Paper

Applying the relational modelling and knowledge-based techniques to the emitter database design

Janusz Dudczyk, Jan Matuszewski, and Marian Wnuk

Abstract — The appropriate emitter database is one of the most important elements in the present electronic intelligence (ELINT) system. This paper provides an overview of the relational modelling, which is used to construct the emitter database for current ELINT systems. The method described, delivers the entities' relational diagram that is independent from the manner of the data storage in further process of implementation. This approach ensures the integrity of the measured data. The process of final emitter identification is based on "the knowledge-based approach" which was implemented during the process of constructing the database.

Keywords* — *emitter database, relational modelling, knowledge-based-techniques, semantic networks, confidence factor.

1. Introduction

The last local military conflicts show that success on the modern battlefield depends on the following aspects ([6]):

- detecting electromagnetic emissions and finding the direction of incoming signals;
- gathering basic information about an enemy's situation and his capabilities;
- analysing the emitter's characteristics such as technical parameters, operating role and geographic location;
- providing current and real-time information about hostile activities in the areas of interest and warn of threats;
- monitoring any changes of situation and target parameters;
- communicating the most important data as soon as possible (task, report, exchange information);
- providing the control, command and supporting of the forces on the electronic battlefield.

The present electronic intelligence system must be able to protect specific requirements. In this case, ELINT system ought to include correctly designed database. The process of designing the optimal structure of emitter database is a very complicated and sophisticated task. The main problem that appears during the process of constructing the database is the difficulty with correct selection of the features. The relational modelling (*tool of information engineering, used to construct the high quality entities' relational diagram*) is an essential element in forming the examined system.
The method of relational modelling delivers the "notional model" that is independent from the manner of the data storage in further process of implementation. The integrity of the measured data is an advantage of this approach.

2. The process of designing database, the entities' relational diagram

The emitter database is designed according to the following stages, illustrated in Fig. 1:

- notional model – in the form of entities' relational diagram;
- logical model – specific form of database (definite type of database);
- physical model – implemented according to the selection of physical organization.

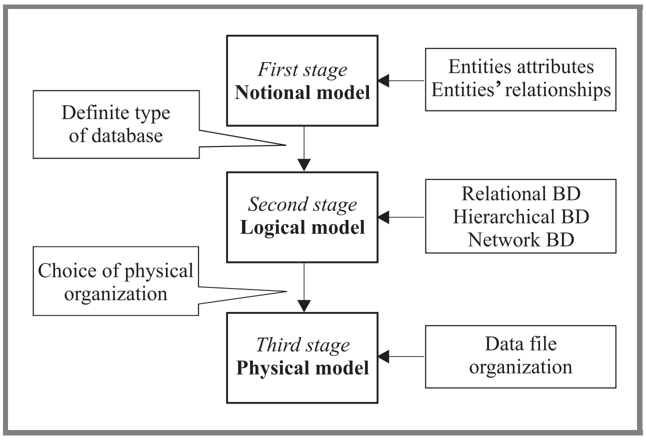

Fig. 1. The three – stage structure of designing database.

Principal aspects of relational modelling shown in Fig. 2, are the following [1, 2]:

- identification of important things in ELINT system /entities/;

- qualification of the properties of these things /attributes /;
- qualification of the kind of relationships between entities /entities' relationships/.

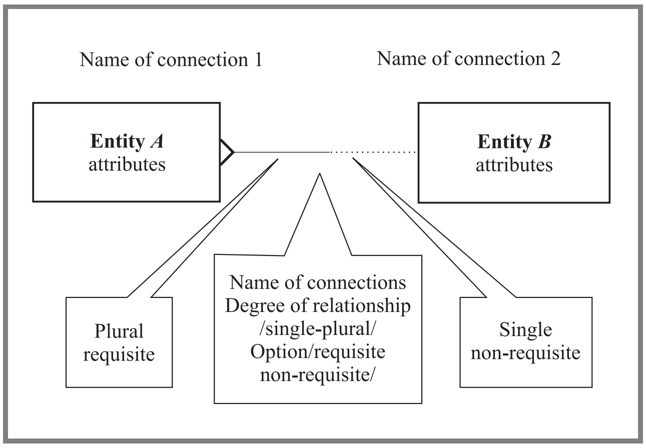

Fig. 2. Example of relationship between entity *A* and entity *B*.

An entity – can be defined as a thing or object, real or non-real. All information about it must be well known and stored.
Entity's relationship – can be defined as an essential connection between two entities.
It is advisable to add, the process of database designing based on relational modelling is accurately defined. Every entity must be univocally identified. Also every relationship must be determined. An entity should be described by its attributes.
As shown in Fig. 3, the relational diagram is the first stage of database designing [3, 4]. An entity is illustrated by a frame. An entity's name is located in the middle of the frame, for example: **Technical parameters**, **Radar platform**. The line-connected two entities' frames together illustrate the relationship between entities. Every relationship must be defined by the degree of relationship (it can be single or plural), the option (option defines the type of connection: requisite or non-requisite) and the name of connection (Figs. 2, 3). The conception of creation "notional model" should take into account "radar signature" in database. The "radar signature" in database includes all available data about radar signals. The main problem is to decide which information should be stored in database and correlate it with data types. In this case every entity should have a substitute in earlier prepared "radar signature".

3. Applying the knowledge-based techniques to emitter database

Now in ELINT systems knowledge-based techniques are widely examined [5, 7]. They may be applied to merge information and emitter identification. Usually information concerning the radar platforms known to be present, their locations, their intentions, their history of recent operational use, behaviour and their expected actions is not used. This is the kind of knowledge that is currently possessed only by the ESM operator and his supervisor. Usually part knowledge available to the knowledge-based ESM systems takes the form of individual radar details, their platforms and relationships between them. Knowledge-based techniques provide a means of studying this kind of knowledge and, ultimately, a means of representing it in a coherent manner.
The knowledge-base employs a declarative, rule-based representation of facts about the radar domain. The most important characteristics, which are related to each other in a specific type of radar and permit to recognize its application, are following:

- the principal parameters of radar signal that correspond to technical characteristics of the radiating set are: pulse width, carrier frequency, pulse shape, pulse repetition frequency, type of scan, beam width;
- carrier frequency is related to: antenna dimension, beam width, maximum range of radar;
- pulse width affects: range resolution and minimum range of radar;
- pulse repetition frequency limits the maximum unambiguous range of a pulse radar;
- pulse shape shows the range measurement accuracy;
- type of scanning (circular, sector, conical, helical, spiral, raster, etc.) is related to the application of radar;
- beam width affects the angular resolution.

Generally, a scheme of emitter identification may be based on rules or semantic networks. The simplest way of knowledge representation by rules is as follows:

IF *fact A is true* **AND** *fact B is true* **THEN** *conclude X* **ELSE** *conclude Y*.

For example:

IF (pulse width is less than 0.5 μs) **AND** (type of scan is circular – sector) **THEN** (the radar of battlefield surveillance was detected).

In real EW expert systems such procedures are much more sophisticated. Searching for the best solution needs other more complicated strategies (Fig. 4).
In order to make a decision in case of uncertainty, the probability theory or confidence factors (*CF*) may be used. The rules are activated in the moment when the values of this *CF* exceed the calculated thresholds, e.g.

IF *fact* (*CF* = 0,3) **THEN** *conclusion*.

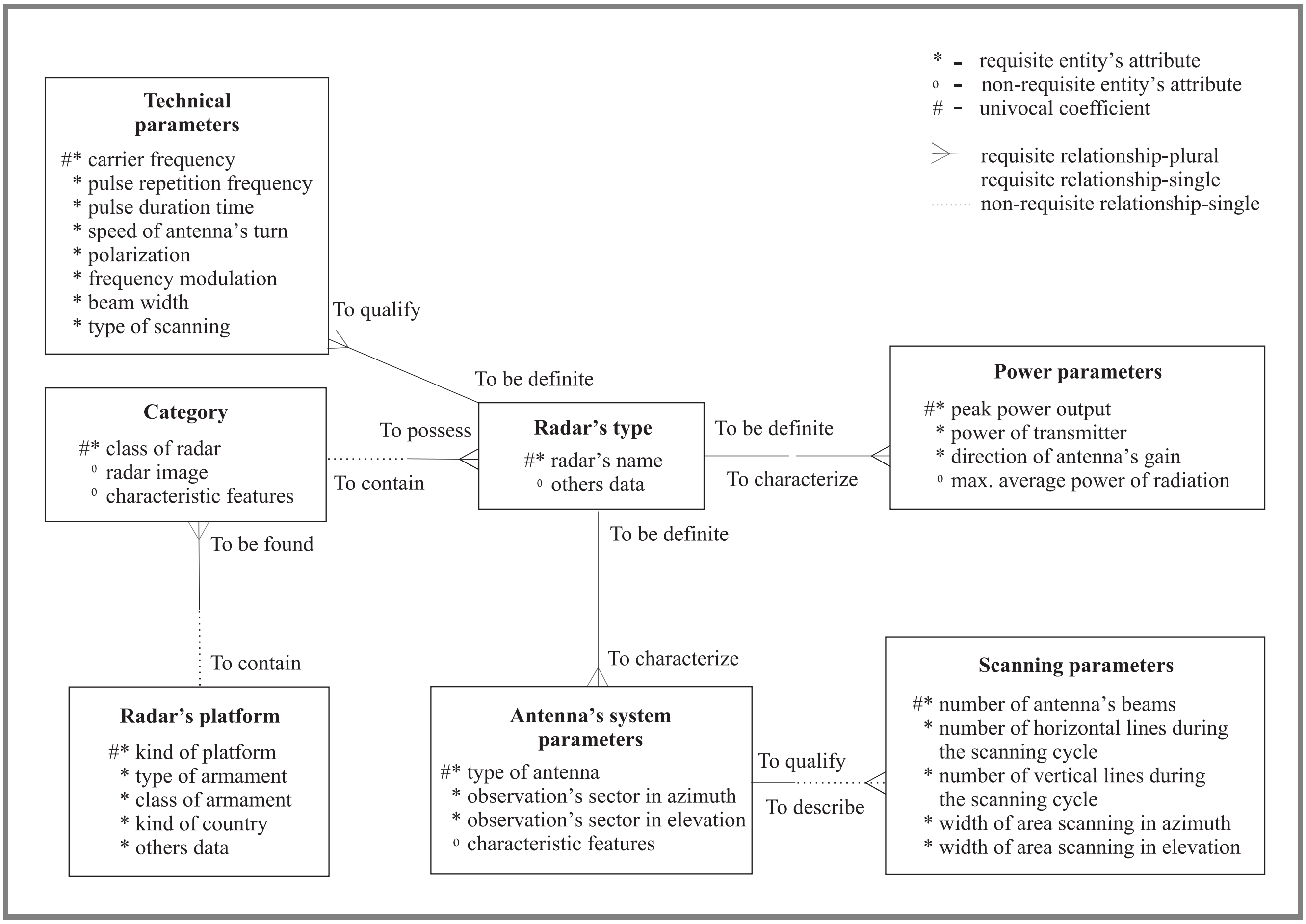

Fig. 3. The entities' relational diagram of ELINT system's database.

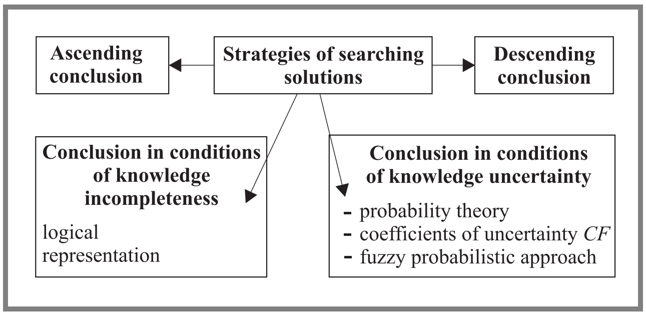

Fig. 4. Strategies of searching solutions.

In a fuzzy probabilistic approach, the classical two-values function f of membership of the object x to set A, is replaced by a "fuzzy" function:

$$f(x) = 1, \quad \text{if } x \in A$$
$$f(x) = 0, \quad \text{if } x \notin A$$
$$\downarrow$$
$$f : A \to \{0,1\}.$$

In the description of a real situation the following concepts: "nearly", "enough", "a little" which depict the surrounding reality very well, are often used.

4. Conclusion

Designing an optimal structure of ELINT system's database is a very sophisticated task. The database described in this paper was designed by using the relational modelling. The diagram of entities' relational-the most important stage during the process of designing was illustrated in Fig. 3. The database was estimated in size of the hard disc memory, taking into account the size of fields' types, the quantity and the character of tables. The process of final emitter identification based on "the knowledge-based approach" was implemented during the database constructing. Furthermore, entities' relational diagram deprives database of redundancy features and can be used in the electronic intelligence system or another military application.

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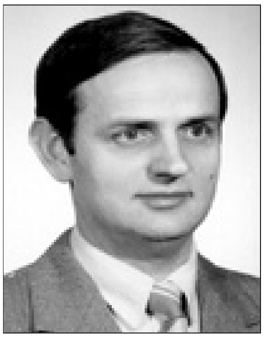

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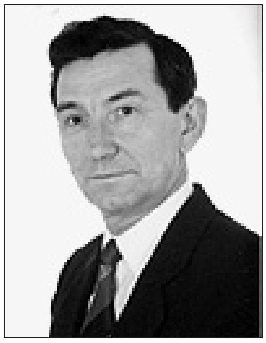

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