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The Relational Data Model for the University Website with Search Engine Optimization

Muhammad Riza Alifi[1], Hashri Hayati[2]
Department of Computer Engineering and Informatics
Politeknik Negeri Bandung
West Bandung, Indonesia
[1]muhammad.riza@polban.ac.id
[2]hashri.hayati@polban.ac.id

Muhammad Galih Wonoseto
Informatics Department
UIN Sunan Kalijaga
Yogyakarta, Indonesia
muhammad.wonoseto@uin-suka.ac.id

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***Abstract*— The visibility of a university's website on the search engine becomes an essential factor to reach a wider audience. One way to improve the visibility of a website is through Search Engine Optimization (SEO). University's website development with SEO is inseparable from the data model because SEO supporting factors are parts of the consideration in the components and structure of the data model. This study aims to build a data model for a university website accompanied by SEO. The relational data model is used in this study based on the performance and maturity in defining schema-based design. This study was conducted through four sequential stages: literature review, planning, implementation, and evaluation. The resulting relational data model is one that has accommodated four supporting factors for SEO, namely Meta description, Meta keywords, URL structure, and image description. This study has succeeded in building a relational data model at the abstraction level of conceptual and logical. In the conceptual data model, one entity and 11 attributes are formed. The logical data model was implemented in independent work environments using RelaX and operational requirements can be fulfilled by representing each table or relationship in the schema using relational algebra.**

Keywords—website's visibility; conceptual data model; logical data model; supporting factors; functional requirements

1 INTRODUCTION

The advancement of information and communication media necessitates a more significant role for universities in providing society with the information it requires. The society in this case consists of prospective students, prospective staff, and the stakeholders who want to get to know each other better to establish synergy and become part of the university. A website is a crucial tool for universities because it is still considered an effective medium for publishing the most recent official information [1] and building brand recognition, especially for positions in international competition [1]–[3].

The habit of people today when searching for information is by entering keywords in search engines to find relevant information. Most people only open the information presented on the first page displayed by search engines. This habit breeds competition among websites so they can appear on the first page of the search results. If a website appears on the first page of a search engine, it indicates that the website has high online visibility. Search engine optimization (SEO) is one way to increase and get the best position visibility or strategic ranking on search engines [2].

University websites can use SEO to increase web visibility and accessibility to support digital marketing efforts [1] or to help national and international students search for research conferences, university grants, and admission information [4]. SEO strategy is also an important consideration for university's branding [5]. Furthermore, the visibility of websites on the search engine has become an essential factor in making it easier for people to find the information they need. Therefore, SEO for university websites have become an essential thing to do [2]. Many universities make use of ready-to-use open-source CMS [6]. SEO plugins are also available in some CMS [7], [8]. However, there are issues of continued support from developers and security when using an open-source CMS, so building a website independently is one option that can be chosen. On the other hand, the option of developing a website independently has challenges that must be addressed. At least it must be able to handle metadata management.

Developing a website independently that supports SEO is certainly inseparable from the data model. In this case, the relationship of websites with SEO and data models is to provide metadata storage allocation that supports SEO for websites in databases. Therefore, the data model is needed to ensure that the results of the implementation are under requirements and helpful in minimizing errors during the implementation process of forming the database schema. The more detailed the data model is, the higher the quality of the data and information that is managed [3], [9].

The data model can be represented at several levels of abstraction, including canonical, conceptual, logical, and physical data model. A conceptual data model is a data model that is very close to the business domain. A conceptual data model is generally represented in the form of ERD (Entity Relationship Diagram) with Peter Chen notation excelling in support and intuitiveness [10], [11]. Meanwhile, a logical data model is a fully normalized data model and closely related to the physical data model. Several related studies [12]–[15] are more dominant using physical data models with crow's foot notation.

The relational data model was carried out in this study. Performance consideration [12]–[14], [16] and maturity in defining schema-based design [10] are used to select relational data model. The contribution of this study is in designing a relational data model that considers metadata management for SEO, especially in the case of university website development.

This study method consists of four main stages: literature review, planning, implementation, and evaluation. At the planning stage, the determination of functional requirement, determination of entity, attribute, relationship, and environmental are carried out. The determination is carried out by considering system requirements in terms of content and supporting factors for SEO that include metadata for description and keywords, a URL (Uniform Resource Locator) structure on each page of the website, and image description.

Implementation of this study consists of the conceptual and logical data model. The conceptual data model uses ERD with Peter Chen notation and is based on the determination of entity, attribute, and relationship. Crow's foot notation was used in the logical data model. The conceptual data model was evaluated based on its suitability to the functional requirements. Meanwhile, the logical data model was evaluated based on the completeness of data retrieval operations using relational algebra. This study uses RelaX as the work environment to evaluate the logical data model.

2 METHOD

The study is carried out in four stages, beginning with (1) literature review to examine the problem; (2) planning to establish a case study and focus on the problem to be resolved; (3) implementation is a problem-solving process to produce a solution; and (4) evaluation to ensure the resulting solution conform to specification and produce a good output.

2.1 Literature Review

References in conceptual and logical data models in relational data models are analysed, including topics concerning university website development. References that have been studied to raise the problem are identified.

2.2 Planning

2.2.1 Determination of Case: The development of university website with SEO is the case to be observed in this study. The case's scope includes managing articles, pages, photo galleries, comments, users, staff, publications, and contacts. Furthermore, supporting factors can help website be indexed more optimally on Google's search engine [17]. Supporting factors in this case include metadata for description and keywords, a URL structure on each page of the website, and image description.

Table 1. Supporting Factors for SEO

Code	*Supporting Factor*	*Description*
SEO-01	Meta description	Summary or *excerpt* of the content that appears on each page of the website. Meta description plays an important role because it can be used by Google's search engine as a snippet in search results.
SEO-02	Meta keywords	Keywords that describe the content on a website page. Meta keywords were no longer used by Google's search engine starting in 2009 [18]. In this case, the meta key from the *tag* collection is still provided because there is still the possibility of influence and will be reused.
SEO-03	URL structure	The URL or *slug* structure on each page of a website needs to be structured to be more meaningful and easier to understand the context so that search engine can index and influence ranking on search results. Furthermore, Google recommends that the URL constructed contain the words used in the website's page title.
SEO-04	Image description	The image *description* is necessary to provide textual information about images while making it easier for Google's search engine to find images relevant to user's keywords. In this case, the image and description of the article include part of the content.

2.2.2 Determination of Functional Requirements: The process that was used to determine functional requirements includes: (1) finding a university website for reference, both at home and abroad, that has a good reputation based on the world university ranking website (webometrics.info); (2) benchmarking some university websites obtained by grouping commonly found features; (3) adding a description of the requirements of each feature of the grouping and translate it as a list of requirements; and (4) completing the list of requirements with the SEO supporting factors defined in Table 1.

There are six websites at department, faculty, and university levels used as references to compile a list of requirements: (1) ITB (itb.ac.id); (2) ITB-Informatics (if.stei.itb.ac.id); (3) UI (ui.ac.id); (4) UI-Computer Science (cs.ui.ac.id); (5) Singapore Polytechnic (sp.edu.sg); and (6) MIT-Electrical Engineering and Computer Science (eecs.mit.edu). The six websites have adequately represented the variety of information required by universities. The selection of the websites is also influenced by the preference of the authors who have informatics engineering background.

Table 2. Requirements for University Website Development with SEO

Code	*Requirement*	*Feature*
REQ-01	The contributor can add only articles with the status "draft".	Article
REQ-02	The editor can modify and publish an article written by authors by changing the status to "published."	Article
REQ-03	The editor can add, modify, publish, and delete articles.	Article
REQ-04	An article that can be permanently deleted must have a "Trash" status.	Article
REQ-05	The administrator can add, modify, and publish manuscripts for articles.	Article
REQ-06	The visitor can read the article that includes the following elements: title, content, excerpt, author, editor, published date, and updated date.	Article
REQ-07	More than one image and description can be included in an article's content.	Article
REQ-08	The article has one or more authors.	Article
REQ-09	An article has the slug for easy search engine indexing support.	Article
REQ-10	The administrator can create, modify, and delete category.	Category
REQ-11	An article must and only be classified in one category.	Category
REQ-12	The contributor can change the category of the article that she/he wrote.	Category
REQ-13	The editor can change the category of articles they write or edit.	Category
REQ-14	The category has the slug to support search engine indexability.	Category
REQ-15	The category has a description to provide further explanation.	Category
REQ-16	The administrator can change the category of the entire article.	Category
REQ-17	The administrator can add, change, and remove tags.	Tag
REQ-18	The article is required to have more than one tag.	Tag
REQ-19	The contributor can change the tag on the article that has been written.	Tag
REQ-20	The editor can change the tag on the article that has been written or edited.	Tag
REQ-21	The administrator can change the tag on the whole article.	Tag
REQ-22	The tag has a slug for easy search engine indexing support.	Tag
REQ-23	The tag has a description to provide further explanation.	Tag
REQ-24	The visitor can comment on articles by including their name, email address, and comments.	Comment
REQ-25	The administrator can approve comments.	Comment
REQ-26	The editor and administrator can add, modify, publish, and delete pages.	Page
REQ-27	The visitor can read the article that consists of the title, content, excerpt, author, editor, published date, updated date.	Page
REQ-28	The page content includes text, table, image with description, video, and other HTML (HyperText Markup Language) supported format.	Page
REQ-29	The page has the slug to support search engine indexability.	Page
REQ-30	The page can be multiple authors.	Page
REQ-31	The editor and administrator can add, modify, publish, and delete the galleries.	Gallery
REQ-32	The gallery can contain multiple photos, each accompanied by a description.	Gallery

Table 3. Requirements for University Website Development with SEO (continued)

Code	*Requirement*	*Feature*
REQ-33	The gallery has a slug for search engine indexability.	Gallery
REQ-34	The visitor can view a gallery that includes the title, description, uploader, published date, and updated date.	Gallery
REQ-35	The visitor can view the data of the university's staff (lecturers and staff), which includes identification and written work.	Staff
REQ-36	The staff data includes name, study program, field, profession (lecturers and staff), and active status.	Staff
REQ-37	The editor and administrator can add, modify, publish, and delete staff.	Staff
REQ-38	The visitor can only view data on currently employed employees (not retired or not resigned).	Staff
REQ-39	Each staff member's (lecturer's) publication includes the title, published date, description, publisher, and type (journal, conference, book, patent, etc).	Staff
REQ-40	The visitor can send a message to the university by filling out the form on the website page and including their name, email address, subject, and message content.	Contact
REQ-41	The administrator can mark the read status for each incoming message.	Contact
REQ-42	The administrator can add, change, and deactivate the user account.	User
REQ-43	The user data includes account information, profile photo, and biodata.	User

Furthermore, it is mandatory to map the supporting factors of SEO to ensure that the functional requirements have covered the entire case study. Table 4 shows the mapping that the supporting factors of SEO have been accommodated in the functional requirements.

Table 4. Mapping Supporting Factors of SEO with Functional Requirements

Supporting Factor	*Functional Requirement*	*Description*
SEO-01	REQ-06, REQ-27, REQ-34	Define excerpt for article, page, and gallery.
SEO-02	REQ-18	Define tag of keyword for the article
SEO-03	REQ-09, REQ-14, REQ-22, REQ-29, REQ-33	Define slug to construct URL structure for article, page, gallery, category, tag
SEO-04	REQ-07, REQ-28, REQ-32	Define image description in the content of article, page, and gallery.

2.2.3 Determination of Entity, Attribute, and Relationship: The relational data model, particularly at the conceptual abstraction level, must begin with the definition of the necessary components, which are an entity, attribute, and relationship formed based on functional requirements in Table 2 and Table 3. Table and Table 6 contains 13 entities, 67 attributes, and 12 relationships that have been defined. Cardinality is defined in each relationship by a 1-to-N statement to express one-to-many and an M-to-N statement to express many-to-many.

Table 5. Entity, Attribute, and Relationship

No.	*Entity (Alias)*	*Attribute*	*Relationship*
1	Article (a)	• Article ID • Title • Slug • Content • Excerpt • Published At • Updated At • Status (“Draft”, “Publish”, “Trash”)	• Comment (Article ID): 1-to-N
2	Category (c)	• Category ID • Name • Slug • Description	• Article (Category ID): 1-to-N
3	Tag (t)	• Category ID • Name • Slug • Description	• Article (Tag ID): M-to-N
4	Comment (cm)	• Comment ID • Name ●Email • Content • Submitted At • Approval Status (“True”, “False”)	--
5	Page (p)	• Page ID • Title • Slug • Content • Excerpt • Published At • Updated At • Status (“Draft”, “Publish”, “Trash”)	--
6	Gallery (g)	• Gallery ID • Title • Slug • Content • Published At • Updated At • Status (“Draft”, “Publish”, ”Trash”)	• Media (Gallery ID): 1-to-N
7	Media (m)	• Media ID • Path	--
8	Staff (s)	• Staff ID • Name • Profession (“Lecturer”, ”Officer”) • Active Status (“True”, “False”)	• Publication (Staff ID): M-to-N
9	Expertise (e)	• Expertise ID • Name	• Staff (Expertise ID): 1-to-N
10	Study Program (sp)	• Study Program ID • Name	• Staff (Study Program ID): 1-to-N
11	Publication (pb)	• Publication ID • Title • Type (Journal, Conference, Book, Patent, Other) • Publisher • Description • Published At	--

Table 6. Entity, Attribute, and Relationship (continued)

No.	*Entity (Alias)*	• *Attribute*	*Relationship*
12	Contact (cn)	• Contact ID • Name • Email • Subject • Content	--
13	User (u)	• User ID • Username • Password • Name • Email • Photo • Biodata • Role (Contributor, Editor, Administrator) • Active Status (“True”, ”False”)	• Article (User ID): M-to-N • Page (User ID): 1-to-N • Gallery (User ID): 1-to-N • Staff (User ID): 1-to-N • Contact (User ID): 1-to-N

2.2.4 *Determination of Environmental:* Besides being independent of the database engine, the work environment for implementing the resulting data model should support operation using relational algebra. This is closely related to the evaluation stage of a logical data model.

The tool chosen to provide a work environment while fulfilling these requirements is RelaX (dbis-uibk.github.io/relax), a web-based relational algebra calculator. RelaX developed by Johannes Kesler of the University of Innsbruck, can execute both relational algebra and SQL (Structured Query Language) on large data sets.

2.3 Implementation

2.3.1 *Implementation of Conceptual Data Model:* The conceptual data model is built on E-RD using the Peter Chen notation rules. It includes information indicating the degree of minimum (modality) and maximum relationship (cardinality). The conceptual data model should be designed following Table .

2.3.2 *Implementation of Logical Data Model:* Crow's foot notation is used on the logical data model to provide a visual close to the implementation phase and still include modality and cardinality. The logical data model emphasizes the display of the results of relationships in the form of a foreign key that refers to the primary key and a table derived from a relationship with M-to-N cardinality (many-to-many).

2.4 Evaluation

2.4.1 *Evaluation of Conceptual Data Model:* The principle evaluation of the conceptual data model is to ensure that the model is built in accordance with business requirements. A checklist used during the examination process, referring to Table 2, which contains a list of functional requirements.

2.4.2 *Evaluation of Logical Data Model:* The process evaluation of logical data model consists of four steps: (1) building a table structure or relationship based on the logical data model that has been produced, using RelaX; (2) populating the sample data in each table or relationship that has been built; and (3) defining a list of operations as an instrument of examination of the logical data model. Table shows a list of operations that must retrieve data from the entire table or relationship; and (4) ensure that each list of operations can be performed using relational algebra using RelaX. The evaluation of the logical data model only ensures that the list of operations can be performed, so it does not include measuring the performance of the operation. Furthermore, the measurement of performance can only be done on the physical data model of a particular database engine.

Table 7. The List of Operations

No.	*Operation*	*Table/Relation*
1	Retrieve published articles with the category name	Article, Category
2	Retrieve authors by article	User, Article
3	Retrieve tags by article	Tag, Article
4	Retrieve published comments by article	Comment, Article
5	Retrieve published pages with author-name	Page, User
6	Retrieve published galleries with media and uploader name	Gallery, Media, User
7	Retrieve active staff with study program and expertise	User, Study Program, Expertise
8	Retrieve publications by the lecturer	Publication, User
9	Retrieve contact message that has been read	Contact
10	Retrieve users with the role as administrator and active status	User

3 RESULT AND DISCUSSION

3.1 Result of Conceptual Data Model

Figure 1 is the result of a conceptual data model in E-RD with Peter Chen notation. The entity is depicted in a rectangular shape. Each entity's characteristics are depicted in oval form. Special key attributes are denoted by underscores in the attribute name text. Relationships between entities are depicted using lines.

Each relationship formed consists of a modality and a cardinality, which are indicated at the end of the line of close relationships with the entity. The opening and closing square bracket formats are used to indicate the value of modality and cardinality. Modality is the minimum value of the relationship's degree, and cardinality is the maximum value of the relationship’s degree.

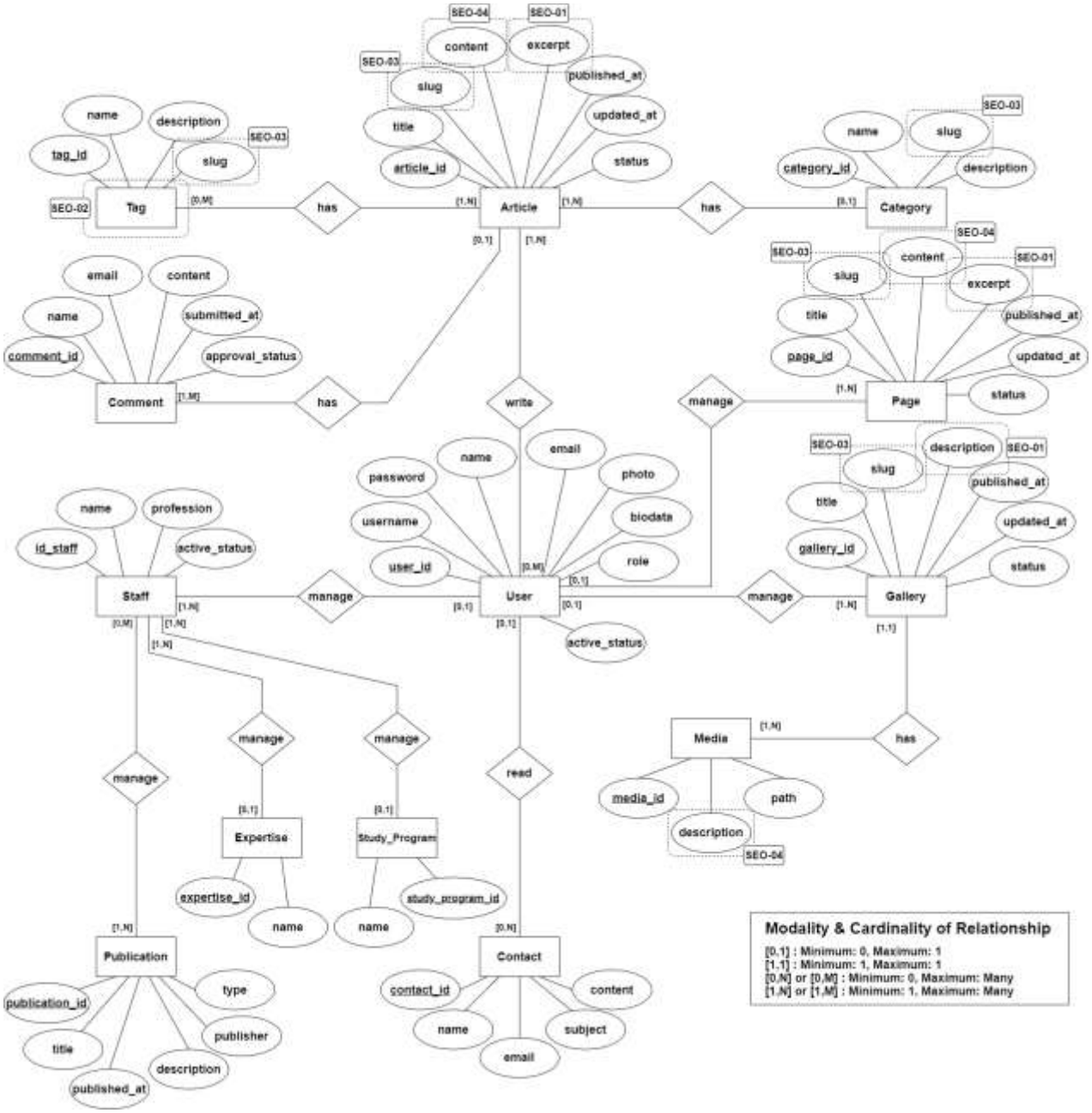

Figure 1. The result of conceptual data model

Meanwhile, in Figure 1. *The result of conceptual data model* there are annotations to show the supporting factors of SEO that have been successfully implemented in the form of one entity and 11 attributes in the conceptual data model. Table shows the results of implementing supporting factors of SEO in the conceptual data model in more details.

Table 8 .The Implementation of Supporting Factors of SEO in the Conceptual Data Model

Supporting Factor	*Entity*	*Attribute*
SEO-01	--	Excerpt (Article) Excerpt (Page) Description (Gallery)
SEO-02	Tag	--
SEO-03	--	Slug (Article) Slug (Page) Slug (Gallery) Slug (Category) Slug (Tag)
SEO-04	--	Content (Article) Content (Page) Content (Gallery)

Evaluation of the conceptual data model is based on a checklist that contains 43 items of functional requirements in Table 2. The evaluation results show that the conceptual data model had been designed to fulfill all functional requirements (100%).

3.2 Result of Logical Data Model

The relational model with crow's foot notation at the level of logical abstraction was successfully designed. Modality and cardinality are still shown in the logical data model that uses symbols at each line's end. A zero-value modality is formed as an "empty" circle. While the modality of one is formed as a short single line. If the line is in a vertical relationship, then the single line short cardinality will be positioned horizontally, vice versa. Cardinality is formed as a short single line, just like a modality, and can coexist. While cardinality is worth a lot, it is formed to resemble the claws of crows.

Figure 2 shows visual information that clarifies the impact of the relationship formed. First, the foreign key (FK symbol) is derived from the primary key (PK symbol). Second, each M-to-N relationship between entities will produce a new table. There are three additional tables of the relationship, namely: (1) article_tag for the article and tag; (2) article_user for the article and the user; and (3) publication_staff for the staff and the publication. Third, data types are included to facilitate the implementation process. There are three types of "common" data supported by RelaX: number, string, and date.

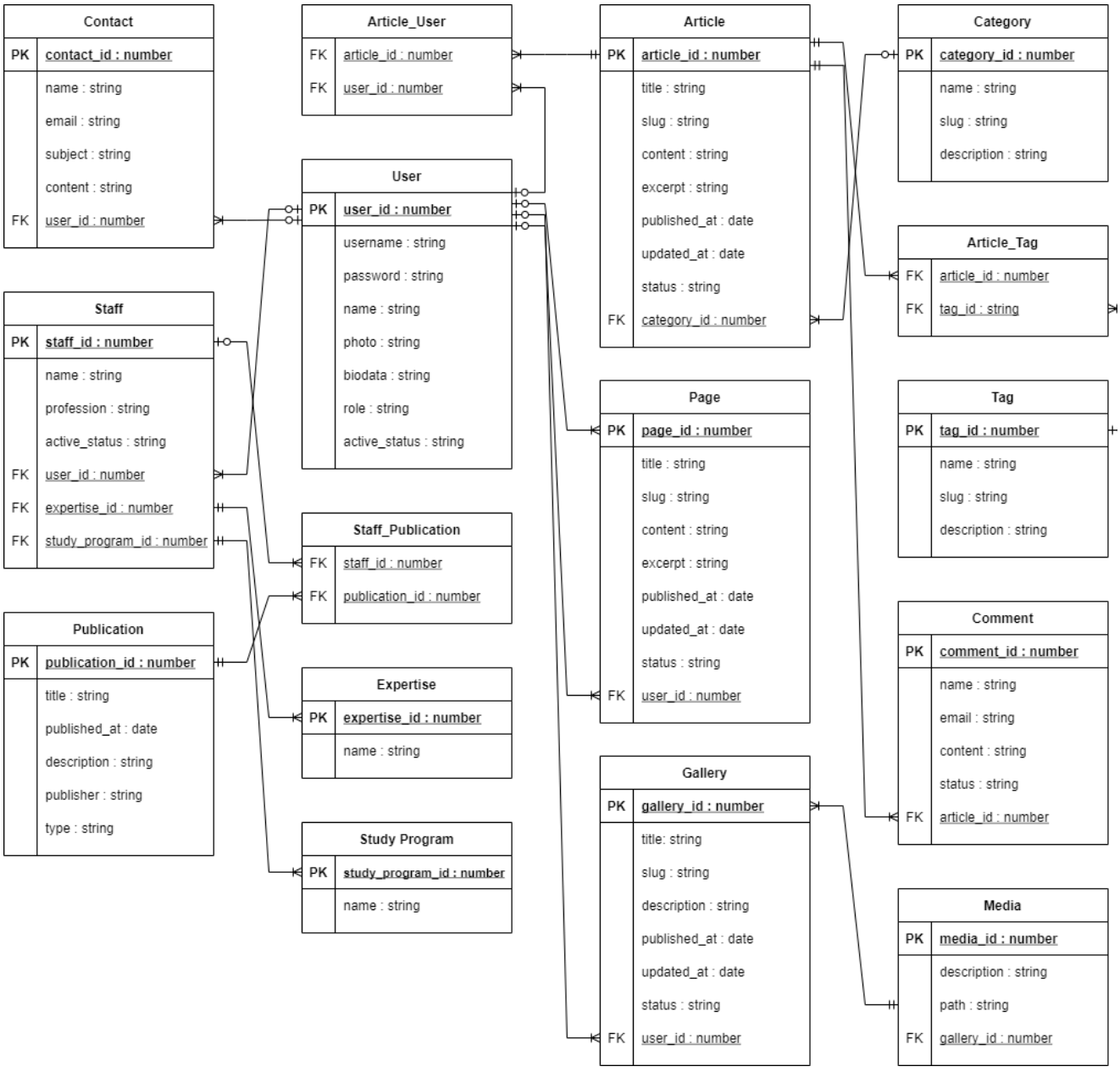

Figure 2. The result of logical data model

Evaluation of logical data model requires a schema (consisting of tables or relations) formed based on model and sample of data to be operable using relational algebra. The schema has been prepared (git.io/JX8wD) and appropriately imported on RelaX. Table shows the list of operations in Table in the form of relational algebra to retrieve data stored on the schema, successfully executed entirely with "passed" statues (100%).

Table 9. The result of evaluation of logical data model

No.	*Operation in Relational Algebra*	*Status*
1	ρ category_name←c.name π a.article_id, a.title, a.slug, a.content, a.excerpt, a.published_at, a.updated_at, a.status, a.category_id, c.name σ a.status = 'publish' (ρ a article ⋈ a.category_id = c.category_id ρ c category)	Passed
2	ρ author_name←u.name π au.article_id, au.user_id, u.name σ au.article_id = 5 (ρ au article_user ⋈ au.user_id = u.user_id ρ u user)	Passed
3	ρ tag_name←t.name π at.article_id, at.tag_id, t.name σ at.article_id = 5 (ρ at article_tag ⋈ at.tag_id = t.tag_id ρ t tag)	Passed
4	σ article_id = 2 and approval_status = 'Y' comment	Passed
5	ρ author_name←u.name π p.page_id, p.title, p.slug, p.content, p.excerpt, p.published_at, p.updated_at, p.status, p.user_id, u.name σ p.page_id = 1 (ρ p page ⋈ p.user_id = u.user_id ρ u user)	Passed

Table 10. The result of evaluation of logical data model (continued)

No.	*Operation in Relational Algebra*	*Status*
6	ρ uploader_name←u.name π g.gallery_id, g.title, g.slug, g.description, g.published_at, g.updated_at, g.status, g.user_id, u.name, m.media_id, m.description, m.path, m.gallery_id σ g.gallery_id = 1 and g.status = 'publish' ((ρ g gallery ⋈ g.user_id = u.user_id ρ u user) ⋈ g.gallery_id = m.gallery_id ρ m media)	Passed
7	ρ study_program_name←sp.name, expertise_name←e.name π s.staff_id, s.name, s.profession, s.active_status, s.user_id, s.expertise_id, s.study_program_id, sp.name, e.name σ s.active_status = 'Y' ((ρ s staff ⋈ s.study_program_id = sp.study_program_id ρ sp study_program) ⋈ s.expertise_id = e.expertise_id ρ e expertise)	Passed
8	ρ lecturer_name←s.name π s.name, pb.publication_id, pb.title, pb.published_at, pb.description, pb.publisher, pb.type σ s.active_status = 'Y' and s.profession = 'lecturer' ((ρ pb publication ⋈ pb.publication_id = spb.publication_id ρ spb staff_publication) ⋈ spb.staff_id = s.staff_id ρ s staff)	Passed
9	σ user_id ≠ null contact	Passed
10	σ role = 'administrator' and active_status = 'Y' user	Passed

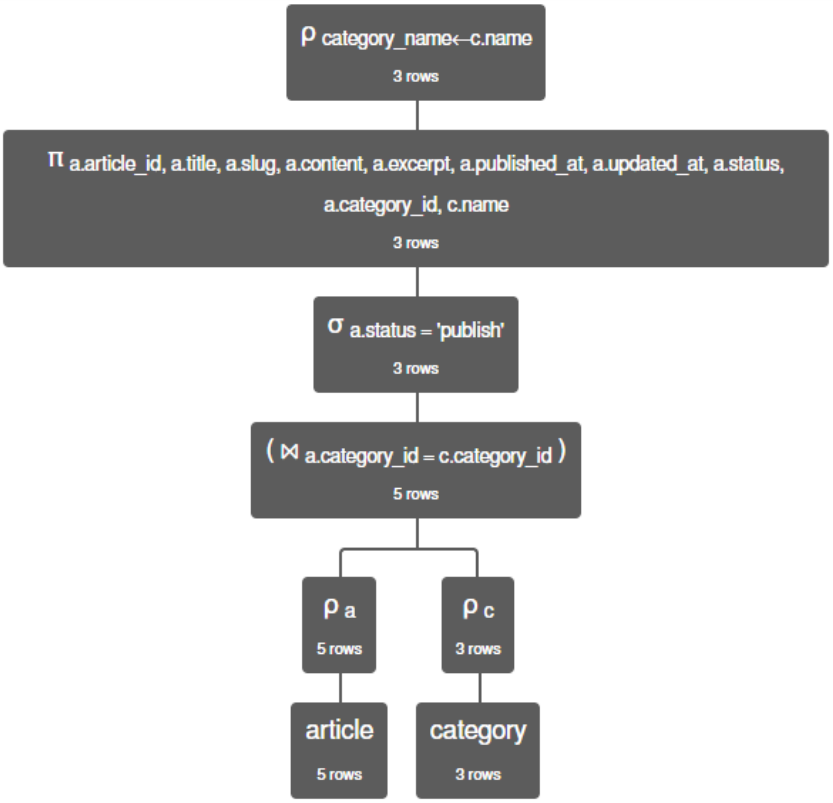

Figure 3. Example of relational algebra operation results in RelaX

ρ category_name←c.name π a.article_id, a.title, a.slug, a.content, a.excerpt, a.published_at, a.updated_at, a.status, a.category_id, c.name σ a.status = 'publish' (ρ a article ⋈ a.category_id = c.category_id ρ c category)

a.article_id	a.title	a.slug	a.content	a.excerpt
1	'JTK Raih Lulusan D3 Terbaik di Wisuda Polban 2020'	'jtk-raih-lulusan-d3-terbaik-di-wisuda-polban-2020'	'Pada wisuda tahun ini JTK berhasil meraih gelar wisudawan terbaik D3 se-Polban berkat M. Wahyu Maulana Akbar (171511019)...'	'JTK berhasil meraih gelar wisudawan terbaik D3 se-Polban'

Figure 4. Example of execution stages of relational algebra in RelaX

4 CONCLUSION

The Relational data model for the university website with SEO at the level of conceptual and logical abstraction has been successfully designed according to the functional requirements and can be implemented well in an independent work environment.

- The conceptual data model fulfills all the functional requirements for developing a university website with SEO.
- In the conceptual data model, one entity and 11 attributes are formed, resulting from the implementation of supporting factors of SEO.
- The M-to-N relationships of the conceptual data model generate three new tables or relations in the logical data model: article_tag, article_user, and staff_publication.
- The logical data model can be implemented in independent work environments using RelaX and can be fulfilled operational requirements by representing each table or relationship in the schema using relational algebra.

AUTHOR'S CONTRIBUTION

All authors contributed to the conduct of this study. The contribution of each author can be seen as follows:

1. Muhammad Riza Alifi. Finding the problem; determining the case study and its scope; mapping and implementing the proposed solution in a data model, including validation in an independent work environment.
2. Hashri Hayati. Checking the flow of methods, problem-solving, and adoption of solutions; enriching and verifying the review of literature; validating implementation results; and finalizing the manuscript.
3. Muhammad Galih Wonoseto. Sharpening the problems and clarifying proposed solutions, especially elaborating the novelty; and verifying the results of the translation of the manuscript.

COMPETING INTERESTS

We declare that this paper upholds publication ethics and is free from conflicts of interest (COI) or competing interests (CI).

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