SIR SQL for Logical Navigation and Calculated Attribute Free Queries to Base Tables.

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SIR SQL stands for SQL generalized to Stored and Inherited Relations (SIRs). The benefit is the logical navigation free (LNF) and calculated attribute free (CAF) typical queries to base tables being SIRs, while the same outcome typical queries to base tables at present require LN or CAs specs within. Recall that LN means cumbersome procedural equijoins on foreign and referenced keys, in Codd's original meaning of these terms, while CA specs are value expressions with LN or with sub-queries with aggregate functions, also often annoyingly procedural. A SIR R is any base table defined as presently and referred to implicitly as R_, enlarged with some inherited attributes (IAs). The latter are defined as if they were in a specific view of R_, including LN or CA specs that typical queries to R_ has to contain at present, at least partly. Same output queries to R may address IAs instead, remaining LNF or CAF consequently.

Below, we first illustrate the problem with LN or CA specs in typical SQL queries more in depth. We then describe step-by-step the solution brought by SIR SQL. Afterwards, we outline the design of SIR SQL front-end to an SQL DBS. We claim that a few months of work should suffice for any popular SQL DBS. We point to the proof-of-concept prototype in Python reusing SQLite3. We conclude by claiming that courses and textbooks on relational DBs should take notice of SIR SQL. Also, every popular DBS should provide for SIR SQL "better sooner than later". 7+ million SQL clients worldwide, of the most used DB language by far, providing for 31B+ US$ market size of SQL DBSs, will benefit from.

CCS Concepts •Information systems~Data management systems~Database design and models~Relational database model

Additional Keywords and Phrases: SQL, Stored and Inherited Relations

1 THE PROBLEM

All present SQL DBSs bother the clients, users and developers, with unnecessary procedurality of queries to the base tables. The 1st culprit is the logical navigation (LN) in typical queries addressing base tables with foreign keys and referenced tables. Recall that LN means equijoins on foreign and referenced keys, as Codd originally defined these terms in [1] and result from his sheer idea of a foreign key (FK). The procedurality that the LN implies, i.e., the necessary length of the SQL join clauses defining it, may easily double the one of the query without. Not surprisingly, clients usually at least dislike the LN. Especially, - when it includes outer joins, [4]. In short, queries to base tables requiring LN at present should be LNF instead.

The 2nd culprit is the impossibility for any SQL dialect at present, to declare base tables with the calculated attributes (CAs), defined by value expressions with, e.g., aggregate functions or sub-queries or sourced in other tables. If a CA a query needs was in the base table, the query could address it by name only, i.e., could be CAF. Since it cannot be the case at present, SQL clients must define such CAs in the queries. The increase to the query procedurality may be substantial, e.g., may double the query. The sheer complexity of some CAs, defined by sub-queries especially, also bothers many.

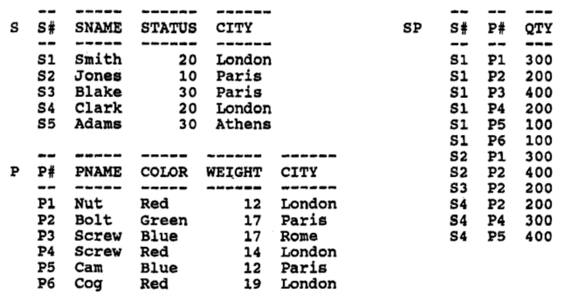
E.g., consider Supplier-Part DB of Codd, Fig. 1, the “mother of all the relational DBs”, [1], [2]. In other words, Supplier-Part design principles are the typical ones of any DBs at present and our examples related to generalize accordingly. We refer to Supplier-Part in short as S-P DB. S, P, SP are 1NF stored relations, (SRs), also called base tables. For Codd, SR means that none of its stored attributes, (SAs), can be calculated through the DB schema and content. Next, S.S#, P.P# and SP(S#,P#) are the primary keys (PKs). Finally SP.S# and SP.P# are foreign keys (FKs) for Codd, originally, [1]. That is, each is the implicit “logical pointer” to the (unique in S-P) PK with the same name and, for every FK value, to the, unique in the referenced table and thus in S-P, tuple with the same PK value.

A typical query to SP, i.e., searching for every supply so and so…, would address some of SP attributes together with some attributes of S or P. The rationale is that all the non-key SAs of S and P should be in fact also SAs of SP, as, conceptually, they are obviously attributes of SP as well. They are not actually, since normalization anomalies for SP that would result are unacceptable for the relational model as well known. E.g. consider a query searching for the basic data of smaller supplies, say Q1: “For every supply, select S# and, possibly, SNAME as well as P# with PNAME, whenever known and QTY, whenever QTY <= 200”. Q1 could simply formulate in SQL as:

Select S#, SNAME, P#, PNAME, QTY From SP Where QTY < 200;

Q1 expresses only the necessary projection and restriction. It would suffice if SNAME and PNAME were attributes of SP. However, they are not. Hence, Q1 formulates at present as Q2 below regardless of SQL dialect used or with an equivalent From clause:

Select S#, SNAME, P#, PNAME, QTY From SP Left Join S On SP.S#=S.S# Left Join P On SP.P#=P.P# Where QTY < 200;



S	S#	SNAME	STATUS	CITY
	S1	Smith	20	London
	S2	Jones	10	Paris
	S3	Blake	30	Paris
	S4	Clark	20	London
	S5	Adams	30	Athens

P	P#	PNAME	COLOR	WEIGHT	CITY
	P1	Nut	Red	12	London
	P2	Bolt	Green	17	Paris
	P3	Screw	Blue	17	Rome
	P4	Screw	Red	14	London
	P5	Cam	Blue	12	Paris
	P6	Cog	Red	19	London

SP	S#	P#	QTY
	S1	P1	300
	S1	P2	200
	S1	P3	400
	S1	P4	200
	S1	P5	100
	S1	P6	100
	S2	P1	300
	S2	P2	400
	S3	P2	200
	S4	P2	200
	S4	P4	300
	S4	P5	400

Fig. 1 S-P database

The reason is that whatever SP tuple Q1 selects, nothing in S-P scheme indicates SNAME & PNAME values Q1 should reference through the foreign keys, when these values exist. The LN in Q2 does it therefore instead. The “price” is that Q2 becomes twice as procedural.

Next, every supply has obviously some weight, say T-WEIGHT, defined as QTY * WEIGHT, where WEIGHT value is the one referenced through SP.P# value of the supply, if it is in P. If T-WEIGHT was of

interest to clients and obviously it would often be in practice, it should be a CA of SP. Then, e.g., query Q3 providing the ID and T-WEIGHT of every supply could simply be:
Select S#,P#,T-WEIGHT From SP;

Q3 would be a CAF query, with respect to T-WEIGHT and LNF query with respect to P. However, as even SQL beginners know, T-WEIGHT cannot be a CA of SP for any popular SQL dialect. Hence one has to express Q3 as Q4 with the T-WEIGHT scheme in it, e.g.:
Select S#,P#, QTY * WEIGHT As T-WEIGHT From SP Left Join P On SP.P# = P.P#;

As one can see, Q4 is more than two times more procedural than Q3.

Recall finally that the problems of LNF and of CAF queries to base tables, is anything but new. Already in early 80ties, Meyer & Ullman proposed the, so-called, universal relation idea as a solution for the LNF queries. However, despite its initial popularity, the concept did not prove practical. For the CAF queries, Sybase SQL dialect introduced, also in early 80ties, the *virtual* (dynamic, computed, generated….) *attributes* (VAs). Other SQL dialect adopted VAs since. Nevertheless, the result was and remains only a partial solution, as we discuss more later on. E.g., T-WEIGHT cannot be a VA in any SQL dialect we are aware of.

2 OUR SOLUTION

Presented in several papers indexed on our home page, [9], by title and usually by abstract and for some in [5], this one consisted of the following steps.

1. The relational model has two 1NF constructs: the already mentioned SR with SAs only and the *Inherited Relation* usually called View, with IAs only, [1]. Add to these constructs the 1NF construct we called *Stored and Inherited Relation* (SIR). As the name hints to, every SIR, say R, has both stored and inherited attributes (SAs and IAs). One declares the SAs as if they were within a base table at present, named R_ by default. This includes any table constraints and options, the definition of the primary key (PK) especially and, perhaps, of any FKs of R. IAs are basically defined and calculated for each SIR R tuple as if they were at present within specific view R. This one should have, (i), the same list of attributes as SIR R, with the scheme of every SA stripped to its name only, prefixed with R_ if the need occurs, and (ii) the same From clause. The latter should be furthermore such that (iii) for every stored tuple that one could insert into the table formed by the SAs, given any table constraints, there should be a view tuple with the same values for every IA named upon an SA and vice versa. We qualified every such view of *C-view R*, C standing for *canonical*. For every tuple of SIR R, the value of every IA is then the one of the same name IA in C-view R. The difference between SIR R and C-view R is thus physical only: every SA in SIR R is the same name and values IA in C-view R. In particular, we consider that the outcome of any query involving SIR R is the one of the same query involving C-view R instead at present. Finally, for SIR SQL the term *base table* includes also any SIRs.

2. In practice, one should obviously define a SIR through extensions to Create Table of some existing SQL dialect, e.g., SQLite. One should also extend Alter Table of the dialect so it applies to SIRs. Call *kernel* (SQL) the dialect chosen. Call *SIR SQL* (dialect) any kernel (dialect) with these statements extended. Accordingly, consider that any SIR SQL Create Table provides for any attributes, table constraints and options definable in kernel's Create Table and for any attributes definable in kernel's Create View. For every SIR R, call accordingly *base of R* and name it by default R_, the projection of R on all and only attributes that could be in Create Table R_ of the kernel. R_ defined so is in practice the base table the theoretical definition of a SIR above refers to. Basically, R_ is all and only SAs of R. For some kernels however, R_ may also include the

already mentioned VAs. Recall, , e.g. from our papers on SIRs, that every VA is in fact an IA inherited from R_ through arithmetic value expression with, perhaps, scalar functions over SAs or other VAs of R_ and with an implicit 'From R_' clause. It is in fact the latter property that makes VAs schemes slightly less procedural than if they were equivalently defined in a C-view conform to the kernel SQL and made them popular view-savers accordingly. Notice however that, as shown in our earlier papers, for any VA, one may always define in SIR SQL an equivalent IA with the implicit 'From R_' as well. In practice, suppose for VAs the syntax provided by the kernel SQL. Whether R_ has VAs or not, suppose R_ name usable by queries and C-view R scheme, as well as the update statements, as discussed in Step 6.

The attributes in SIR SQL Create Table R defined as if they were in a Create View R of the kernel are all the IAs of R other than VAs, if there is any VA. From clause of Create View R should follow the entire attribute list of Create Table R that can mix SAs, VAs and (other) IAs of R. The clause should precede in contrast any eventual R_ table constraints or options. From clause should in particular make view R it defines through (i) extended to any VAs if there are any and through (ii), should make it a C-view, i.e., should make it conform also to (iii). We say that IAs other than perhaps VAs in SIR R and all their values *enlarge* (every tuple of) R_. Finally, operationally, we put any consecutives IAs among SAs and all consecutive IAs followed by From clause, in < { } brackets, replacing the usual SQL ',' separators. The convention proved facilitating the implementation. Actually, we apply the same convention to the usual presentation of a base table scheme, if the latter should define a SIR.

For any SIR R, we call *Inheritance Expression* (IE) any scheme defining IAs of R other than eventual VAs. An *explicit* IE defines every IA or uses SQL '*' for some and defines the From clause. A *valid* From clause defines, through (i) and (ii), C-view R or is *invalid*. An IE can alternatively be *implicit*. It then omits some or even all IAs or parts of, or even entire From clause. An implicit IE may be *empty*, i.e., without any IA and From clause. Any implicit IE is pre-processed into the explicit one for any further processing.

The obvious advantage of any implicit IE, whenever such an IE is possible, is to be less procedural than the explicit one. Besides, we have shown that for every SIR R, even the explicit IE can be less procedural to define and maintain than Create View R for C-view R. Regardless of why a C-view R could be wished, to define and maintain SIR R should be always less procedural than Create Table R_ and Create View R. This also means that such Create View R is also always more procedural than the IE. The reason is that for every SA of SIR R, C-view R must redefine it as an IA, as above outlined, unlike the IE. In present terms, every SIR R is thus a *view saver* for C-view R. Like every VA is a view saver for the equivalent view at present.

E.g., consider the following SP scheme instead of the original one, namely SP (<u>S#</u>, <u>P#</u>, QTY):

(1) SP (<u>S#</u>, <u>P#</u>, QTY {SNAME, STATUS, S.CITY, PNAME, COLOR, WEIGHT, P.CITY From SP_ Left Join S On SP.S#=S.S# Left Join P On SP.P#=P.P#});

Let us call S-P1 the S-P DB with SIR SP (1). Fig. 2 shows the base tables of S-P1. S and P are the same as in S-P at Fig. 1. S-P1.SP schema and content at the figure is the one that would appear to SIR SQL client, e.g., through the Select * From SP query (except, perhaps for the Italic font for the IAs). Next, (<u>S#</u>, <u>P#</u>, QTY) is the base of S-P1.SP, i.e. SP_. It is thus the original S-P.SP renamed by default. In fact, it is also the only actually stored content of S-P1.SP. The brackets in (1) delimit the IE, in only one part here. View SP it would lead to through (i) and (ii) could be C-view SP within S-P, if view SP was added to. Renaming of the original SP, by default to SP_, would be accordingly necessary. No SQL dialect allows for two tables with the same (proper) name in a DB. We leave as exercise the Create View SP for C-view SP, given IE in (1). Same, - for the calculus of how much more procedural that one would be than the IE.

From clause in (1) is a valid one, i.e. view SP formed according to (i) - (ii) is C-view SP. Indeed, as (iii) requires, for every tuple one could possibly insert to SP_, it provides for view SP tuple with the same S#, P# and QTY values. E.g. for SP_ tuple (S1, P1, 300), there is one and only one view SP tuple (S1, P1, 300, Smith, 20, London, Nut, Red, 12, London). It is then also the logically the same SIR SP tuple, except that, physically, S#,P#,QTY are SAs and not IAs of view SP. Likewise, for the tuple (S6, P1, 200), possible for SP_ as no table constraint prohibits it, with respect to SP content at Fig. 1, SIR SP, as well as C-view SP, would each have the tuple (S6, P1, 200, null…null), with every IA being null. But if one replaced, e.g., the left Join S with Inner Join S, then the latter tuple would not be in view SP anymore. Hence, view SP would not be C-view SP neither and the envisaged From clause would be invalid. It would be valid iff one declares SP.S# as FK referencing S.S#. The referential integrity (table) constraint would prohibit the latter tuple. Notice, that the original From clause from (1) would remain valid.

Observe that for S-P1, LNF Q1 becomes possible. The obvious reason is that it may address in SP the IAs defined through the LN. For S-P, Q2 needs in contrast such LN, as it must address the sources of the IAs. Moreover, S-P1 clients could similarly issue any LNF query selecting any SP tuple so and so…, while also addressing any attributes of S or P inherited by SIR SP. Unlike any clients of S-P could do. By extrapolation, the example clearly hints on the practical potential of SIRs.

Table S

S#	SNAME	STATUS	CITY
S1	Smith	20	London
S2	Jones	10	Paris
S3	Blake	30	Paris
S4	Clark	20	London
S5	Adams	30	Athens

Table P

P#	PNAME	COLOR	WEIGHT	CITY
P1	Nut	Red	12	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	17	Oslo
P4	Screw	Red	14	London
P5	Cam	Blue	12	Paris
P6	Cog	Red	19	London

Table SP

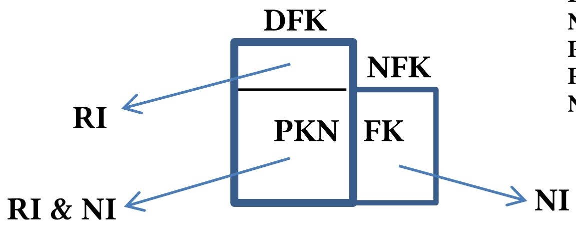
S#	P#	QTY	*SNAME*	*STATUS*	*S.CITY*	*PNAME*	*COLOR*	*WEIGHT*	*P.CITY*
S1	P1	300	*Smith*	*20*	*London*	*Nut*	*Red*	*12*	*London*
S1	P2	200	*Smith*	*20*	*London*	*Bolt*	*Green*	*17*	*Paris*
S1	P3	400	*Smith*	*20*	*London*	*Screw*	*Blue*	*17*	*Oslo*
S1	P4	200	*Smith*	*20*	*London*	*Screw*	*Red*	*14*	*London*
S1	P5	100	*Smith*	*20*	*London*	*Cam*	*Blue*	*12*	*Paris*
S1	P6	100	*Smith*	*20*	*London*	*Cog*	*Red*	*19*	*London*
S2	P1	300	*Jones*	*10*	*Paris*	*Nut*	*Red*	*12*	*London*
S2	P2	400	*Jones*	*10*	*Paris*	*Bolt*	*Green*	*17*	*Paris*
S3	P2	200	*Blake*	*30*	*Paris*	*Bolt*	*Green*	*17*	*Paris*
S4	P2	200	*Clark*	*20*	*London*	*Bolt*	*Green*	*17*	*Paris*
S4	P4	300	*Clark*	*20*	*London*	*Screw*	*Red*	*14*	*London*
S4	P5	400	*Clark*	*20*	*London*	*Cam*	*Blue*	*12*	*Paris*

Fig. 2. S-P1 base table schemes and content. IAs in SP are *Italic*. S and P are the same as in SP at Fig. 1.

Observe finally that no IA in (1) introduces normalization anomalies, i.e., storage, insert, update or delete anomaly. Indeed the redundant with respect to S and P IA values in SP, e.g., in 6 tuples for S1 there, Fig. 1, do not cost any additional storage, inserts or updates if a source value varies, e.g., S1 changes the name to John. Likewise, no need for any additional deletes, if the referential integrity implies the cascading and any source tuple gets deleted, e.g., S.S1. These anomalies would in contrast necessarily occur, contradicting thus the relational model, if every IA of S-P1.SP was, trivially, an SA instead. They would lead in particular, to the risk of inconsistencies in the DB, if any of the redundant manipulations went awry. The discussed absence of normalization anomalies provided by IAs of S_P1.SP makes thus possible for SP to have, as conceptually it does, all the non-key attributes of S and P as the attributes as well with all the corresponding values. Unlike for S-P.SP, conform to the (present) relational model, we recall. These properties generalize obviously to any DBs with SIRs hence, potentially, in particular to DBs with billions of tuples in practice.

3. Enlarge the present SQL FK concept to SIRs. For this purpose, it appeared useful to merge the former with (our perception of) Codd's original idea, [1], [3]. Fig. 2 sums up the result for SIR SQL. First, one defines any *declared* SIR SQL FK using the familiar Foreign Key clause. A declared FK implies accordingly the referential integrity (RI). In practice, one specifies a declared FK as one would do for an FK using the kernel SQL (dialect). The only semantical difference is that a declared FK may reference a SIR. Next, for SIR SQL, any non-PK declared FK referencing a PK with the same proper name is a (declared) *primary key named* FK, (PKN FK). Finally, in SIR SQL, for any SIR R, any non-PK atomic SA A such that (a) there is only one PK with proper name A and (b) A is not within a declared PKN FK in R, is also a PKN FK. It is a *natural* (PKN) FK (in R).

The characteristic property of every PKN FK in SIR SQL is, as we called it, the *natural* inheritance (NI). NI in base table R with some PKN FKs, designates mandatory IAs named upon every non-PK attribute in every table referenced by every PKN FK of R. In sum, for SIR SQL, each PKN FK is not only the reference to a PK, but also the shorthand for all the IAs with the names and values of all the non-key attributes of the table with the PK. Called then, besides, NI *from* that table or *through* the FK. Likewise, we call *natural* every IA within NI, (NIA). The NIA values in R-tuples are calculated considering every FK as the "logical pointer", in Codd's terminology. Namely, for every PKN FK, these values are defined by the equijoin FK=PK, i.e., by the LN. The possibility of such calculus for queries selecting values of some attributes of R and of some of the referenced tables was novel by then and apparently motivated the "logical" qualifier.



DFK : Declared FK
NFK : Natural FK
PKN FK : PK Named FK
RI : Referential Integrity
NI : Natural Inheritance

Fig. 3 SIR SQL Foreign Keys

Recall however that the overall rationale for the FK concept was for Codd that in a "well designed" DB, all the non-key attributes referenced by an FK of R were conceptually attributes of R as well, with the values accompanying the values of the referenced PK equal to FK values as the "logical pointers". These were, e.g., the attributes we spoke about for S-P.SP, i.e., every non-key attribute of S and of P. However, actually, none of such attributes was in R. As SAs in Codd's model necessarily, they would imply normalization anomalies. The latter would typically offset the practical interest of the LNF queries to such base tables with respect the equivalent ones with LN to the normalized tables. However, when these attributes become IAs instead, no normalization anomaly can ever occur. This makes the discussed LNF queries to any R with NI attractive again, as it will appear more in details below. It is also our rationale for NI concept.

For SIR SQL, the referenced table and PK attribute names for a declared PKN FK are as usual in SQL. For any natural PKN FK, the referencing is implicit by FK=PK name equality, qualified of *natural* as well. The NI presence means further that, for SIR SQL; any R with PKN FKs is, necessarily, a SIR R. Natural FKs imply the NI only. Any declared PKN FK implies both: NI and RI. Thus for a SIR SQL FK, RI is not mandatory but optional only, while NI is the characteristic property of any PKN FK. Unlike it is of course for any SQL FK. Codd, apparently however, originally considered RI as we do. Also, NI was for him the characteristic property of any FK, as e.g., in S-P. It was however implicit and for queries and views only. In other words, for Codd, apparently FKs were mainly SIR SQL PKN FKs, [1,2,3].

Notice finally that for a natural FK, there may be tuples with FK values for which there is no referenced PK values. NIAs are then null, i.e., the LN consists of an outer left or right join. Recall also that in some SQL dialects, an FK may reference a candidate key instead of the PK. Possibly, even with the same proper name as the FK. Observe that however, no such (declared) FK can be a PKN FK. Consequently, for SIR SQL, any such FK implies RI only, as at present. Finally, observe that, also as at present, any SIR SQL FK has to be an SA.

E.g., whether in S-P scheme or in S-P1 one, SP.S# and SP.P# are natural FKs, as there is no FK clause in any SP scheme. They do not imply any RI, but do imply NI from S and P. The IAs list and the From clause in { } in (1) define the NI, consisting of the IA names and values in Fig. 2. Alternatively to being natural FKs, one could declare these FKs through Foreign Key clauses as for SP.SP at present. This would imply the same NI and the RI. Finally, both FKs are SAs whether natural or declared, as SIR SQL requires for any FK.

Next, in SIR SQL, one may declare any R with NI, through the Create Table defining everything for R except NI. Such Create Table and R scheme within are referred to as *implicit*. In particular, every present SQL Create Table R for R with PKN FKs, is the implicit one of R for SIR SQL. Notice that any such scheme defines in fact R_ except for the name R_ itself. The *explicit* Create Table R adds to the NI *clause*, as in (1) and is the actual R scheme. As we have shown, any R with NI may indeed have the implicit scheme since one can infer NI from the latter through a rather simple algorithm exploring the meta-tables. The algorithm places by default the NI scheme, again as in (1), after all the R_ attribute schemes and before any table constraints and options. The rationale for implicit schemes is that they are obviously always less procedural than the explicit ones. Also, on a SIR SQL enabled DBS, a DBA may then create SQL DBs as at present, while providing for the LNF queries without any additional effort.

4. More formally, suppose that by analogy to the SQL '*', for some Create Table R with some PKN FKs F1…Fk and, perhaps, with some table constraints and options, one denotes as R_.* all the attributes schemes defined as they could be at present in some SQL dialect. Next, let us continue to denote for every Fi, the base table referenced by Fi as R'i and, as R'i.#, all the non-primary key attributes of R'i. Then, consider that the implicit Create Table R has the usual form:

Create Table R (R_.* [<Table constraints>) <Table options>];

The explicit one would be then as follows, with NI scheme in { } brackets.

Create Table R (R_.* {R'1.#,…,R'k.# From R_ Left Join R'1 on R_.F1 = R'1.F1 … Left Join R'k on R_.Fk = R'k.Fk} [<Table constraints>]) [<Table options>];

Observe that From clause above defines in fact the LN from R towards every referenced base table. Also, the NIAs are named upon all the referenced attributes. As we already signaled, unlike presently thus, no typical query to R, i.e., addressing some R-attributes and some of non-PK ones in one or more R' tables, requires any LN. It may indeed address R with NIAs instead. Every such query becomes LNF in consequence, an obvious practical benefit from SIRs with NI.

Ex. For S-P, we may consider the following Create Table SP as the present one, with '…' meaning the data type and Primary (S#, P#) being the only table constraint:

Create Table SP(S#..., P#..., QTY… Primary Key (S#, P#));

For SIR SQL, since S# and P# are (natural) PKN FKs, this would be the implicit Create Table with empty IE for the explicit one as follows:

Create Table SP (S#...,P#...,QTY… {SNAME, STATUS, S.CITY, PNAME, COLOR, WEIGHT, P.CITY From SP_ Left Join S On SP.S#=S.S# Left Join P On SP.P#=P.P#} Primary Key (S#, P#));

The statement creates clearly the already discussed scheme (1) of S-P1.SP. Accordingly, Q1 becomes possible. More generally, any query addressing any among all of SP attributes, as well as any among all of S or P non-PK attributes, may be an LNF one. Unlike their present equivalents, we recall. Observe also that the implicit Create Table SP is the one the S-P DBA would use for S-P.SP at present. In other words, for SIR SQL, present S-P scheme defines in fact S-P1. Altogether, in SIR SQL, the LNF queries, likely making every (presumed) present S-P client happier and surely more productive, become standard, without any additional data definition work.

5. Furthermore, consider now that some SIR R has some IAs not in NI, e.g., some CAs that are not VAs, if the kernel provides for the latter. Suppose accordingly that the IE has From clause referring to R_ only or defining also (explicitly) LN to some tables other than those of NI. Furthermore, suppose that this clause does not contain any Where clause. We haven't indeed seen any need for the latter as yet. If it nevertheless occurred, we suppose basically the definition of the CA in the need through a sub-query. Next, consider that R.* stands for all the attribute schemes in Create Table R and that [<explicit From>] designates the just discussed optional From clause. Then R should have Create Table R in the form:

Create Table R (R.* {[<explicit From>]} [<Table constraints>]) [<Table options>];

This Create Table is the explicit one if R does not have any PKN FK. Otherwise, it is an implicit one, with implicit NI and IE. The latter would not be however empty anymore, although it might have no From clause. As before, SIR SQL Create Table processing would pre-process the scheme to the explicit one, with the (explicit) NI thus, as follows this time:

Create Table R (R.*, {R'1.#,…,R'k.# [<explicit From>] Left Join R'1 on R_.F1 = R'1.F1 … Left Join R'k on R_.Fk = R'k.Fk} [<Table constraints>) <Table options>];

The idea is of course to let the DBA to issue Create Table R as non-procedural as reasonably possible. E.g., for SP with T-WEIGHT one could accordingly state:

Create Table SP (S#...,P#...,QTY {QTY*WEIGHT As T-WEIGHT} Primary Key (S#,P#));

Observe that for T-WEIGHT, we have declared only the value expression. Within SQL specs for SAs and for IAs (in views), it is not possible to have any less procedural Create Table for SP. Since SP has PKN FKs, the scheme would be the implicit one for:

Create Table SP (S#...,P#...,QTY {QTY*WEIGHT As T-WEIGHT From SP_ Left Join S On SP.S#=S.S# Left Join P On SP.P#=P.P#} Primary Key (S#, P#));

Any further Create Table SP processing would concern the latter. Notice that the explicit IE appears more than three times more procedural than the implicit one. C-view would be even more procedural, as it's easy to find out. Observe especially that Q3 is now possible, unlike for the original S-P.SP. In the same time the LNF queries like Q1 remain valid. Moreover, LNF queries may now also address T-WEIGHT. E.g., as in the following one:

Select S#, SNAME, P#, PNAME, QTY From SP Where T-WEIGHT > 2000;

In other words, a query to SP may now be both: LNF addressing any attributes in S-P1, hence also in S-P, and CAF for T-WEIGHT.

The result actually generalizes nicely to any SIR R with NI and CAs. Namely, let us call *naturally dependent* (on its NI source tables) any such R. E.g. S-P1.SP is ND on S and P. Observe that an NI source can be ND in turn and so on. Under some theoretical conditions, too advanced to discuss them here, but actually rather typical, NI in R, may then directly or indirectly naturally inherit from every non-PK attribute of every base table in the DB other than R. It results that a SIR SQL query addressing some R attributes, possibly CAs among these, together with some attributes inherited through the NI, may be LNF and, possibly, CAF, while indirectly addressing thus any attributes of base tables other than R. In contrast, any equivalent SQL query to the DB defined by the same implicit scheme has to include the LN and, possibly the CAs schemes. Being then perhaps even several times more procedural than the former.

6. Let us call SIR (enabled) DBS, any relational DBS (RDBS) providing for SIR SQL. To implement a SIR DBS "simply", i.e. through a couple of months of developer's effort, stick to the *canonical* implementation. In the nutshell, SIR DBS consists then from the front-end called *SIR-layer*, reusing an existing kernel RDBS, e.g., SQLite3. The tandem works as follows:

- SIR-layer takes care of every SIR SQL dialect statement and returns any outcomes. Every SIR SQL dialect extends to SIRs the kernel SQL dialect.

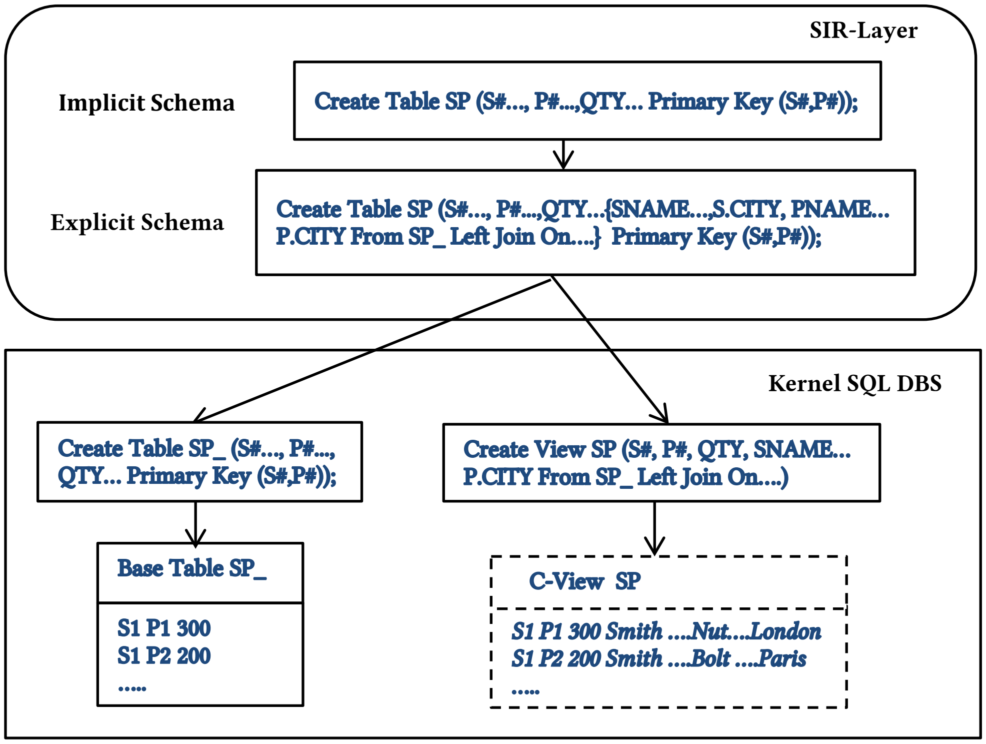

SIR-Layer
Implicit Schema
Create Table SP (S#..., P#...,QTY... Primary Key (S#,P#));
Explicit Schema
Create Table SP (S#..., P#...,QTY...{SNAME...,S.CITY, PNAME... P.CITY From SP_ Left Join On....} Primary Key (S#,P#));
Kernel SQL DBS
Create Table SP_ (S#..., P#..., QTY... Primary Key (S#,P#));
Create View SP (S#, P#, QTY, SNAME... P.CITY From SP_ Left Join On....)
Base Table SP_
S1 P1 300
S1 P2 200
.....
C-View SP
S1 P1 300 Smith ....Nut...London
S1 P2 200 Smith ....Bolt ....Paris
.....

Fig. 4. Canonical Implementation of SIR SP with the actual content with the kernel SQL DBS. C-view SP content is virtual only, as usual for any views.

- The kernel is the actual storage for every SIR SQL DB. That one becomes the same name DB in the kernel.

- SIR-layer forwards to the kernel every Create Table R submitted without PKN FKs and without any IA other than, perhaps, those declared as if they were VAs for the kernel. Any Create Table R with PKN FKs is for SIR-layer an implicit scheme, pre-processed accordingly to the explicit one with the (explicit) NI. Besides, SIR-layer parses every explicit Create Table R to Create Table R_ and Create View R defining C-view R. It then forwards both statements as an atomic transaction to the kernel. Fig. 4 illustrates the result for S-P1.SP processing.

- SIR-layer also forwards to the kernel every (SIR SQL) Alter Table R that does not contain SIR-specific clause termed IE clause. It is indeed supposed kernel SQL Alter Table, addressing thus base table R that is not a SIR and should remain so. SIR-layer also forwards any Alter Table R_. IE clause may be explicit or implicit, even empty. It always means that R is or should become a SIR. If R is a SIR already, SIR-layer issues to the kernel Alter View R with new C-view R produced from IE clause and, for an implicit IE clause, from R scheme in kernel's meta-tables. If R is not yet a SIR, SIR-layer similarly produces and sends to the kernel as an atomic transaction: Alter Table R renaming R to R_ and Create View R with C-view R. See SIR papers for more.

- Furthermore, SIR-layer forwards to the kernel any Drop Table R if R is not a SIR. Otherwise it issues an atomic transaction with Drop Table R_ and Drop View R.

- For the SIR SQL data manipulation statements, SIR-layer simply forwards any submitted query to the kernel. For any update statements for SIRs, safe policy for every kernel and every SIR R is to address R_. E.g., Insert To SP_..., Update SP_... and Delete From SP_... for S-P1.SP. Update stements addressing SIR R directly instead, e.g., Insert To SP…, may or may not work. It depends on kernel's view update capabilities. The kernel would indeed address any such queries to view R. In particular, no present kernel provides for CA updates. Again, see the SIR papers for more.

7. Finally, validate the canonical implementation through the proof-of-concept prototype, e.g. with SIR-layer in Python and SQLite3 as the kernel. The actual prototype available at present provides also for a self-running demo. The overall effort was 2-3 months of makeshift Python's developer, i.e., the effort conform to expectations. The demo creates S-P1, either from the explicit SP scheme or from the S-P.SP scheme. The latter is assimilated to SIR SQL implicit scheme with empty IE, resulting from the natural PKN FKs S# and P#. Then, one manipulates S-P1, through LNF queries or, after adding T-WEIGHT CA, through LNF and CAF queries. Users familiar with Python may easily alter the demo. E.g., to prepare their own SIR DBS reusing another kernel: DB2, SQL Server, PostgreSQL, MySQL… you name it. See [9] for more on the prototype.

3. CONCLUSION

Since their inception, i.e., five decades for early birds, every SQL DBS requires the clients with typical queries to base tables, to specify the LN and the CAs, at least other than VAs for some dialects, in the queries. The procedurality of the LN and of CA specs is usually substantial, i.e., can easily double or triple the query size and bothers many. Our proposal gets rid of this annoyance, simplifying such queries to the LNF and CAF ones. The LNF queries become possible for the base table defined as generally at present. For CAF queries, it may suffice to add to Create Table only the value expressions defining the CAs. Finally, the prototype SIR DBS with SQLite as the kernel proved simple. Although the problem of LNF and CAF queries is anything but new, our solution is the only of the kind, to our best knowledge.

Summing up all this, since 1974, when IBM introduced SQL, SQL clients were uselessly typically bothered with the LN, unknowingly to everyone, of course. Likewise, clients needing queries with CAs were generally bothered with the need for CA schemes within, while our extensions to Create Table, possibly minimally procedural in practice, may provide for the CAF queries instead. DB courses and textbooks should thus from now on take notice of SIR SQL. Also, popular DBSs should provide for SIR SQL, “better sooner than later”. 7+ million clients worldwide of the most used DB language by far, [6], [7], including 70% of all developers and providing for estimated 31B US$ market size of SQL DBSs, [8], should benefit from.

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