

# **A UML model towards a portal and search engine to facilitate academic and research collaboration in engineering and education**

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## **ABSTRACT**

International academic and research collaborations are of great importance at this time but currently it is not easy to search and find researchers in the engineering field in Latin America and the Caribbean. Some countries in this region, such as Colombia, have published online the curriculum vitae of its researchers and classified research group according to their productivity, but the information is in Spanish and other countries in the region do not offer the same information. Many universities in the region do not publish the names and emails of their professors. Scholar and citation databases exist but only list publications written in English. Many scholars in Latin America and the Caribbean publish in other languages, such as Spanish or Portuguese. National Science Foundation and European funding agencies have placed increased emphasis on international collaboration. There is a need for a portal and search engine to find Who's Who in Engineering Education in the Americas to facilitate searching for possible collaborators for future research proposals or exchanges. The Latin American and Caribbean Consortium of Engineering Institutions (LACCEI) proposes to develop such a portal with a database of universities and researchers built on an object-oriented architecture that include publications in English, Spanish, Portuguese and French, starting with those indexed by LACCEI, to support cooperation and partnerships among member institutions in the areas of engineering education, technology advancement and research. This paper examines the interfaces and derives the architecture of some common social networks, such as Facebook, LinkedIn and Academia, and develops a proposed model for the LACCEI portal. The proposed architecture allows narrowing down searches and finding peers for collaboration and partnership.

**Keywords:** Academic collaboration, international collaboration, research collaboration, database, search engine

## **1. INTRODUCTION**

In this day and age, it is critical for the international competitiveness of the Americas to collaborate in research and academia within the Americas and with the rest of the world to increase the international visibility of its scholars and universities. Researchers that publish in English are visible in many scholar databases and citation indexes, but how can one find a researcher that is publishing in other languages? Some countries in this region, such as Colombia, have published online the curriculum vitae of their researchers and classify research groups according to their productivity, but the information is in Spanish and other countries South America do not offer the same information. Many universities in this area do not publish the names and emails of their professors, for that reason it is hard to locate, contact and collaborate with them. Many scholars in Latin America and the Caribbean publish in other languages, such as Spanish, Portuguese and French.

The Latin American and Caribbean Consortium of Engineering Institutions (LACCEI) intends to develop a search engine to facilitate locating and contacting possible partners for academic and research collaborations by developing a Who's Who in Engineering Education. It will be a search engine and database with information of professors, researchers and universities in Latin America, the Caribbean and other parts of the world interested in

collaborating with this region [1]. The LACCEI's database currently has more than 3500 authors that have published in LACCEI Proceedings and Journal and lists their publications. LACCEI publications, authors and initiatives is expanding every year; authors can publish in English, Spanish, Portuguese or French, the languages of the Americas, and all publications are available online with free public access.

The Unified Modeling Language (UML) model developed represents the basic structure and relationships of a social network for academic collaboration purposes. The object-oriented architecture of some existing social network were reversed engineered from their interfaces and key aspects incorporated into the UML model that will form the basis for the LACCEI portal. In the future it will be expanded into a complete system that will allow searching for information related to Engineering Education and the network of people working in that field, particularly in Latin America and the Caribbean, and those collaborating with the region.

## **1.1. MOTIVATION**

LACCEI is a non-profit organization headquartered at Florida Atlantic University in the USA with the mission to bring innovations in engineering education and research and foster partnerships among academia, industry, government and private organizations. LACCEI works closely with the Ministers of Science and Technology of the 34 countries member of the Organization of American States (OAS), in the OAS Engineering for the Americas initiative. The goals and objectives of LACCEI include the cooperation and partnerships among member institutions in the areas of engineering education, research, and technology advancement with emphasis, among other areas, on faculty and student exchange, innovation of engineering education, laboratory development and sharing of resources, faculty development, cooperative programs, career development, and solicitation of funds for joint training and research programs [2]. Organizations have been asking LACCEI to identify researchers and engineering institutions in the Latin America and Caribbean region because of the difficulty in locating such information. The Global Engineering Dean's Council (GEDC) has asked LACCEI to identify the Engineering Deans in the region. Likewise program directors from the National Science Foundation have asked LACCEI to identify possible academic and research collaborators and active research laboratories in the region to solicit collaborators from universities from Latin America and the Caribbean for international research proposals. Thus, the objective of this work is to study existing social networks to understand how the popular social networks are structured with the intention to incorporate common aspects and fine tune their behavior to for use in the LACCEI engineering academia and research fields. The existing LACCEI database model is shown, together with the proposed model contains key elements found in the comparison with popular social networks.

## **1.2. OVERVIEW**

Our approach is analyze the interfaces to reverse-engineer their UML model of relevant social networks: Facebook, LinkedIn and Academia. Summarize and compare common UML classes based on a chosen criteria. A restructuring of the LACCEI database model is proposed that can better support a social academic network. The proposed model explains all the aspects considered in the comparison and the enhancements adopted from other models.

## **1.3. APPROACH USED BY FACEBOOK**

Facebook uses connections among people to refine their searches. Their success means that it can find a specific person without knowing personal information just by making connections. The connections can be very general, such as both having selected the same entity as a "favorite".

## **1.4. APPROACH USED BY LINKEDIN**

LinkedIn is more professional and work-oriented than Facebook. LinkedIn has to do with how many connections within your circle someone has and the degrees of separation. A first degree connection between two people indicates they are directly connected. A second degree connection means that the person is directly connected to someone who is directly connected to the target, and so forth. Their success is based on finding a specific person,

company, or job without knowing personal information just by making connections and searching through names, companies and some aspects in common.

## **1.5. APPROACH USED BY ACADEMIA**

Academia focuses on papers from an author and utilizes the connections they have from their other social connections, such as Google, Facebook and LinkedIn.

## **2. MODELS COMPARISON**

The analysis we use to compare social networks is the Grounded Theory approach, which systematically analyzes the recorded data with an established qualitative research method. Martin and Turner (1986) cited by Walter D. Fernandez [3], indicate that they created the Grounded Theory approach as an "inductive theory discovery methodology that allows the researcher to develop a theoretical account of the general features of the topic while simultaneously grounding the account in empirical observations of data". Also, Glaser [4] stated that the actions and concepts can be interrelated with other actions and concepts. Other authors such as Charmaz [5] explained that the Grounded Theory "offers a logically consistent set of data collection and analysis procedures aimed to develop theory and models."

By merging all these authors' ideas, the procedures will allow the identification of patterns in data, and by analyzing them, a theory can be derived as valid. On the other hand, there is a need to adopt a template to develop a pattern for an academic social network. Buschmann et al [6] describe a pattern as "a solution for a recurring problem that arises in a specific context". Additionally, the theory building process is tied with a resultant theory that will be consistent. Since Orlikowski [7], who won the MIS Quarterly's Best Paper Award in 1993, the Grounded Theory has been used in Information Systems because it had the focus on elements of context and process and on actions. The Grounded Theory facilitates the generation of complex theories of process, sequence, and change to organizations, positions that correspond closely to the data and forces diversity on it. Additionally, Glaser [4] indicates the diversity is achieved by the comparison between properties of a category, trying to observe as many underlying uniformities and diversities as possible.

Moreover, the use of the Grounded Theory methodology has been proven useful in how humans merge UML models by Lutz, Wurfel and Diehl [8]. They use the Grounded Theory approach in an experimental design showing how users compare and merge visual models and develop some guidelines for a future tool design.

Additionally, the construction of Cooperative Information Systems helps any system to integrate the different entities considered as data, application, model, process and others, to have a global view of all information systems with the objective to communicate and cooperate. According to Weston as stated in Benabdellah Chaouni, Fredj, and Mouline [9], the integration is defined as the "combination of components in such a way as to form a new set constituting a unit for creating synergy." This integration will follow two basic steps:

1. Comparison: It will be based on a set of mapping rules that identify the correspondence between all the elements from the models.
2. Integration: The models mapped in the previous step and integrated using strategies of merging the matched elements and some rules of incorporating elements not in the original model that enhance the result model.

Another aspect considered in the comparison was the specific approach: syntactic approach, semantic approach, local structural approach, global structural approach, and hybrid approach [9]. In this case, the approach used was hybrid, combining the semantic, global structure approaches. The semantic approach compares the meaning of the compared items, and the global structural approach compares elements related to the elements to compare. Therefore, the purpose is to provide a hybrid approach, incorporating the Grounded Theory in Cooperative Information Systems with integration of the three models.

### **2.1. COMPARISON OF COMMON CLASSES**

By studying their interfaces the UML models of Facebook, Linked-In and Academia were reverse-engineered [10]. Some extracts of these models appear in the Appendix of this paper. The analysis of the common classes includes the classification into categories of some of the elements, classes and association classes; determination of the relations between categories; and description of each category according to its properties. The categories were classified into core categories considered as the most important to compare, including:

- a. Person
- b. Relationship
- c. Education
- d. Work- Experience
- e. Interest Area- Skill
- f. Organization- Group- Network
- g. Message

For each core category, the design of each class and its association classes is shown by model. For the rest of the classes the figures will appear in [10] but are listed in the current appendix.

## 2.2. ENHANCEMENTS

Each of the models analyzed have a particular area in which they emphasize their behavior, a complete organization of a special category (class), or some aspects that are considered original. These elements do not belong to all of them, but they represent an enhancement separate from the common classes with the aim to point out those aspects for future reference in a proposed model. They are:

- a. University
- b. Education
- c. Paper
- d. Interest- Research Area
- e. Event
- f. Skill

### 2.3.1 University

The social network Academia summarizes a good view of the class University. Figure 1 shows an extract of the model considering the entities of University and Department for their relation considered in existing models. This is a very simplified view of the University structure which varies by university: a University has Schools or Colleges that can have Departments that can offer Programs. A person can be assigned to one or more Department. However, Academia does not address these complexities. We see in LinkedIn different structure in Figure 2, where School is used instead of University to include High School, Vocational School, etc. This more generalized view is used is from the perspective of a Student obtaining an Education, not from the context of Faculty associated with a University.

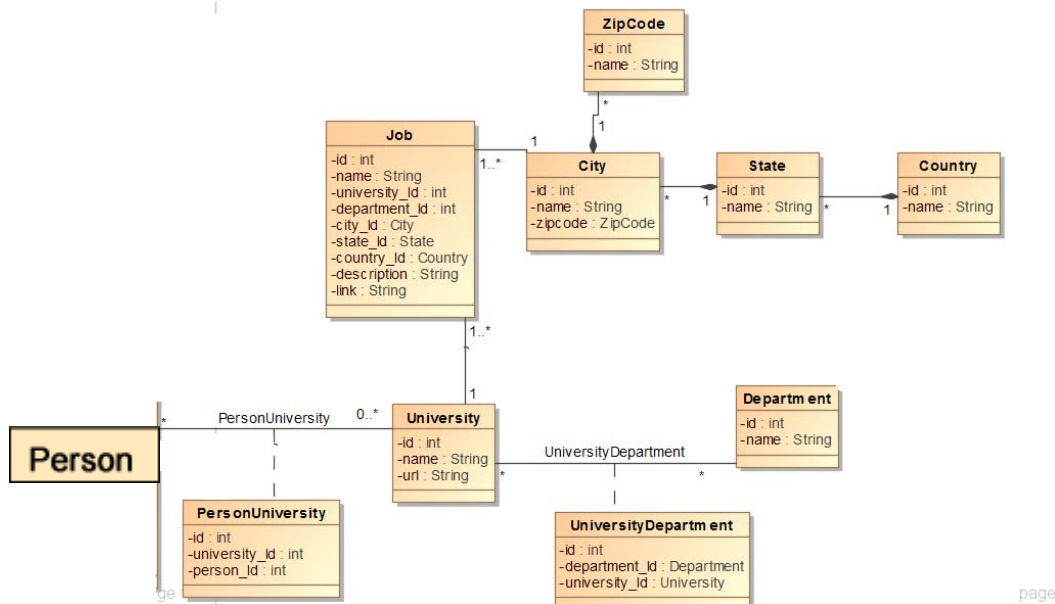


Figure 1. Classes for University- Academia

### 2.3.2 Education

LinkedIn uses the class Education and relates more classes such as: Degree, field of study, school, and also every school by city, as seen in Figure 2.

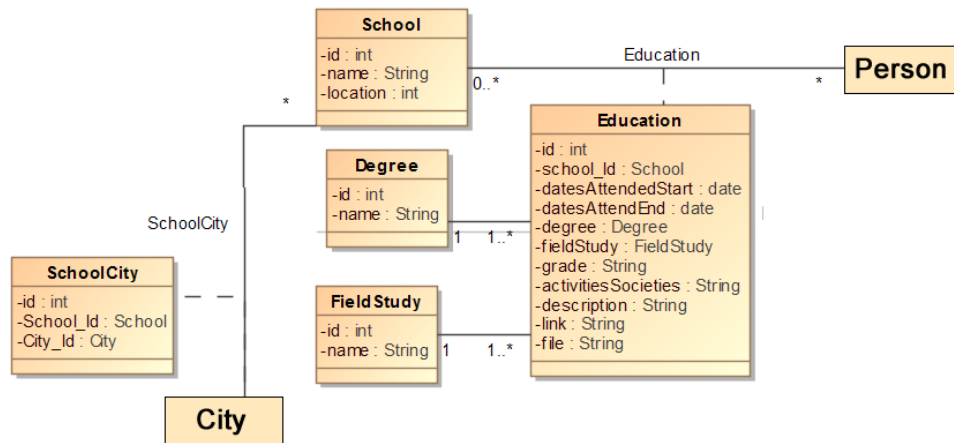


Figure 2. Classes for Education- LinkedIn

### 2.3.3 Paper

Academia gives a complete approach related to a Paper and its publication. It includes the classes PaperPerson where the paper is linked to the person by the type of section (books, talks, teaching documents, drafts, books reviews, conference presentation and thesis chapters). Also it establish a relation with the following aspect Research Area.

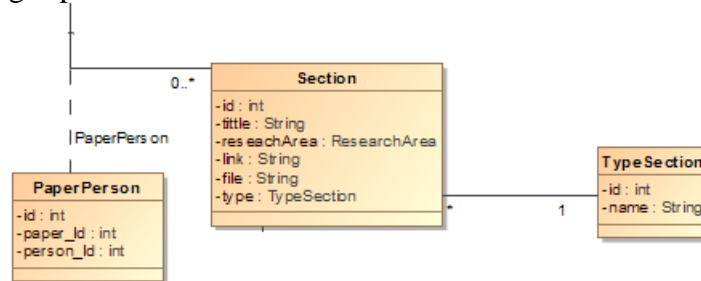


Figure 3. Classes for Paper- Academia

### 2.3.4 Interest- Research Area

Depending on the social network's audience, the interest area involves any main concentration that the person has in their profile. If it is Facebook related, the interest area could be books, music, movies, person, TV shows, sports, restaurants, places, and others, and shown in Figure 4. In LinkedIn, interest is relates work interest area as shown in Figure 5. In Academia it relates to research interest, as shown in Figure 6. Besides the differences, all of them have common objectives, depending on the social networking audience will vary the specific interest area.

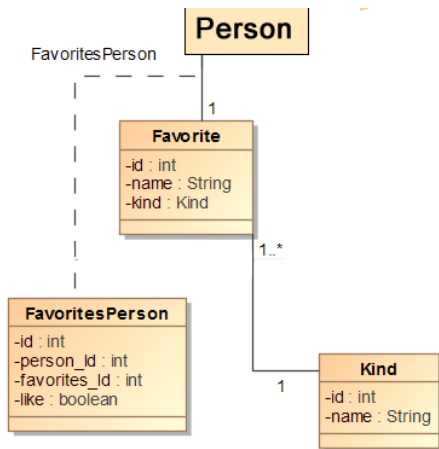


Figure 4. Classes for Interest Area/ Favorites- Facebook

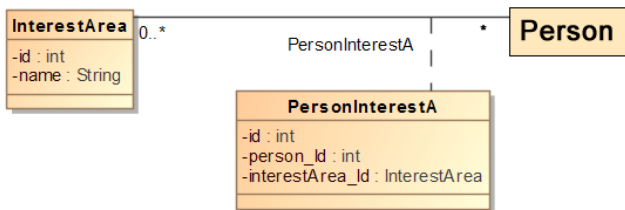


Figure 5. Classes Interest Area- LinkedIn

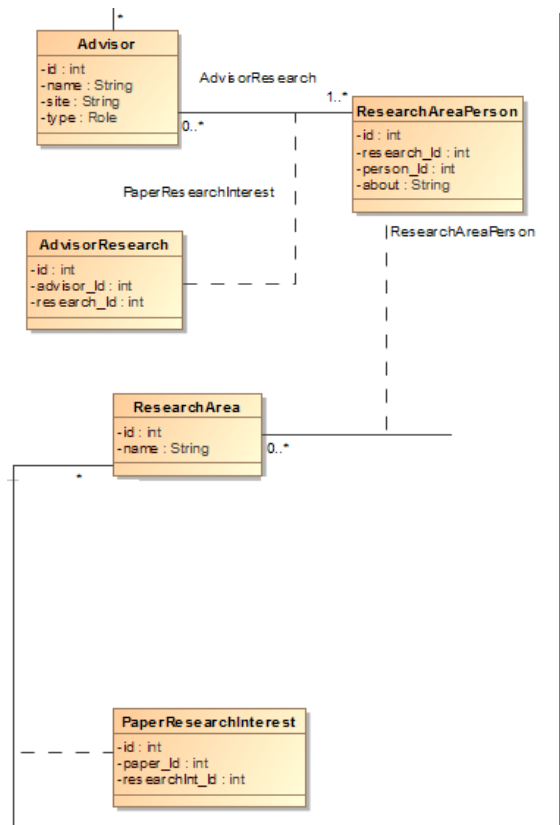


Figure 6. Classes for Research Area- Academia

### 2.3.5 Skills

Lastly one important aspect that defines a person is skill. The skill is considered only by LinkedIn, with the structure shown in Figure 7.

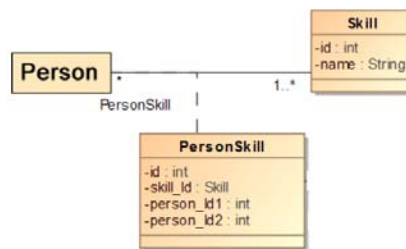


Figure 7. Classes for Skill- LinkedIn

### 2.3.6 Event

Facebook is the only of the three social networks that include an Event. The event relates to a Location, with an Invitation from a Person who has a relationship with the attendee, see Figure 8.

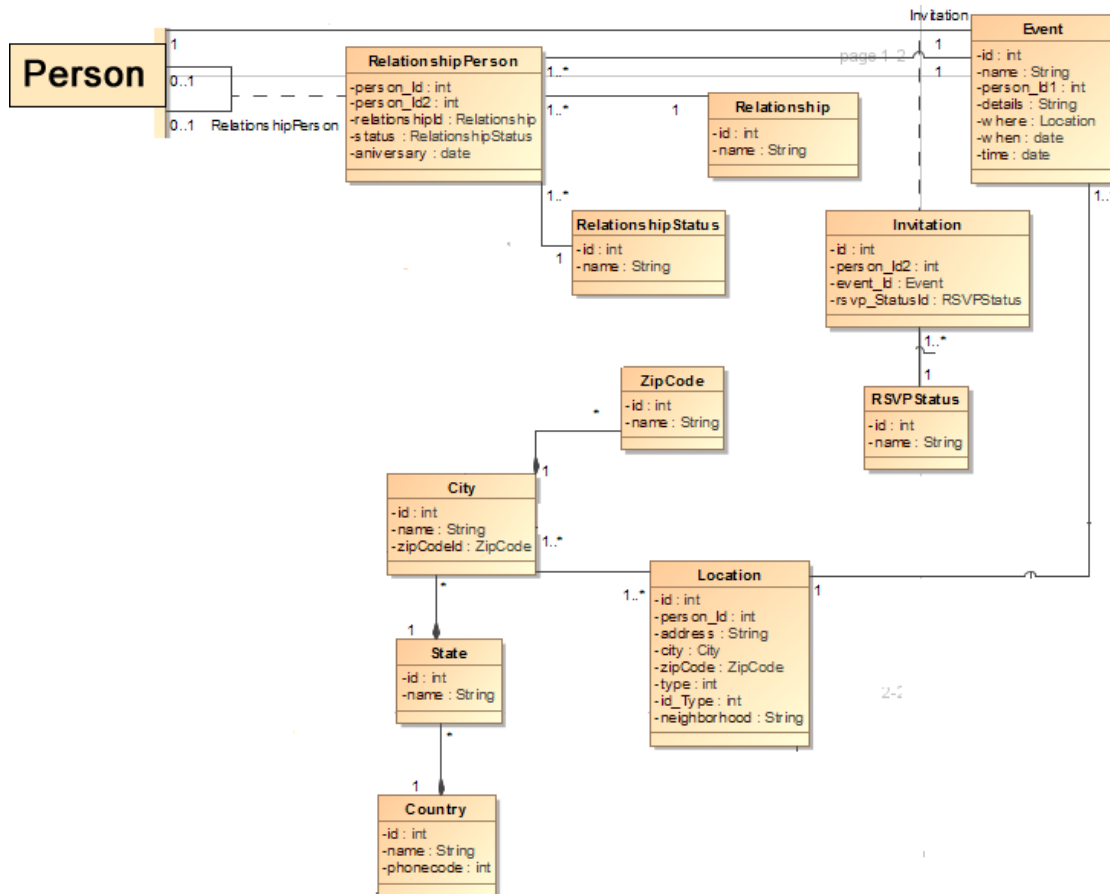


Figure 8. Classes for Event- Facebook

In summary, by the analysis given previously from the comparison between Facebook, LinkedIn and Academia social networks, there are some common aspects to consider in the creation of new models. Using the Grounded Theory, the research developed a discovery of various enhancements and original classes to be part of the observation data. The next chapter demonstrates the development of the second step called integration that organizes and matches all the information from previous steps for an expected proposed result model.

### 3. ACTUAL MODEL AND PROPOSED MODEL

LACCEI has a database it has used for the past 10 years. It has information from researchers and students who attended Conferences. The actual data model in use for the LACCEI Database is shown below. The model includes personal information, universities across Latin America and the Caribbean and other parts of the world, and specific information about conferences, event, publications and papers from their authors, participants and individuals that attended LACCEI Conferences. This model (see Figure 30 in the appendix) does not include information about research area, universities attended, skills, work information, and other important aspects to be considered by the search engine. The basic data model will need to include classes considered from previous chapters such as those shown in Table 2.

**Table 1. Classes from the comparison**

| Common classes from the comparison of models: | Enhancements classes to include: |
|---|----------------------------------|
| a. Person                                     | a. University                    |
| b. Relationship                               | b. Education                     |
| c. Education                                  | c. Paper                         |
| d. Work- Experience                           | d. Interest- Research Area       |
| e. Interest Area- Skill                       | e. Event                         |
| f. Organization- Group- Network               | f. Skills                        |
| g. Message                                    |                                  |

The new model will need to consider a design pattern for academic social networks. As a result the new model is a product of the pattern (to appear in [10]) created in conjunction with some of the classes from the actual model and the summary of the comparison from the three derived UML models for the three social networks studied: Facebook, LinkedIn, and Academia. Figure 9 illustrates the proposed UML model for LACCEI towards a portal and search engine to facilitate academic and research collaboration in engineering and education. It evolved using the comparison approach based on Grounded Theory.

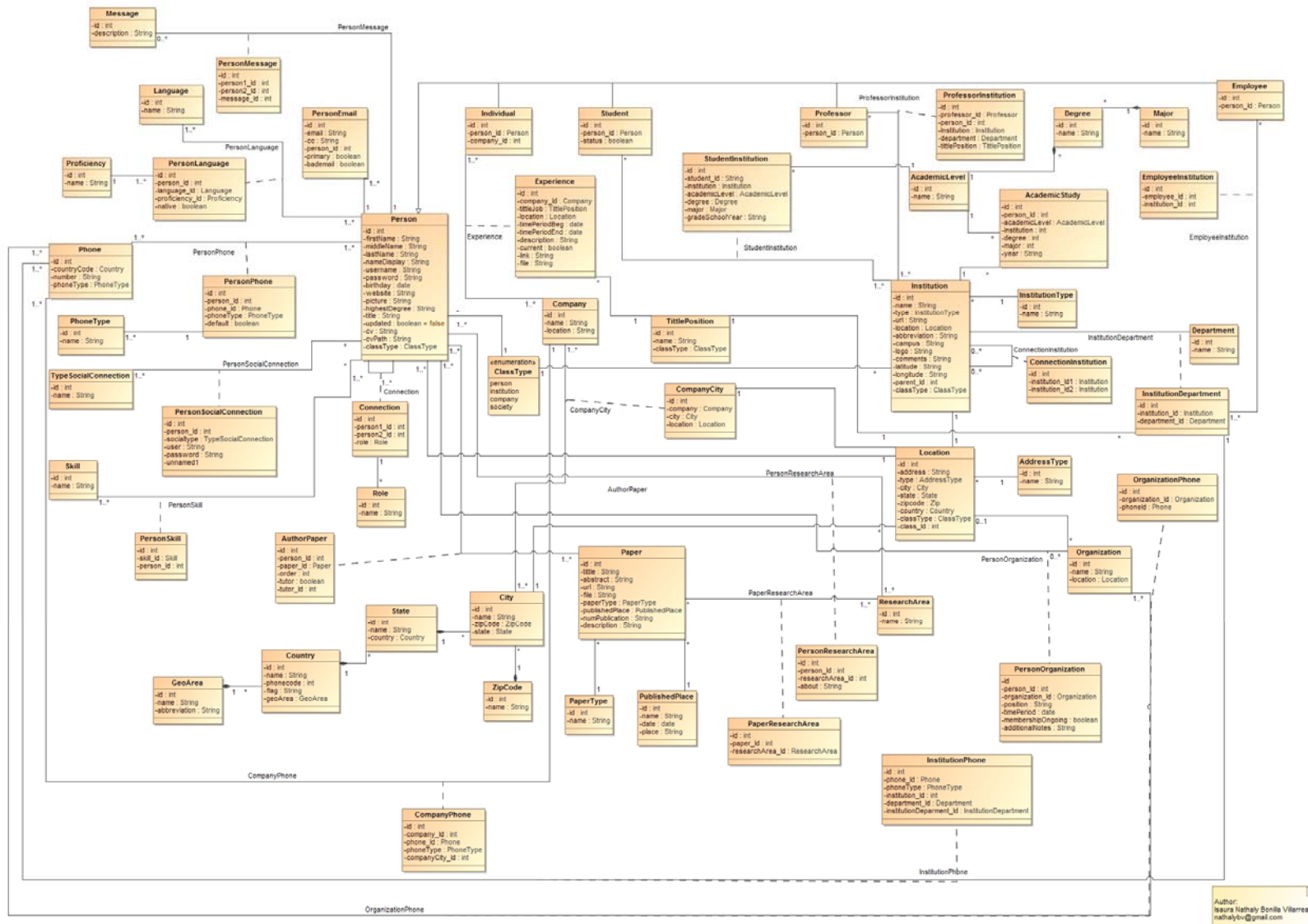
#### 4. CONCLUSIONS

Analyzing the interfaces of three social networks (Facebook, LinkedIn and Academia), their respective UML models were reversed-engineered. Then, using the Grounded Theory approach, these models were analyzed, common classes were identified, and classes that they contained deemed useful to enhance the proposed Portal for Who's Who in Engineering Education were also identified. Further analysis has yielded a design pattern for academic social network to appear in [10]. The current LACCEI database was re-engineered to include existing LACCEI data and also the common and enhanced classes resulting from the analysis of the three popular social networks. This resulted in a proposed UML model for the Who's Who in Engineering Education portal that will continue to be developed.

This portal when completed will provide access to the database with information of professors and researchers and universities interested in collaborating with the Latin America and the Caribbean and their related work in designated disciplines. This will permit access to researchers who publish in languages other than English, it will include support for the languages of the Americas: English, Spanish, Portuguese and French.

The design and development of the proposed academic social network with an incorporated search engine of the LACCEI database will benefit those who needs to search for collaborators. The LACCEI database currently contains information over 3500 registrants and authors and their publications within LACCEI. It also includes the most complete listing of the universities that offer Engineering or Technology degrees in Latin American and the Caribbean. This will serve as a foundation that will be expanded to include the Deans, Department Chairs, Research Groups/Centers, Faculty and other key administrators, such as Vice President of Research, Director of International Relations. This information is being gathered and includes more than 10,000 additional individuals. LACCEI intends to honor the privacy of individuals by allowing them to keep their contact information private, yet allowing the visibility of their research and their university and research groups to be increased to foster international collaboration.





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Figure 9. Proposed LACCEI UML Model

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APPENDIX

Common classes from Facebook, LinkedIn, Academia

a. Person

FACEBOOK model

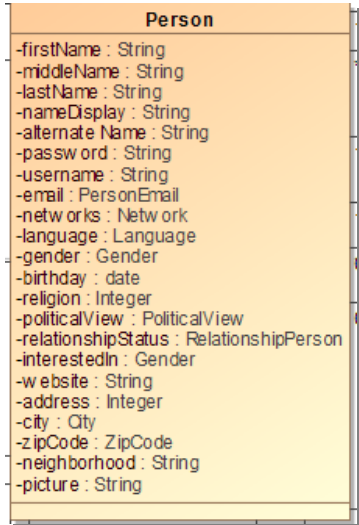


Figure 10. Class Person-Facebook

LINKEDIN model

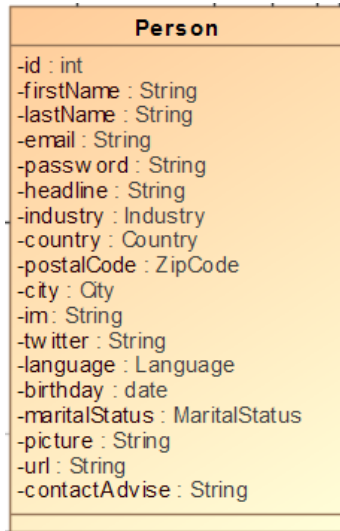


Figure 11. Class Person-LinkedIn

ACADEMIA model

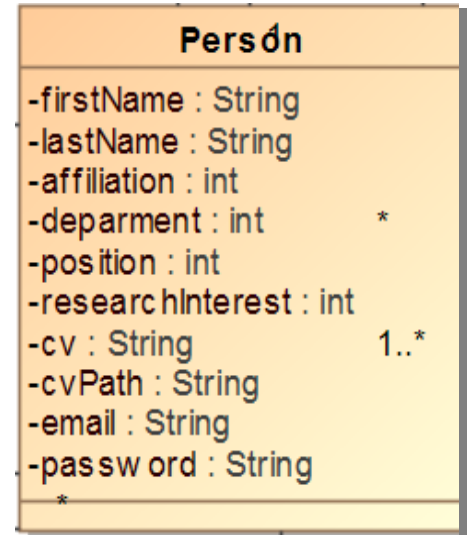


Figure 12. Class Person-Academia

b. Relationship

From FACEBOOK model

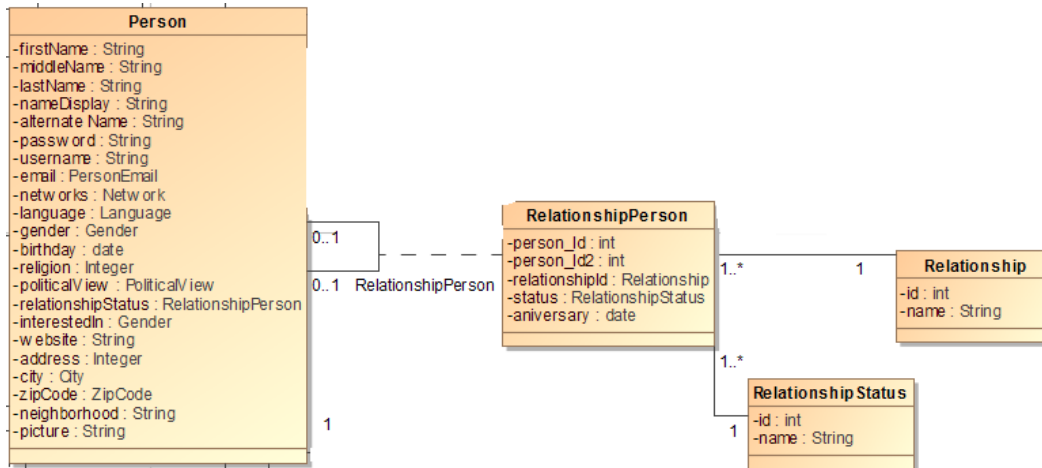


Figure 13. Classes Relationship- Facebook

From LINKEDIN model

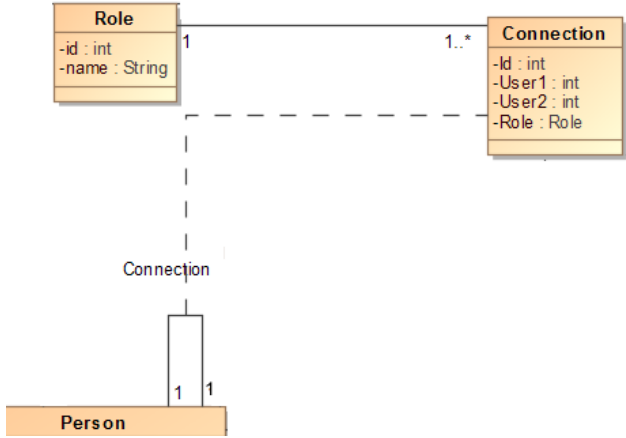


Figure 14. Classes Relationship- LinkedIn

From ACADEMIA model

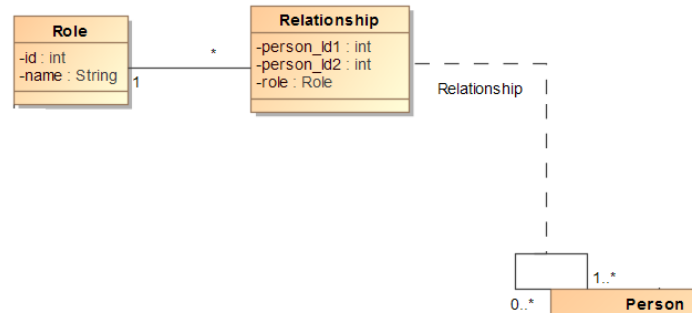


Figure 15. Classes Relationship- Academia

c. Education

- From FACEBOOK model

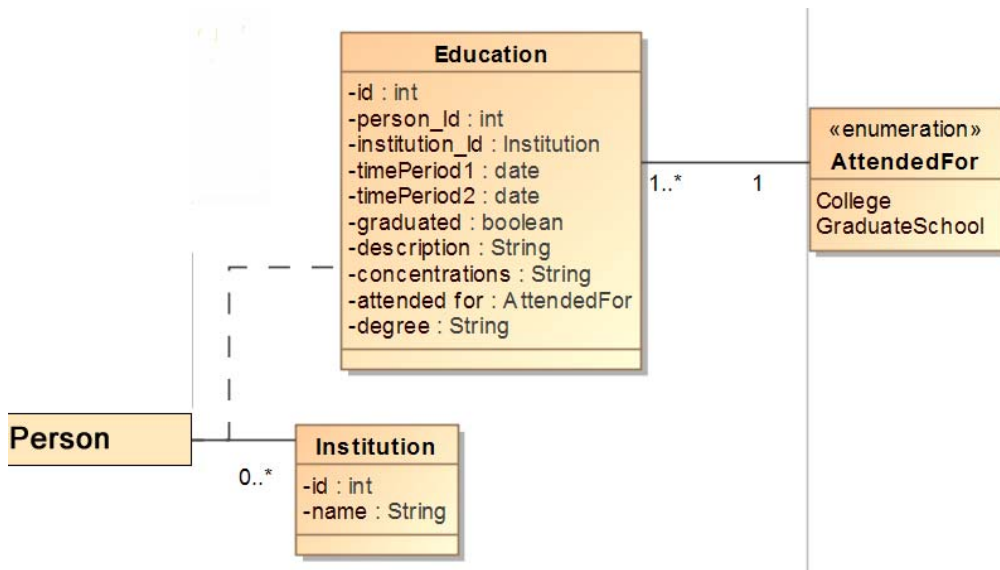


Figure 16. Classes Education- Facebook

- From LINKEDIN model

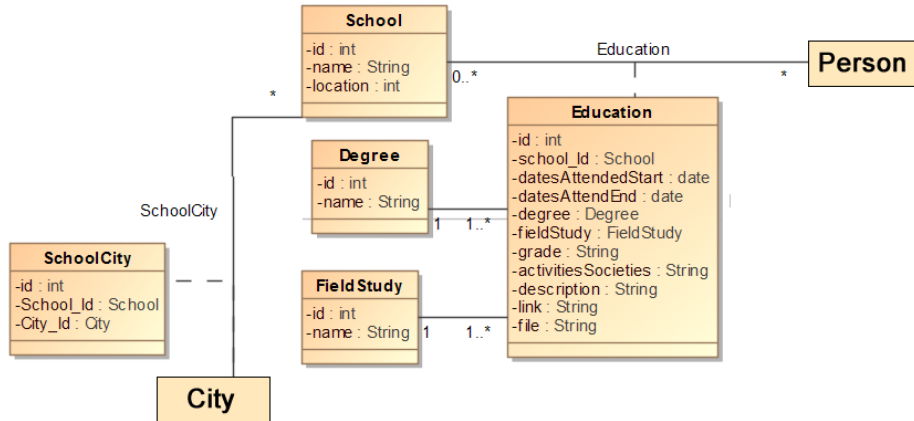


Figure 17. Classes Education- LinkedIn

- From ACADEMIA model

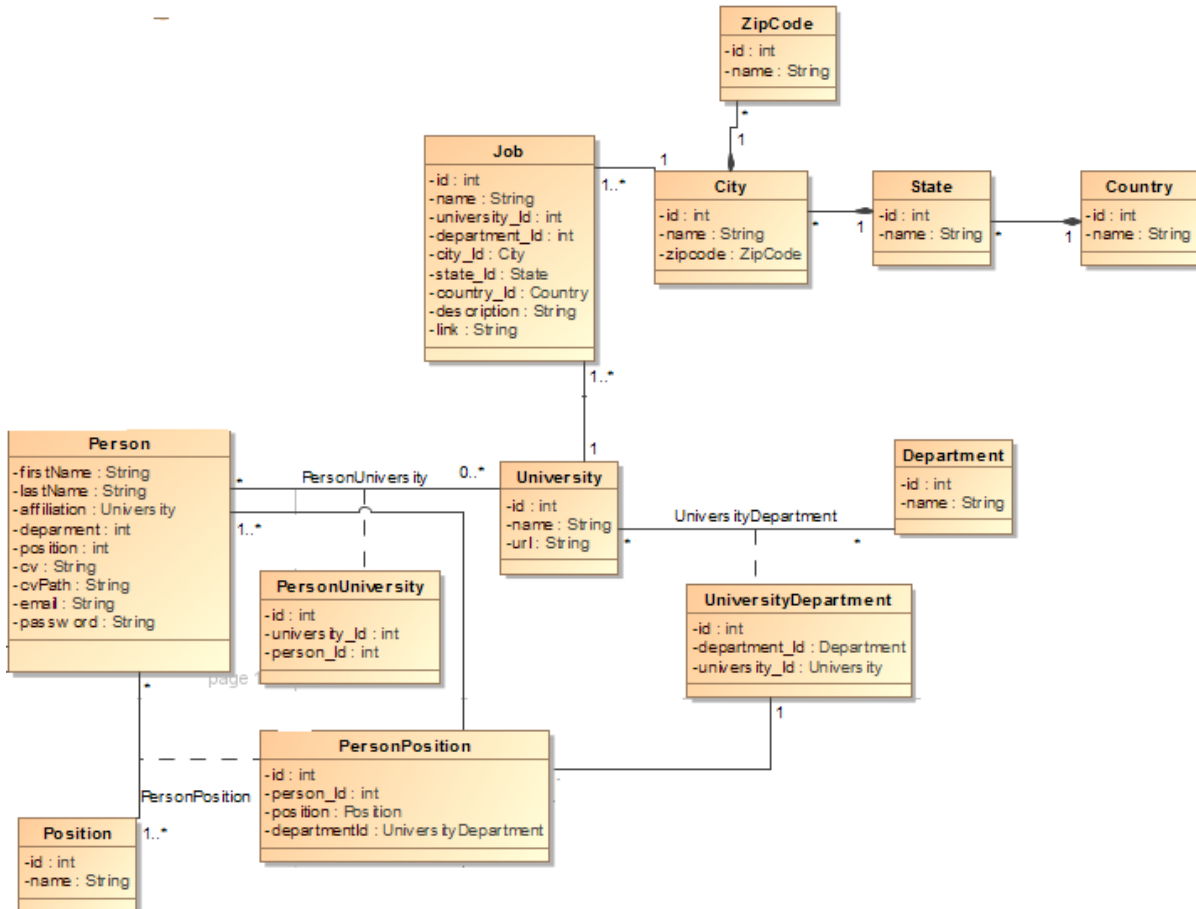


Figure 18. Classes Education- Academia

d. Work- Experience

- From FACEBOOK model

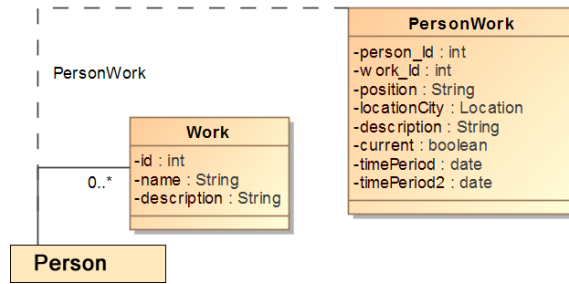


Figure 19. Classes Work- Facebook

- From LINKEDIN model

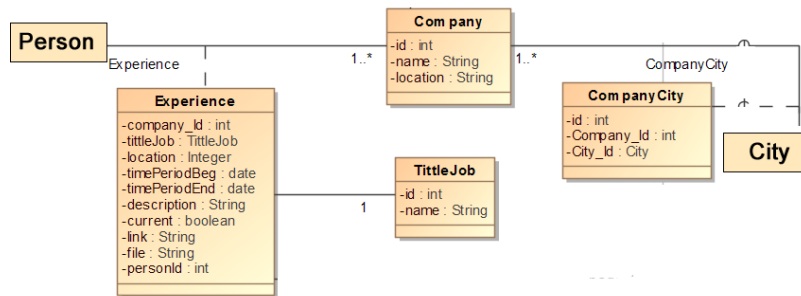


Figure 20. Classes Work- LinkedIn

- From ACADEMIA model

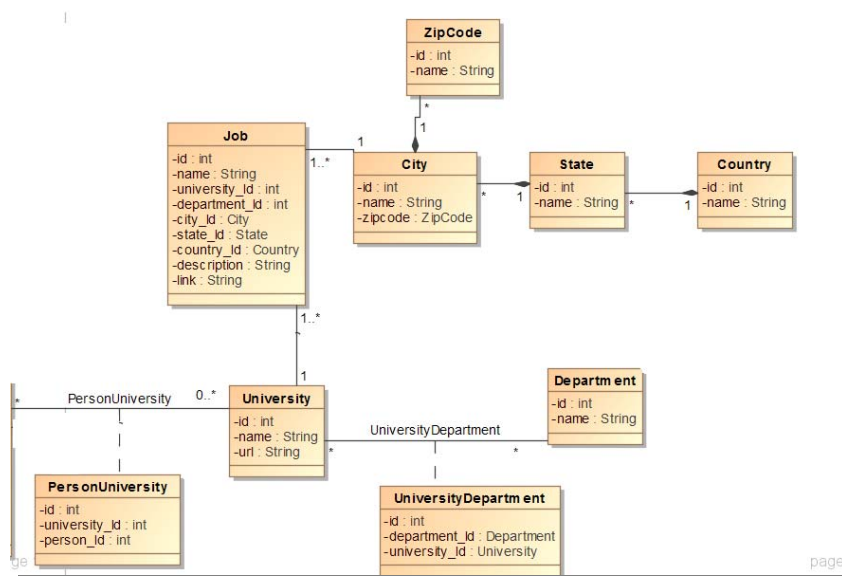


Figure 21. Classes Work- Academia

e. Interest Area- Skill

- From FACEBOOK model

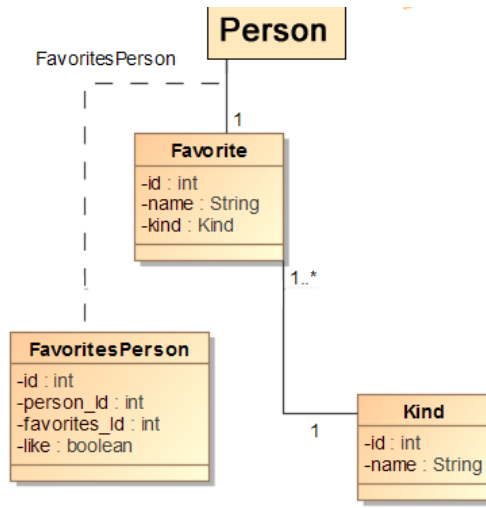


Figure 22. Classes Favorites- Facebook

- From LINKEDIN model

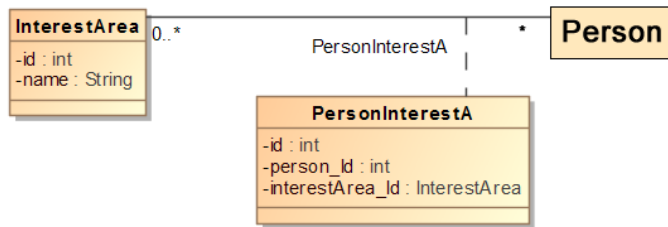


Figure 23. Classes Favorites- LinkedIn

- From ACADEMIA model

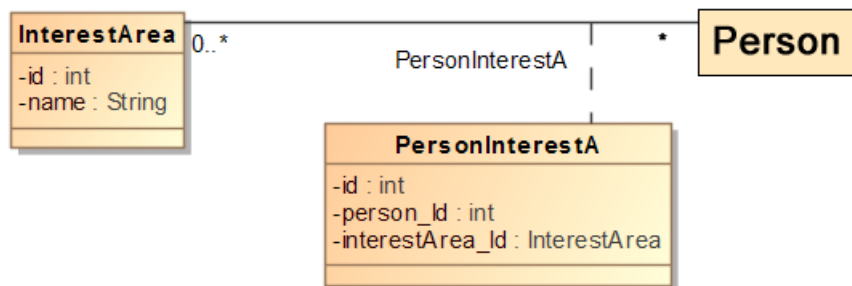


Figure 24. Classes Favorites- Academia

f. Organization- Group- Network

- From FACEBOOK model

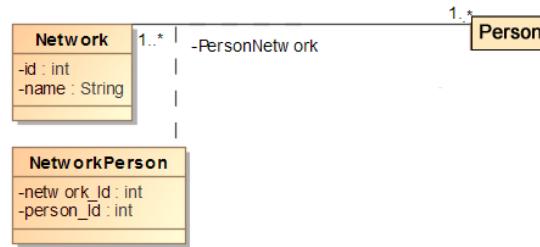


Figure 25. Classes Network- Facebook

- From LINKEDIN model

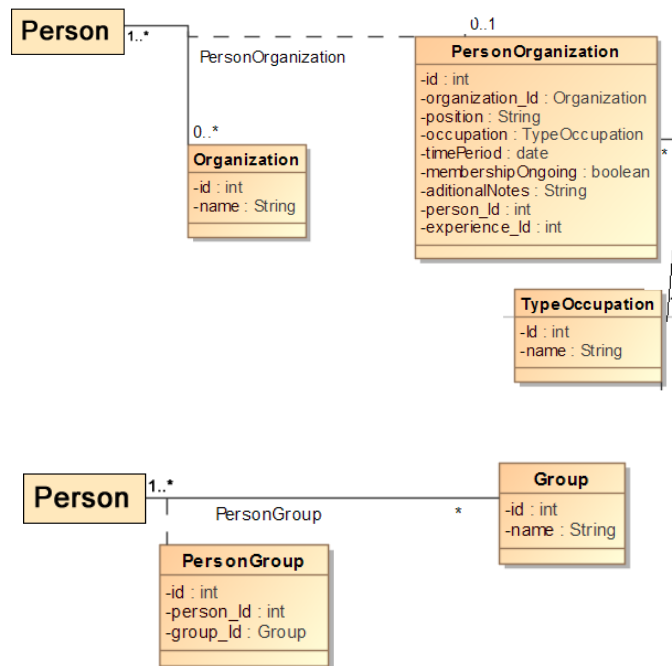


Figure 26. Classes Group- LinkedIn



g. Message

- From FACEBOOK model

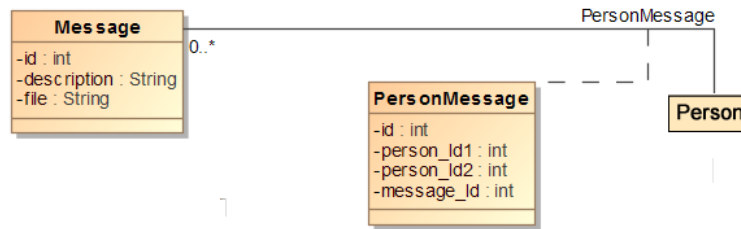


Figure 27. Classes Message- Facebook

- From LINKEDIN model

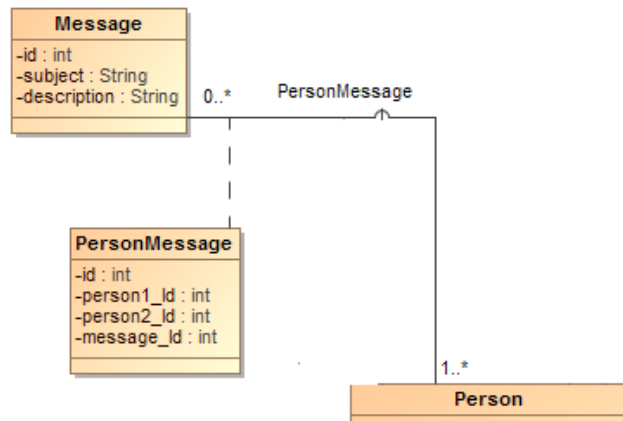


Figure 28. Classes Message- LinkedIn

- From ACADEMIA model

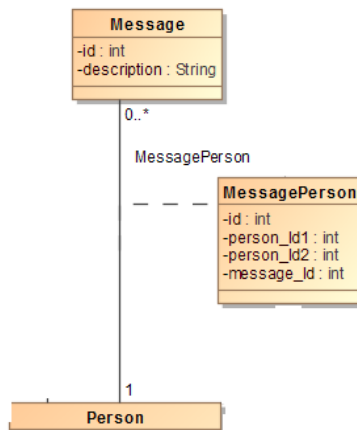


Figure 29. Classes Message- Academia

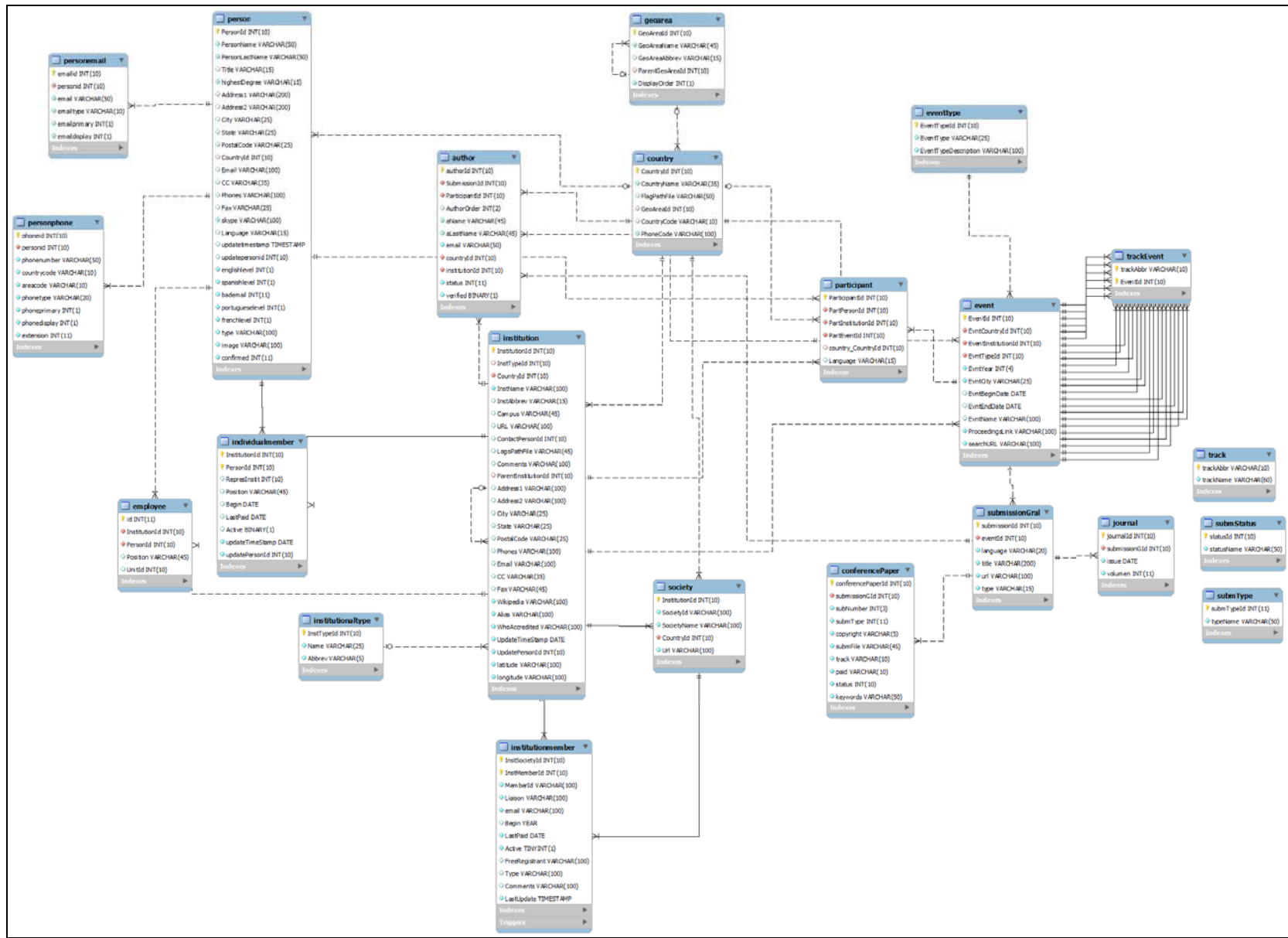


Figure 30. Original LACCEI database