LSINF2335 – Programming paradigms

Project 1: A SQL Interpreter in Prolog

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1 How are your tables/rows stored in the Prolog knowledge base?

I use three predicates to store the metadata of the tables.

table_db The first one is table_db(X). This predicate is used to know if X is a table that exists in the database. It's useful to insert a table, to not overwrite an existing table.
Example:

```
table\_db(client).
```

arity The second one ,arity(T, A), store the information about the arity of a table. T is the table and A is the number of variables of the table T. This is used in a lot of queries.
Example:

```
arity(client ,6).
```

var The third one is var(T, I, N) that store the association between a variable his index in the table. The indexes start at 0.
Example:

```
var(client ,2 ,adresse).
```

In the table 'client', 'adresse' is the variable at the index 2.

The data are stored into predicates where the name of the predicate is the name of the table and the parameters are the variables of the table.
For a better visualization, here is a small example of the representation of a table in the knowledge base of Prolog:

```
table_db(father).

arity(father, 2).

var(father, 0, parent).
var(father, 1, child).

father('Homer', 'Bart').
father('Homer', 'Lisa').
father('Homer', 'Maggie').
father('Abraham', 'Homer').
```

2 What is the "mismatch" between SQL and Prolog that forces us to write code to handle the differences?

The difference is that SQL is primarily a relation engine and Prolog is primarily a rule of inference engine. One can do what the other does but we have to write more code to achieve this.
Both are declarative languages but the grammar is not the same at all. SQL has a syntax which is easily readable (that's one of the goal of SQL[1]) and Prolog follow the logic programming paradigm with predicates that are Horn clauses.
So to transform a SQL query into a Prolog query, there is some adaptation to do by parsing the query and building a tree with it. With this tree, we have a structured representation of the query and it's easier to execute it in prolog. Hopefully, it's easy to parse a different grammar in prolog using the DCG notation.

3 Examples of Prolog queries.

For a better readability, the results of the queries have been beautified. Normally, they stand on one line per variable.

3.1 Load/reset the example data.

```
?- load.
?- reset.
```

3.2 Create a new table.

```
?- parse("CREATE TABLE father (parent, child);", T, V).

T = create_table(
        table(father),
        var([
            parent,
            child
        ])
    ).
```

[1] https://fr.wikipedia.org/wiki/Structured_Query_Language#Syntaxe_g.C3.A9n.C3.A9rale

3.3 Insert a row in a table.

```
?- parse("INSERT INTO father VALUES (\"Hommer\", \"Bart\");", T, V).

T = insert(
        table(father),
        val([
            string(Hommer),
            string(Bart)
        ])
    ).
```

3.4 Select all rows in a table.

```
?- parse("SELECT * FROM client;", T, V).

T = select(
        var(all),
        table(client)
    ),
V = [[B062,Goffin,72, rue de la Gare,Namur,B2,-3200],
[B112,Hansenne,23, rue Dumont,Poitiers,C1,1250],
[B332,Monti,112, rue Neuve,Geneve,B2,0],
[B512,Gillet,14, rue de l Etat,Toulouse,B1,-8700],
[C003,Avron,8, rue de la Cure,Toulouse,B1,-1700],
[C123,MERCIER,25, rue Lemaitre,Namur,C1,-2300],
[C400,Ferard,65, rue du Tertre,Poitiers,B2,350],
[D063,Mercier,201, boulevard du Nord,Toulouse,B2,-2250],
[F010,Toussaint,5, rue Godefroid,Poitiers,C1,0],
[F400,Jacob,78, chemin du Moulin,Bruxelles,C2,0],
[K111,Vanbist,180, rue Florimont,Lille,B1,720],
[L422,Franck,60, rue de Wepion,Namur,C1,0],
[S127,Vanderka,3, avenue des Roses,Namur,C1,-4580],
[S712,Guillaume,14a, chemin des Roses,Paris,B1,0],
[F011,PONCELET,17, Clos des Erables,Toulouse,B2,0],
[K729,NEUMAN,40, rue Bransart,Toulouse,B2,0]].
```

3.5 Select all rows that match a predicate.

```
?- parse("SELECT * FROM commande WHERE date=\"2009-01-02\";",T,V).

T = select_where(
        var(all),
        table(commande),
        conditions(
            cond(
                date,
                op(=),
                string(2009-01-02)
            )
        )
    ),
V = [[30185,F011,2009-01-02],
[30186,C400,2009-01-02],
[30188,B512,2009-01-02],
[30185,F011,2009-01-02],
[30186,C400,2009-01-02],
[30188,B512,2009-01-02]].
```

3.6 Select some columns from rows that match a predicate.

```
?- parse("SELECT nom, compte FROM client WHERE compte < 0;", T, V).

T = select_where(
        var([
            nom,
            compte
        ]),
        table(client),
        conditions(
            cond(
                compte,
                op(<),
                num(0)
            )
        )
    ),
V = [[Goffin,-3200],
[Gillet,-8700],
[Avron,-1700],
[MERCIER,-2300],
[Mercier,-2250],
[Vanderka,-4580]].
```

3.7 Select all rows from a cross join between two

tables.

```
?- parse("SELECT * FROM client CROSS JOIN commande;", T, V).

T = cross_join(
        table_var(all),
        join(
            table1(client),
            table2(commande)
        )
    ),
V = [[B062,Goffin,72, rue de la Gare,Namur,B2,-3200,30178,K111,2008-12-22],
[B062,Goffin,72, rue de la Gare,Namur,B2,-3200,30179,C400,2008-12-22],
[B062,Goffin,72, rue de la Gare,Namur,B2,-3200,30182,S127,2008-12-23],
[B062,Goffin,72, rue de la Gare,Namur,B2,-3200,30184,C400,2008-12-23],
[B062,Goffin,72, rue de la Gare,Namur,B2,-3200,30185,F011,2009-01-02],
[B062,Goffin,72, rue de la Gare,Namur,B2,-3200,30186,C400,2009-01-02],
[B062,Goffin,72, rue de la Gare,Namur,B2,-3200,30188,B512,2009-01-02],
[B112,Hansenne,23, rue Dumont,Poitiers,C1,1250,30178,K111,2008-12-22],
[B112,Hansenne,23, rue Dumont,Poitiers,C1,1250,30179,C400,2008-12-22],
[B112,Hansenne,23, rue Dumont,Poitiers,C1,1250,30182,S127,2008-12-23],
[B112,Hansenne,23, rue Dumont,Poitiers,C1,1250,30184,C400,2008-12-23],
[B112,Hansenne,23, rue Dumont,Poitiers,C1,1250,30185,F011,2009-01-02],
[B112,Hansenne,23, rue Dumont,Poitiers,C1,1250,30186,C400,2009-01-02],
[B112,Hansenne,23, rue Dumont,Poitiers,C1,1250,30188,B512,2009-01-02],
[B332,Monti,112, rue Neuve,Geneve,B2,0,30178,K111,2008-12-22],
[B332,Monti,112, rue Neuve,Geneve,B2,0,30179,C400,2008-12-22],
[B332,Monti,112, rue Neuve,Geneve,B2,0,30182,S127,2008-12-23],
[B332,Monti,112, rue Neuve,Geneve,B2,0,30184,C400,2008-12-23],
[B332,Monti,112, rue Neuve,Geneve,B2,0,30185,F011,2009-01-02],
[B332,Monti,112, rue Neuve,Geneve,B2,0,30186,C400,2009-01-02],
[B332,Monti,112, rue Neuve,Geneve,B2,0,30188,B512,2009-01-02],
[B512,Gillet,14, rue de l Etat,Toulouse,B1,-8700,30178,K111,2008-12-22],
[B512,Gillet,14, rue de l Etat,Toulouse,B1,-8700,30179,C400,2008-12-22],
[B512,Gillet,14, rue de l Etat,Toulouse,B1,-8700,30182,S127,2008-12-23],
[B512,Gillet,14, rue de l Etat,Toulouse,B1,-8700,30184,C400,2008-12-23],
[B512,Gillet,14, rue de l Etat,Toulouse,B1,-8700,30185,F011,2009-01-02],
[B512,Gillet,14, rue de l Etat,Toulouse,B1,-8700,30186,C400,2009-01-02],
[B512,Gillet,14, rue de l Etat,Toulouse,B1,-8700,30188,B512,2009-01-02],
[C003,Avron,8, rue de la Cure,Toulouse,B1,-1700,30178,K111,2008-12-22],
[C003,Avron,8, rue de la Cure,Toulouse,B1,-1700,30179,C400,2008-12-22],
[C003,Avron,8, rue de la Cure,Toulouse,B1,-1700,30182,S127,2008-12-23],
[C003,Avron,8, rue de la Cure,Toulouse,B1,-1700,30184,C400,2008-12-23],
[C003,Avron,8, rue de la Cure,Toulouse,B1,-1700,30185,F011,2009-01-02],
[C003,Avron,8, rue de la Cure,Toulouse,B1,-1700,30186,C400,2009-01-02],
[C003,Avron,8, rue de la Cure,Toulouse,B1,-1700,30188,B512,2009-01-02],
[C123,MERCIER,25, rue Lemaitre,Namur,C1,-2300,30178,K111,2008-12-22],
[C123,MERCIER,25, rue Lemaitre,Namur,C1,-2300,30179,C400,2008-12-22],
[C123,MERCIER,25, rue Lemaitre,Namur,C1,-2300,30182,S127,2008-12-23],
[C123,MERCIER,25, rue Lemaitre,Namur,C1,-2300,30184,C400,2008-12-23],
[C123,MERCIER,25, rue Lemaitre,Namur,C1,-2300,30185,F011,2009-01-02],
[C123,MERCIER,25, rue Lemaitre,Namur,C1,-2300,30186,C400,2009-01-02],
[C123,MERCIER,25, rue Lemaitre,Namur,C1,-2300,30188,B512,2009-01-02],
[C400,Ferard,65, rue du Tertre,Poitiers,B2,350,30178,K111,2008-12-22],
[C400,Ferard,65, rue du Tertre,Poitiers,B2,350,30179,C400,2008-12-22],
[C400,Ferard,65, rue du Tertre,Poitiers,B2,350,30182,S127,2008-12-23],
[C400,Ferard,65, rue du Tertre,Poitiers,B2,350,30184,C400,2008-12-23],
[C400,Ferard,65, rue du Tertre,Poitiers,B2,350,30185,F011,2009-01-02],
[C400,Ferard,65, rue du Tertre,Poitiers,B2,350,30186,C400,2009-01-02],
[C400,Ferard,65, rue du Tertre,Poitiers,B2,350,30188,B512,2009-01-02],
[D063,Mercier,201, boulevard du Nord,Toulouse,B2,-2250,30178,K111,2008-12-22],
[D063,Mercier,201, boulevard du Nord,Toulouse,B2,-2250,30179,C400,2008-12-22],
[D063,Mercier,201, boulevard du Nord,Toulouse,B2,-2250,30182,S127,2008-12-23],
[D063,Mercier,201, boulevard du Nord,Toulouse,B2,-2250,30184,C400,2008-12-23],
[D063,Mercier,201, boulevard du Nord,Toulouse,B2,-2250,30185,F011,2009-01-02],
[D063,Mercier,201, boulevard du Nord,Toulouse,B2,-2250,30186,C400,2009-01-02],
[D063,Mercier,201, boulevard du Nord,Toulouse,B2,-2250,30188,B512,2009-01-02],
[F010,Toussaint,5, rue Godefroid,Poitiers,C1,0,30178,K111,2008-12-22],
[F010,Toussaint,5, rue Godefroid,Poitiers,C1,0,30179,C400,2008-12-22],
[F010,Toussaint,5, rue Godefroid,Poitiers,C1,0,30182,S127,2008-12-23],
[F010,Toussaint,5, rue Godefroid,Poitiers,C1,0,30184,C400,2008-12-23],
[F010,Toussaint,5, rue Godefroid,Poitiers,C1,0,30185,F011,2009-01-02],
[F010,Toussaint,5, rue Godefroid,Poitiers,C1,0,30186,C400,2009-01-02],
[F010,Toussaint,5, rue Godefroid,Poitiers,C1,0,30188,B512,2009-01-02],
[F400,Jacob,78, chemin du Moulin,Bruxelles,C2,0,30178,K111,2008-12-22],
[F400,Jacob,78, chemin du Moulin,Bruxelles,C2,0,30179,C400,2008-12-22],
[F400,Jacob,78, chemin du Moulin,Bruxelles,C2,0,30182,S127,2008-12-23],
[F400,Jacob,78, chemin du Moulin,Bruxelles,C2,0,30184,C400,2008-12-23],
[F400,Jacob,78, chemin du Moulin,Bruxelles,C2,0,30185,F011,2009-01-02],
[F400,Jacob,78, chemin du Moulin,Bruxelles,C2,0,30186,C400,2009-01-02],
[F400,Jacob,78, chemin du Moulin,Bruxelles,C2,0,30188,B512,2009-01-02],
[K111,Vanbist,180, rue Florimont,Lille,B1,720,30178,K111,2008-12-22],
[K111,Vanbist,180, rue Florimont,Lille,B1,720,30179,C400,2008-12-22],
[K111,Vanbist,180, rue Florimont,Lille,B1,720,30182,S127,2008-12-23],
[K111,Vanbist,180, rue Florimont,Lille,B1,720,30184,C400,2008-12-23],
[K111,Vanbist,180, rue Florimont,Lille,B1,720,30185,F011,2009-01-02],
[K111,Vanbist,180, rue Florimont,Lille,B1,720,30186,C400,2009-01-02],
[K111,Vanbist,180, rue Florimont,Lille,B1,720,30188,B512,2009-01-02],
[L422,Franck,60, rue de Wepion,Namur,C1,0,30178,K111,2008-12-22],
[L422,Franck,60, rue de Wepion,Namur,C1,0,30179,C400,2008-12-22],
[L422,Franck,60, rue de Wepion,Namur,C1,0,30182,S127,2008-12-23],
[L422,Franck,60, rue de Wepion,Namur,C1,0,30184,C400,2008-12-23],
[L422,Franck,60, rue de Wepion,Namur,C1,0,30185,F011,2009-01-02],
[L422,Franck,60, rue de Wepion,Namur,C1,0,30186,C400,2009-01-02],
[L422,Franck,60, rue de Wepion,Namur,C1,0,30188,B512,2009-01-02],
[S127,Vanderka,3, avenue des Roses,Namur,C1,-4580,30178,K111,2008-12-22],
[S127,Vanderka,3, avenue des Roses,Namur,C1,-4580,30179,C400,2008-12-22],
[S127,Vanderka,3, avenue des Roses,Namur,C1,-4580,30182,S127,2008-12-23],
[S127,Vanderka,3, avenue des Roses,Namur,C1,-4580,30184,C400,2008-12-23],
[S127,Vanderka,3, avenue des Roses,Namur,C1,-4580,30185,F011,2009-01-02],
[S127,Vanderka,3, avenue des Roses,Namur,C1,-4580,30186,C400,2009-01-02],
[S127,Vanderka,3, avenue des Roses,Namur,C1,-4580,30188,B512,2009-01-02],
[S712,Guillaume,14a, chemin des Roses,Paris,B1,0,30178,K111,2008-12-22],
[S712,Guillaume,14a, chemin des Roses,Paris,B1,0,30179,C400,2008-12-22],
[S712,Guillaume,14a, chemin des Roses,Paris,B1,0,30182,S127,2008-12-23],
[S712,Guillaume,14a, chemin des Roses,Paris,B1,0,30184,C400,2008-12-23],
[S712,Guillaume,14a, chemin des Roses,Paris,B1,0,30185,F011,2009-01-02],
[S712,Guillaume,14a, chemin des Roses,Paris,B1,0,30186,C400,2009-01-02],
[S712,Guillaume,14a, chemin des Roses,Paris,B1,0,30188,B512,2009-01-02],
[F011,PONCELET,17, Clos des Erables,Toulouse,B2,0,30178,K111,2008-12-22],
[F011,PONCELET,17, Clos des Erables,Toulouse,B2,0,30179,C400,2008-12-22],
[F011,PONCELET,17, Clos des Erables,Toulouse,B2,0,30182,S127,2008-12-23],
[F011,PONCELET,17, Clos des Erables,Toulouse,B2,0,30184,C400,2008-12-23],
[F011,PONCELET,17, Clos des Erables,Toulouse,B2,0,30185,F011,2009-01-02],
[F011,PONCELET,17, Clos des Erables,Toulouse,B2,0,30186,C400,2009-01-02],
[F011,PONCELET,17, Clos des Erables,Toulouse,B2,0,30188,B512,2009-01-02],
[K729,NEUMAN,40, rue Bransart,Toulouse,B2,0,30178,K111,2008-12-22],
[K729,NEUMAN,40, rue Bransart,Toulouse,B2,0,30179,C400,2008-12-22],
[K729,NEUMAN,40, rue Bransart,Toulouse,B2,0,30182,S127,2008-12-23],
[K729,NEUMAN,40, rue Bransart,Toulouse,B2,0,30184,C400,2008-12-23],
[K729,NEUMAN,40, rue Bransart,Toulouse,B2,0,30185,F011,2009-01-02],
[K729,NEUMAN,40, rue Bransart,Toulouse,B2,0,30186,C400,2009-01-02],
[K729,NEUMAN,40, rue Bransart,Toulouse,B2,0,30188,B512,2009-01-02]].
```

3.8 Select all rows from an inner join between two tables.

```
?- parse("SELECT * FROM client INNER JOIN commande ON ncli_co = ncli;",T,V).

T = inner_join(
        table_var(all),
        join(
            table1(client),
            table2(commande)
        ),
        on(
            attr1(
                table_attr(
                    commande,
                    ncli_co
                )
            ),
            attr2(
                table_attr(
                    client ,
                    ncli
                )
            )
        )
    ),
V = [[B512,Gillet ,14, rue de l Etat,Toulouse ,B1,-8700,30188,B512,2009-01-02],
[C400,Ferard ,65, rue du Tertre,Poitiers ,B2,350,30179,C400,2008-12-22],
[C400,Ferard ,65, rue du Tertre,Poitiers ,B2,350,30184,C400,2008-12-23],
[C400,Ferard ,65, rue du Tertre,Poitiers ,B2,350,30186,C400,2009-01-02],
[K111,Vanbist ,180, rue Florimont,Lille ,B1,720,30178,K111,2008-12-22],
[S127,Vanderka ,3, avenue des Roses,Namur,C1,-4580,30182,S127,2008-12-23],
[F011,PONCELET,17, Clos des Erables,Toulouse ,B2,0,30185,F011,2009-01-02]].
```

3.9 Delete rows that matches a predicate.

```
?- parse("DELETE FROM client WHERE cat=\"B2\";", T, V).

T = delete(
        table(client),
        conditions(
            cond(
                cat,
                op(=),
                string(B2)
            )
        )
    ).
```

3.10 Update rows that match a predicate.

```
?- parse("UPDATE client SET cat=\"Bad\", compte=-1 WHERE compte=0;", T, V).

T = update(
        table(client),
        modifications([
            set(
                cat,
                string(Bad)
            ),
            set(
                compte,
                num(- 1))
            ]),
        conditions(
            cond(
                compte,
                op(=),
                num(0)
            )
        )
    ).
```

3.11 Drop a table.

```
?- parse("DROP TABLE client;", T, V).

T = drop(table(client)).
```

3.12 Select some rows that match multiple predicates.

The parser accepts conditions that are constructed with other conditions.

```
?- reset.
?- parse("SELECT nom, localite, cat, compte FROM client WHERE
|    (compte<=0 OR compte=720) AND (cat<>\"B1\" OR localite=\"Toulouse\");",T,V).

T = select_where(
        var([
            nom,
            localite,
            cat,
            compte
        ]),
        table(client),
        conditions(
            cond(
                and(
                    cond(
                        or(
                            cond(
                                compte,
                                op(<=),
                                num(0)
                            ),
                            cond(
                                compte,
                                op(=),
                                num(720)
                            )
                        )
                    ),
                    cond(
                        or(
                            cond(
                                cat,
                                op(<>),
                                string(B1)
                            ),
                            cond(
                                localite,
                                op(=),
                                string(Toulouse)
                            )
                        )
                    )
                )
            )
        )
    ),
V = [[Goffin,Namur,B2,-3200],
[Monti,Geneve,B2,0],
[Gillet,Toulouse,B1,-8700],
[Avron,Toulouse,B1,-1700],
[MERCIER,Namur,C1,-2300],
[Mercier,Toulouse,B2,-2250],
[Toussaint,Poitiers,C1,0],
[Jacob,Bruxelles,C2,0],
[Franck,Namur,C1,0],
[Vanderka,Namur,C1,-4580],
[PONCELET,Toulouse,B2,0],
[NEUMAN,Toulouse,B2,0]].
```

3.13 Two same queries but with more or less white-spaces.

Whatever the number of white-spaces between the words, it gives the same result.

```
?- parse("SELECT ncli FROM client WHERE cat=\"C1\";",T2,V2),
parse("SELECT   ncli   FROM   client   WHERE   cat   =   \"C1\";",T1,V1),
T1=T2, V1=V2.
T1 = T2, T2 = select_where(
                    var([ncli]),
                    table(client),
                    conditions(
                        cond(
                            cat,
                            op(=),
                            string(C1)
                        )
                    )
                ),
V1 = V2, V2 = [[B112],[C123],[F010],[L422],[S127]].
```

3.14 Select some rows from a table join with the same column names.

Each table has its own namespace for columns names.

To test this, we must change the column name 'ncli_co' of the table commande to 'ncli'.

```
?- retract(var(commande, 1, ncli_co)), assert(var(commande, 1, ncli)).
```

So now, we have the table client and command that have the same column name 'ncli'.

```
?- parse("SELECT client.ncli, nom, date FROM client
|   INNER JOIN commande ON client.ncli=commande.ncli;",T,V).

T = inner_join(
        table_var([
            table_attr(
                client,
                ncli
            ),
            table_attr(
                client,
                nom
            ),
            table_attr(
                commande,
                date
            )]
        ),
        join(
            table1(client),
            table2(commande)
        ),
        on(
            attr1(
                table_attr(
                    client,
                    ncli
                )
            ),
            attr2(
                table_attr(
                    commande,
                    ncli
                )
            )
        )
    ),
V = [[B512,Gillet,2009-01-02],
[C400,Ferard,2008-12-22],
[C400, Ferard,2008-12-23],
[C400, Ferard,2009-01-02],
[K111, Vanbist,2008-12-22],
[S127, Vanderka,2008-12-23],
[F011,PONCELET,2009-01-02]].
```

3.15 Load a new database from a CSV file.

It's possible to add additional tables from a CSV file. There is the file 'Mother.csv' in the folder of the project.

```
?- load_file("Mother.csv").
```

You can check that the metadata and the data are well imported by listing 'talbe_db', 'arity', 'var' and the new predicate 'mother'.

```
?- listing(table_db).
```

```
?- listing(arity).
```

```
?- listing(var).
```

```
?- listing(mother).
```