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Conceptual Data Modelling of Modern Human Migration

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Summary

The processes of human migrations have been present for ages, since the very beginnings of human history on the planet Earth. Nowadays, these are amplified to a large scale due to the modern means of communication, transportation, information and knowledge exchange, as well as the complex processes of globalization. Knowing the social, demographic, ethnical and educational structure of the migrants, as well as their geographical trajectory and temporal dynamics of their spatial moving across territories, countries and continents, is of a crucial meaning for both national governments and international policies. There is an emphasized need for identifying, acquiring, organizing, storing, retrieving and analyzing data related to human migration processes. The relational databases provide an ultimate solution, whilst the E-R diagram represents a common graphical tool for conceptual data modelling and relational database design. Within the paper we develop and propose a logical data model of the modern human migration.

Keywords

human migration, E-R diagram, relational schema, relational databases, conceptual data modelling

1. Introduction

Since the dawn of human evolution, more than 70,000 years ago, humans have migrated across continents in search of food, shelter, safety, and hospitable climate. Nonetheless, at the beginning of the 21st century, people still move for these reasons, but new reasons for human migration are arising too, such as job-related relocation and overpopulation. Due to the great technological advances in electronic communications and transportation, the scale of contemporary human migration is even bigger and more dynamic than ever before. It is a global phenomenon of enormous intensity, involving people from various countries, of different age, gender, and race, belonging to various nationalities and religions, and having various social, economical and political backgrounds.

So, what is human migration? According to International Organization for Migration, "no universally accepted definition for migration exists". In fact, there are many definitions of human migration, each of them answering this question in a rather different way. For instance, migration is "a process of moving, either across an international border, or within a state; it is a population movement, encompassing any kind of movement of people, whatever its length, composition, and causes; it includes migration of refugees, displaced persons, uprooted people, and economic migrants" (Perruchoud, 2004, p. 41). On the other hand, Encyclopaedia Britannica defines the term 'migration' as being "a permanent change of residence by an individual or group; it excludes such movements as nomadism, migrant labour, commuting and tourism, all of which are transitory in nature". Finally, Rubenstein (2011, p. 80) defines the migration as being a long-term relocation (movement) of an individual or group outside their place of origin.

No matter how migration has been defined, it is a proven fact that it is considered one of the defining global issues of the early 21st century, as more and more people are on the move today than at any other point in human history. According to International Organization for Migration (2012), there are now about 192 million people living outside their place of birth, which is about 3% of the world's population. The current annual growth rate is about 2.9%. In order to illustrate the complexity, intensity and the global scale of human migrations, we present Figure 1, which depicts graphically the global migration patterns in the world (Rubenstein, 2011, p. 84).

As Figure 1 shows, the main origins of migrants worldwide are the most populated countries, like India, China, Mexico, Brazil, and North-African countries. These also belong to the group of the poorest countries in the world, with low GDP per capita ratio. On the other hand, the main destinations for migrants are USA, Canada, Western European countries, and Australia, i.e. the

countries with the highest GDP per capita ratios. Migration inevitably leads to mixing various cultures and civilization traditions, and very often it causes significant conflicts between migrants and the indigenous population. Sometimes the native population becomes minority, and it has been displaced or culturally assimilated. International Organization for Migration indicates that migration, as an essential and unavoidable component of the economic and social life of every country, has to be properly managed in order to be beneficial for both individuals and societies.

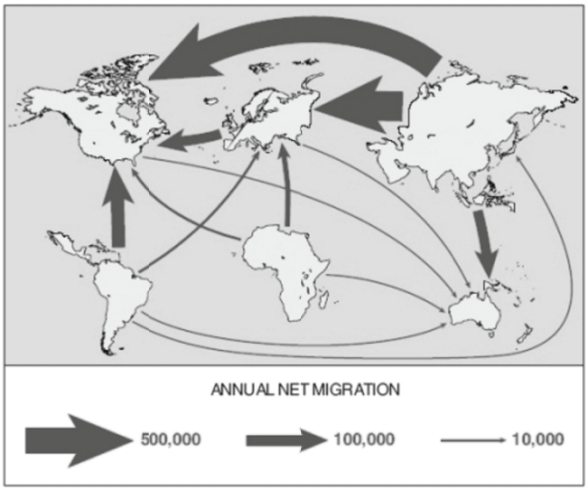

Figure 1 Global migration patterns: the intensity of major international migrant's flows per annum.
Source: Rubenstein, 2011, p. 84, Figure 3-5.

Perhaps the meaning and significance of modern human migrations have been sublimed in a best possible way by Castles & Miller (2009, p. 299), according to whom "population movements have always accompanied demographic growth, technological change, political conflict, and warfare. Over the last five centuries, mass migrations have played a major role in colonialism, industrialization, the emergence of nation-states and the development of capitalist world market. However, international migration has never been as pervasive, or as socio-economically and politically significant, as it is today. Never before have statesmen accorded such priority to migration concerns. Never before has international migration seemed so pertinent to national security and so connected to conflict and disorder on a global scale". In this context, Horn (2007) has posed an important question: "Is there a science base to migration? If there is, it is profoundly important that we all understand it, if we are effectively to meet the challenges and opportunities that migration poses". Lately, there are many efforts to mathematically model the complexity of migration movements, both on a macro and micro level (Aleshkovski & Iontsev, 2006). Some of them employ the theory of Markov chains (Pan & Nagurney, 1994), and others are based on the usage of stochastic models (Fedotov, Moss & Campos, 2008). A plethora of efforts are based on pure statistical modelling (time series analysis, multiple regression analysis etc.), and on performing computer simulations, as well.

All of these impel the unprecedented demand for keeping accurate, up-to-date and policy-relevant migration data. The huge advances in information and communication technologies (ICTs), including the global proliferation of Internet, the miniaturization of the hardware components, the decrease of the prices and the increase of the capacity of secondary memory devices, the boost of the processing power, as well as the advances in storing and retrieving large portions of data, have led to contemporary database systems, capable of performing millions of transactions per second, and keeping track of billions of records within their database files. The current database technologies, interleaved by the Internet technologies, represent a solid fundament for tracking migrants all over the world and keeping relevant data about them.

2. World Migration Databases

Over the past three decades there has been enormous growth in the number and importance of database applications. Databases are used to store, manipulate, and retrieve data in an effective manner.

Recognizing the great potentials of the current ICT technologies, and the importance of keeping records about migrants and migrations, many organizations worldwide have developed and maintain huge databases. The data contained within such databases can be a valuable and indispensable resource for carrying out vital statistical analyses, as well as data mining operations, especially for the needs of the national policy makers.

Hereby we mention just a few of the numerous worldwide databases, keeping records about international migrants and migrations:

- United Nations Global Migration Database (UNGMD);
- OECD International Migration Database;
- Global Migrant Origin Database (Version 4).
- Migration Policy Institute (MPI) Migration Database;

- International Labour Organization (ILO) Migration Database.

Despite the challenge of keeping records about migrations on a global scale, by particular year and country/territory, such organizations are facing huge problems related to the quality of data acquired, since the sources of data are, in fact, individual contributions of national correspondents appointed by a particular world organization (UN, OECD, etc.) and approved by the authorities in each of the member countries. Consequently, these migration data have not been necessarily harmonized, standardized and mutually comparable at international level (OECD International Migration Database, 2012), mainly due to the following reasons, including:

- there are various data collection procedures and methodologies,
- each country uses its own data collection procedure and methodology,
- only few of data sources have been specifically designed to record migration movements,
- there are great variety of sources being used, and different populations may be measured across countries,
- the criteria for registering population and the conditions for granting residence permits vary across individual countries,
- the measurements may differ greatly even if a theoretically unique source is being used.

As a result, the consistency of data acquired is in question. Besides, there is also the problem of the comparability of statistics obtained by different countries. Finally, the global problem is also the coverage of illegal migrants worldwide.

On the other hand, the world migration databases possess advanced filtering, graphing and output capabilities across arbitrary number of countries, gender, years, and vital statistical variables. Some of them store records about stock, flow, net migration, asylum, and naturalization data over time, as well as possibilities for performing comparative migration statistics for regions and countries. They allow export of data in various formats, e.g. Excel spreadsheets (.XLS format), text files (.CSV format), and .XML format, as well as online generation of several types of charts (bar, line, scatter plots, etc.).

In order to illustrate the advanced graphing capabilities of world migration databases (OECD International Migration Database), we give the graphical representation of a single variable: inflows of foreign population in several European countries, by nationality, where the Republic of Macedonia is the country of origin, from 2000 to 2010 (Figure 2).

In addition, we have also generated a bar chart containing information held in the Global Migrant Origin Database, regarding the number of migrants coming into the Republic of Macedonia from the Balkan countries and vice versa as in 2007 (Figure

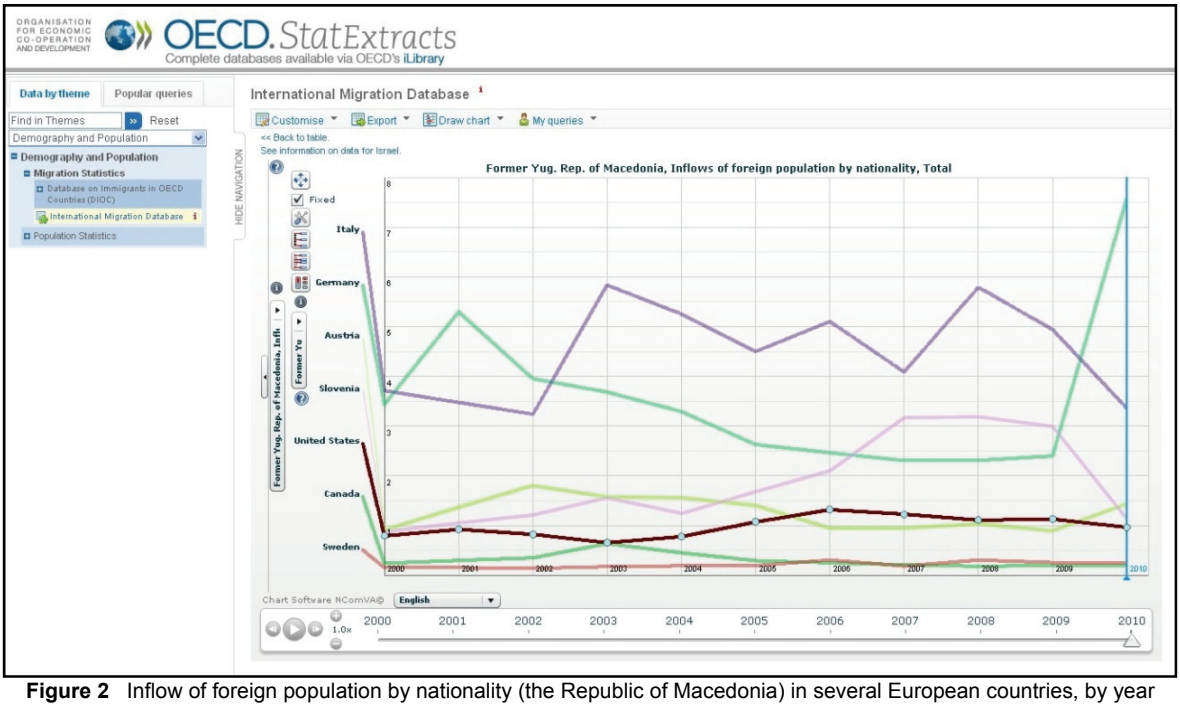

Figure 2 Inflow of foreign population by nationality (the Republic of Macedonia) in several European countries, by year (2000-2010).
Source: OECD International Migration Database, 2012.

3). The database is, in fact, a 226 x 226 matrix in an Excel worksheet format, containing international bilateral migration stock values for 226 countries/territories worldwide (Parsons, Skeldon, Walmsley & Winters, 2007). One can easily count the total number of migrants by country, either leaving or entering the country. This way we have found out that out of 258,851 people migrating from the Republic of Macedonia in 2007, 19.37% (50,151) have migrated into Balkan countries. Also, out of 32,995 people migrating into the Republic of Macedonia in 2007, 98.46% (32,489) originate from the Balkan countries region. The biggest outflow is towards Turkey, Croatia and Slovenia, whilst the biggest inflow originates from Albania.

The examples of world migration databases, previously elaborated, show that, in most cases, underlying databases do not contain detailed information about migrants and their migrations. This is quite comprehensible, since they serve as high-level statistical databases, containing already sublimed information. In the best cases, it is possible to distinguish among the gender of the migrants, the country of origin, the year of migration, and several most important variables taking into account some important characteristics, according to which the migrants can be filtered out.

Having on mind the importance of a detailed description, we propose a conceptual data model of a relational database, capturing the most relevant issues about migrants and migrations, in a form of an Entity-Relationship diagram (E-R diagram). The E-R diagram is a logical representation of the design of the relational database, which can be produced after a thorough analysis has been done. To the best of our knowledge, there is no similar conceptual data model published so far, despite the wide existence of migration databases.

3. The Analysis

The complexity of a given problem can be successfully addressed and managed by keeping the related data in a manner that will provide its effective usage. The design of a database should allow storage of all relevant data and provide quick access and easy modification, as well. According to Stair & Reynolds (2010), the following questions should be carefully considered in the preliminary phase of the designing process:

- Content: What data should be collected and at what cost?
- Access: What data should be provided to which users and when?
- Logical structure: How should data be arranged so that it makes sense to a given user?
- Physical organization: Where should data be physically located?

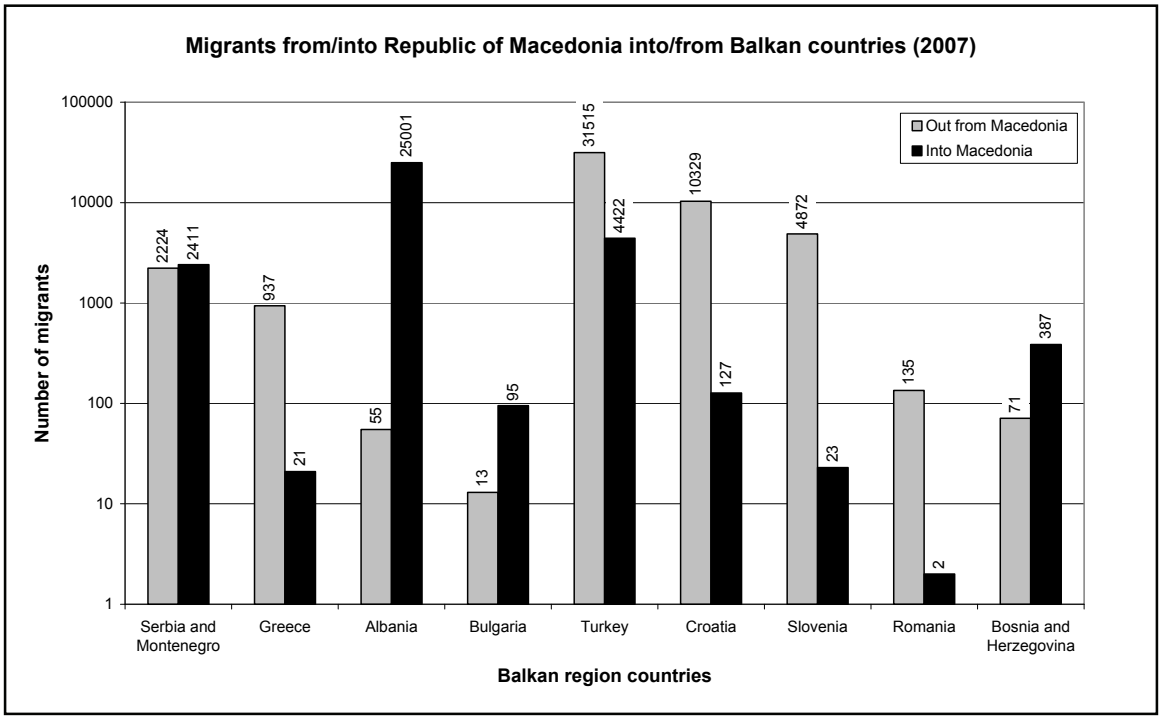

Figure 3 The inflow/outflow of migrants between the Republic of Macedonia and Balkan countries in 2007.
Source: Global Migrant Origin Database (Version 4).

Within the paper we focus solely on the content and the logical structure, as they are a foundation for the conceptual database design. In general, building a database requires two different types of designs, including a logical design and the physical design. The logical design of a database is an abstract model of how the data should be structured and arranged to meet the information needs. It involves identification of relationships among the data items and grouping them in an appropriate way. The physical design starts from the logical design and fine-tunes it for performance and cost considerations, e.g. response time, storage space, operating costs etc. (Stair & Reynolds, 2010; Rob & Coronel, 2009). The physical database design is not in the focus within this paper.

A common tool used for representing data and relationships among data is a data model. Building a data model relies on a thorough understanding of the specific problem, as well as a profound analysis of available data and information, necessary to obtain a relevant solution. Various data models have been developed so far, to help the analysis of data. An Entity-Relationship (E-R) diagram is an example of such a data model.

Within the analysis we take into account all the relevant facts tightly related to the migrants and their migration. The usefulness of the database is directly dependent on the level of abstraction (or level of details) used during the analysis. More detailed description leads towards better, but also more robust database design. Less detailed description results with a light-weight database, but one has to be aware of the fact that once a database has been designed, or, in the worst case, implemented, it is more difficult to add additional details (entities, attributes, or even relationships) or make any change. In most cases, an entire redesign is necessary to be carried out. Still, the conceptual design of the database is just a logical view on the database's structure. As far as the database design is not physically implemented, it is both allowable and easy to make any changes within the E-R model. In this section we emphasize the major pieces of information that have come out from our analysis of the migration processes. These should be included into the E-R model.

3.1. Personal Data

For each migrant, personal data should be notified, including: first name, family name, date of birth, place of birth, country, photo (if available), and children (if any and if they are migrants, too), parents (if any and if they are migrants, too).

3.2. Demographic Characteristics

Demographics usually include the following ones:

- gender (male/female),
- race (Caucasian/White, Negroid/Black, Indian/Red, Asian/Mongoloid/Yellow, …),
- religion (Christian, Muslim, Hindu, …),
- age,
- home ownership (yes/no, address),
- profession,
- level of education,
- languages spoken, including the level of reading, writing, speaking, listening,
- employment status (employed/unemployed),
- location, country of origin (developing/developed; region; continent),
- income level,
- ethnicity (Macedonian, Serbian, Croatian, Russian, Swedish, …),
- marital status:
  - ✓ single (unmarried, divorced, widowed, in a relationship, engaged),
  - ✓ married (unseparated, separated),
- family status (has no children, has children & lives with them, has children & doesn't live with them).

3.3. Migration-related issues

Migration-related issues comprise the following ones:

- migration status (refugee: international/intra-national; asylee),
- authorization status (legal, illegal),
- type of intention (voluntary – planned, forced - unplanned),
- type of stay according to duration (permanent/temporary),
- type of movement (periodic – cyclic, non-periodic),
- direction of movement (immigrant/emigrant),
- migration type (internal/external - international).

3.4. Push Factors

Push factors are the events or conditions that impel an individual to move from the current location. Push factors are forceful factors, which relate to the country/location the person is migrating from. In general, they are problems which result in people wanting to migrate. The most frequent push factors, roughly categorized as political, economic, environmental, and social ones, are as follows:

- Political: war, political/ethnical conflicts; political instability; fear of persecution; dislike of the political system;
- Economic: poverty; unemployment; lack of services; lack of jobs; underemployment; lack of opportunities to start an own business; lack of opportunities to find a job; loss of wealth; lack of food;
- Environmental: natural disasters: flooding, earthquake, volcano eruption, drought; drastic climate changes;
- Social: lack of safety; high level of crime; poor medical care; primitive living conditions; not being able to practice religion; fear of torture; mistreatment; few opportunities; poor educational opportunities.

3.5. Pull Factors

On the other hand, pull factors are the forces of attraction that influence migrants to move to a particular location. Pull factors concern the country/location a person migrates to. In general, they are good things that attract people to migrate to a certain place. The following are the most prominent pull factors, also roughly subdivided into four categories, including political, economic, environmental, and social ones:

- Political: the lure of freedom, the lure of democracy, political stability;
- Economic: higher employment rates; economic wealth; better standards of living; better chances to get a job; better chances to start an own business; better services;
- Environmental: attractive climate conditions; more fertile land; lower risk from natural hazards;
- Social: better education; better medical care; family links; better security: safer living conditions; less crime; better opportunities.

3.6. Immediate Reasons

Besides the push and pull factors being discussed previously, it is also important to know the direct reasons for a particular migration. These can be also grouped in several categories, including family-related, job-related, housing-related and other reasons, as shown below:

- Family-related: change in marital status; to establish own household; other family reasons;
- Job-related: new job/job transfer; to look for work; to be closer to work-easier commute; retirement; other job-related reasons;
- Housing-related: wanted own home, not rented; wanted new/better home/apartment; wanted better neighbourhood/less crime; wanted cheaper housing; foreclosure/eviction; other housing reason;
- Other reasons: to attend/leave college; change of climate; health reasons; natural disaster; other reasons.

Obviously, many of the direct reasons interfere with some of the push/pull factors, previously mentioned. It is a disputable question whether to keep both push/pull factors and direct reasons together within the same database. Still, in our opinion, it is a good practice to take into account the direct reasons, since they can provide an unambiguous insight into the migrant's nature, since the list of direct reasons can be much more detailed in comparison to more generally stated push/pull factors.

4. The E-R Diagram

An Entity-Relationship model (E-R model) is a detailed, logical representation of the data acquired regarding a specific area of interest. The E-R model is expressed in terms of entities being identified in the given environment (area of interest), the relationships (associations) among those entities, and the attributes (properties) of both the entities and their relationships. An E-R model is normally expressed as an entity-relationship diagram (E-R diagram), which is a graphical representation of an E-R model (Hoffer, Prescott & McFadden, 2007, pp. 85-239).

The whole process of designing the E-R diagram is iterative by nature. First, it is crucial to identify the entities and their attributes of interest. An entity can be a person, a thing, or an object that can be uniquely identified as a subject within the system. Each entity has at least one attribute. An attribute is a characteristic of the entity. Then, for each of the entities, a primary key, consisting of one or more attributes, is chosen from the set of all attributes identified for a particular entity. The primary key is an identifier of a particular occurrence (instantiation) of the entity, i.e. two particular instants of a single entity can be mutually differentiated by the value of the primary key. Next, relationships among entities are identified. Each relationship is characterized by its type (unary, binary, ternary, etc…), and cardinality (1:1, 1:N (N:1), and N:M), whilst each end of the relationship is characterized by the type of participation within the relationship (mandatory or optional).

E-R diagrams use basic graphical symbols to show the organization and relationships between data being identified. In most cases, boxes indicate entities, ovals represent their attributes, and diamonds show the relationships among entities. Development of E-R diagrams helps ensure that the logical structure of the data model is both consistent and equivalent with the database data structure. It also helps ensure the correctness of the data structure being physically implemented as a database. In addition, E-R diagrams serve as reference documents after a physical database has been deployed. Besides, building E-R diagrams is a fundamental step towards building a relational database model, which describes data using a standard tabular format. All data available is placed into two-dimensional tables, named relations, which are logical equivalent of files. The tables in a relational database organize actual data in rows (records) and columns (fields), thus simplifying data access and manipulation. Each record within a table, in fact, denotes an instantiation of the entity, i.e. it represents an actual specimen of the corresponding entity, being implemented as a table. Each column (field) within a table represents an attribute, which takes values from the set of allowable values, called a domain.

Based on the analysis provided in Section 3, the resulting E-R diagram we propose is given on Figure 4.

It should be also pointed out that the uniqueness of the E-R model is not its exclusive characteristic, i.e. variations of the same E-R model are possible, too. The efficiency of the corresponding physical database, in terms of its performances (sorting of records, retrieval of data, computation speed, the speed of read/write/update operations, etc.) is directly dependent on the underlying logical design, i.e. the underlying E-R model.

5. The Relational Schema

Given a specific E-R diagram, the next step is to convert it into a corresponding schema of a relational database, according to specific rules, given by Hoffer et al. (2007, pp. 85-239). The following relational schema can be derived from the E-R diagram, shown on Figure 4.

LANGUAGE (lang_id, lang_name)
EDUCATION (edu_id, edu_name)
RACE (race_id, race_name)
ETHNICITY (eth_id, eth_name)
RELIGION (rel_id, rel_name)
PROFESSION (prof_id, prof_name)
COUNTRY (country_id, country_name)
REGION (region_id, region_name)
CONTINENT (cont_id, cont_name)
BELONGS_TO_R (country_id, region_id)
BELONGS_TO_C (country_id, cont_id)
R_BELONGS_TO_C (region_id, cont_id)
REASON_TYPE (r_type_id, r_type_name)
REASON (reason_id, reason_name, *r_type_id*)
F_CATEGORY (f_cat_id, f_cat_name)
PUSH_FACTOR (pushf_id, pushf_name, *f_cat_id*)
PULL_FACTOR (pullf_id, pullf_name, *f_cat_id*)
PLACE (gps, place_name, longitude, latitude, place_type, *country_id*)
PERSON (person_id, first_name, second_name, birth_date, death_date, gender, home_owner, home_address, employ_status, employ_income, marital_status, family_status, photo, note, age, *edu_id*, *race_id*, *is_born_in_place*, *pass_away_in_place*, *eth_id*, *rel_id*)
KNOWS_LANGUAGE (person_id, lang_id, reading, writing, speaking, listening)
IS_FATHER_OF (person_id_1, person_id_2)
IS_MOTHER_OF (person_id_1, person_id_2)
HAS_PROFESSION (person_id, prof_id)
MIGRATION (migration_id, migration_status, author_status, intent_type, stay_duration, move_type, move_direction, migration_type, mig_date_from, mig_date_to, *move_from_gps*, *move_to_gps*)
STAGE (migration_id, stage_no, stage_type, stage_transport, stage_date_from, stage_date_to, *starts_in_gps*, *ends_in_gps*)
INVOLVES (person_id, migration_id)
HAS_REASON (migration_id, reason_id)
PUSHED_BY (migration_id, pushf_id)
PULLED_BY (migration_id, pullf_id)

The resulting relational schema is already in 3NF (third normal form), which is sufficient for most applications. The 3NF ensures that there are neither partial nor transitive functional dependencies of the non-key attributes from the primary key, in each particular relation (table). The relational schema consists of 29 relations in total, a number which speaks itself about the complexity of the problem. Each of the relations is physically implemented as a separate table within the relational database. The relationships among tables are made by means of the mechanism of foreign keys, i.e. the italicized items (attributes) at the end of some relations. The primary keys, which are mandatory for each relation, are given as bolded and underlined attributes at the beginning of each relation.

What is missing in this description is the specification of the corresponding data types for each attribute within relations, e.g. text, numeric, date/time, logical (Boolean), etc. The exact specification of such information is dependent on the actual RDBMS.

The relational schema obtained can be physically implemented in any of the modern relational database management systems (RDBMSs), either commercially available (Microsoft® SQL Server, Microsoft® Access, Oracle, IBM® DB2), or open-sourced, like Sybase® IQ, MySQL etc.

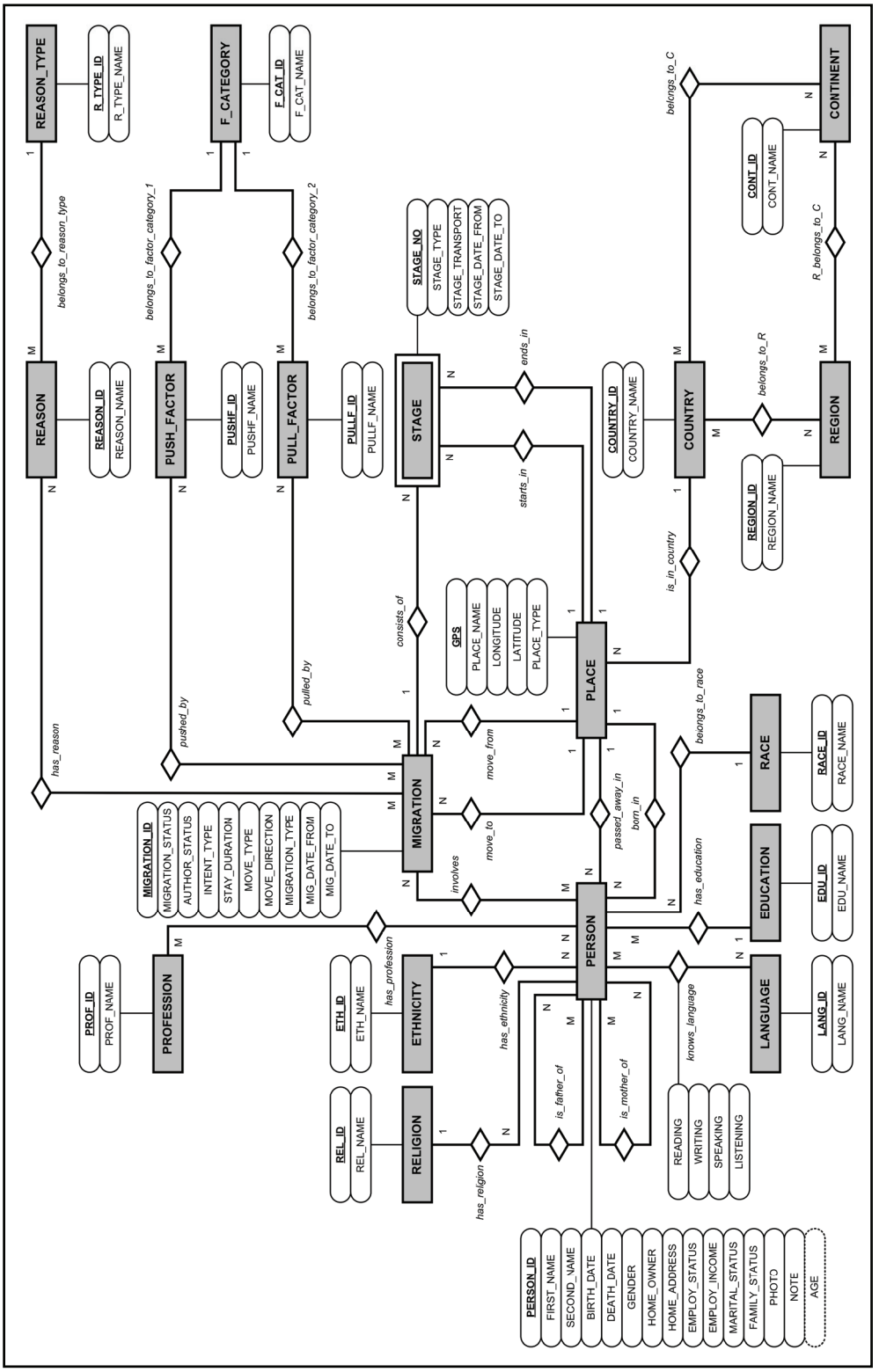

Figure 4 The E-R diagram of the modern human migration relational database.

6. Conclusion

Migration is a complex phenomenon that includes a huge amount of quantitative and qualitative aspects, many of them being interdisciplinary by nature, which have to be properly detected, logically organized, stored and retrieved when needed. The advantage goes to people and organizations that collect, manage, and interpret information in a proper, consistent and cost-effective way. This is especially important when monitoring migration, as a large-scale social phenomenon. Migration is increasingly being acknowledged as an issue that needs a profound and global approach and coordinated responses not only on a bilateral or regional level, but also on a global level. Studying such phenomena and making policies have to be based on relevant and accurate statistical data, which, in turn, rely on well-designed, regularly updated and properly maintained databases.

The conceptual data model of the modern human migrations we propose captures well all relevant data about migrants and their migrations, and is a solid foundation for further enhancements and extensions. It encompasses not only the static data about each migrant, but also it includes genealogical data (both successors and ancestors), as well as the relevant spatial and temporary data about migrants' movements. This way it offers a complete picture on the migration phenomenon.

The relational database that could be possibly built using the proposed relational schema (E-R model) can address key policy questions, many of them being unanswered so far, including:

- What are the main countries of origin of international migrants?
- What is the gender and age distribution of international migrants?
- What are changes in the international migrant stock over time for particular countries of origin or age groups?
- Stock of foreign-born population, by country of birth, by year;
- Foreign born as a percentage of the total population, by year;
- Estimates of the net number of migrants, by five year intervals;
- Inflow of new legal permanent residents by country of birth, by year;
- Inflow of new legal permanent residents, by age and gender, by year;
- Top 10 sending countries of new legal permanent residents by country of birth, by year;
- Refugee admission, by year;
- Top 10 states of refugee's initial resettlement;
- Acquisition of citizenship, by country of former nationality, by year;
- Acquisition of citizenship (total), by year;
- Annual number of asylum applications by nationality, by year.

In addition, such relational database can allow the quantification and monitoring of vulnerable groups that need a special protection, such migrant women, children and stateless persons.

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