state), [electronic]	AW	CF	FU	TX	MJ	YS	SG	LC	MD	RR
(Dimensional-crossover)	AS	CE	FI	TX	MJ	YS	SG	LC	MD	RR

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KEYWORD = (KEYPHRASE + MODULATOR + QUALIFIER) **KEYPHRASE → ( )** **MODULATOR → { }** **QUALIFIER → [ ]** (The symbol → stands for 'Is indicated by')	**Intrinsic Criterion**				**Extrinsic Criterion**					
					Linguistic Criterion			**Cognitive Criterion**		**Spatial Criterion**
	ASC	**CAP**	**FOC**	**CAT**	**COM**	**TOM**	**SOM**	**LOP**	**MOC**	**AOC**
(Dispersion), [spatial]	AS	CE	FI	TX	MJ	YF	SG	LC	MD	RR
(Dispersion-relation)	AW	CE	FD	TX	MC	YA	SG	LC	MD	RR
(Dispersion-relation), [strongly-anisotropic]	AW	CE	FI	TX	MJ	YA	SG	LC	MD	RR
(Dopant-concentration), [low]	AS	CE	FI	TX	MJ	YA	SG	LC	MD	RR
(Dyson-Schwinger-equation)	AS	CE	FI	TT	MJ	YS	SG	LC	MD	RR
(Effective-mass)	AS	CF	FU	TX	MC	YS	SG	LC	MD	RR
(Electromagnetic-wave) {frequency}	AW	CE	FI	TX	MC	YS	SG	LC	MD	RR
(Electromagnetic-wave) {propagation}	AW	CE	FD	TG	MC	YF	SG	LC	MD	RR
(Electron)	AK	CE	FI	TM	MC	YS	SC	LC	MF	RR
(Electron) {correlation}	AK	CE	FI	TG	MJ	YF	SG	LC	MD	RR
(Electron) {gas}, [2d]	AK	CE	FD	TM	MJ	YS	SG	LC	MD	RR
(Electron) {metal}, [D]	AK	CE	FI	TM	MJ	YS	SG	LC	MD	RR
(Electron), [conduction]	AK	CF	FD	TM	MJ	YF	SC	LC	MD	RR
(Electron), [disordered] [itinerant]	AK	CE	FI	TM	MJ	YS	SS	LC	MD	RR
(Electron), [localized]	AK	CE	FI	TM	MJ	YS	SG	LC	MD	RR
(Electron), [exchange interaction]	AK	CF	FU	TM	MJ	YF	SG	LC	MD	RR
(Electronic-state)	AS	CE	FI	TX	MC	YA	SG	LC	MD	RR
(Electron-system), [Graphene-based]	AW	CE	FI	TM	MJ	YA	SG	LC	MD	RR
(Electron-system), [strongly-correlated]	AW	CF	FU	TM	MJ	YA	SG	LC	MD	RR
(Energy-dependence)	AS	CE	FI	TX	MC	YA	SG	LC	MD	RR
(Energy-functional)	AS	CE	FI	TX	MC	YS	SG	LC	MD	RR
(Entropy)	AS	CE	FD	TX	MC	YS	SC	LC	MF	RR
(Fermi-energy)	AS	CE	FI	TX	MJ	YS	SG	LC	MF	RR
(Fermi-level)	AS	CF	FU	TX	MJ	YS	SG	LC	MF	RR

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					Linguistic Criterion			**Cognitive Criterion**		**Spatial Criterion**
	ASC	**CAP**	**FOC**	**CAT**	**COM**	**TOM**	**SOM**	**LOP**	**MOC**	**AOC**
(Fermi-liquid)	AK	CF	FU	TX	MJ	YS	SG	LC	MF	RR
(Fermi-liquid) {fixed-point}	AK	CF	FU	TX	MJ	YA	SS	LC	MD	RR
(Fermi-liquid) {interaction}	AK	CE	FI	TG	MJ	YF	SS	LC	MD	RR
(Fermi-liquid) {interaction}, [exchange]	AK	CE	FI	TG	MJ	YF	SS	LC	MD	RR
(Fermi-liquid) {system}, [marginal]	AK	CE	FI	TX	MJ	YA	SS	LC	MD	RR
(Fermi-liquid) {theory}	AK	CE	FI	TT	MJ	YS	SS	LC	MD	RR
(Fermi-liquid), [disordered]	AK	CE	FI	TX	MJ	YS	SS	LC	MD	RR
(Fermi-liquid), [electronic] [nematic]	AK	CE	FI	TX	MJ	YS	SS	LC	MD	RR
(Fermi-liquid), [Galilean-invariant]	AK	CE	FI	TX	MJ	YS	SS	LC	MD	RR
(Fermi-liquid), [marginal]	AK	CF	FD	TX	MJ	YS	SS	LC	MD	RR
(Fermi-liquid), [nematic]	AK	CE	FI	TX	MJ	YS	SS	LC	MD	RR
(Fermi-liquid), [superfluid] [paramagnetic]	AK	CE	FI	TX	MJ	YS	SS	LC	MD	RR
(Fermi-liquid-Luttinger-liquid-transition)	AS	CE	FI	TG	MJ	YF	SS	LC	MD	RR

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8 CONCLUSION

A method of categorization and classification of keywords on the basis of some specific criteria are proposed here. This study has been partially executed on the subject "Fermi liquid". The viability of this classification scheme for the keywords from other subject areas will be studied later on. The keywords have been classified from four different criteria. In all, 97 keywords have been classified here. The keyword-collection portrays the core and allied contents of a subject. The extrinsic criteria of the keywords define the target audience group, who use it, and the intrinsic criteria define the mode of occurrence of the same. The extrinsic criteria are thus user-specific (how it is interpreted or understood), content-specific (what does it mean) and domain-specific (where it occurs) and the intrinsic criteria are (mode-of-occurrence)-specific. As the keywords are collected from research papers, therefore, in this study, all of them belong to "RR" for spatial criteria, and "LC" for cognitive criteria. The mode of classification of keywords is an indicator of research trend of a subject. The variation of content in a subject due to various

research projects from time to time will be reflected from the classified keywords over a stipulated time span.

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