EMBEDDED SQL

Part 1: Static Statements

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List of Slides

Database Applications

- SQL isn't sufficient to write general applications.

  $\Rightarrow$ connect it with a general-purpose PL!

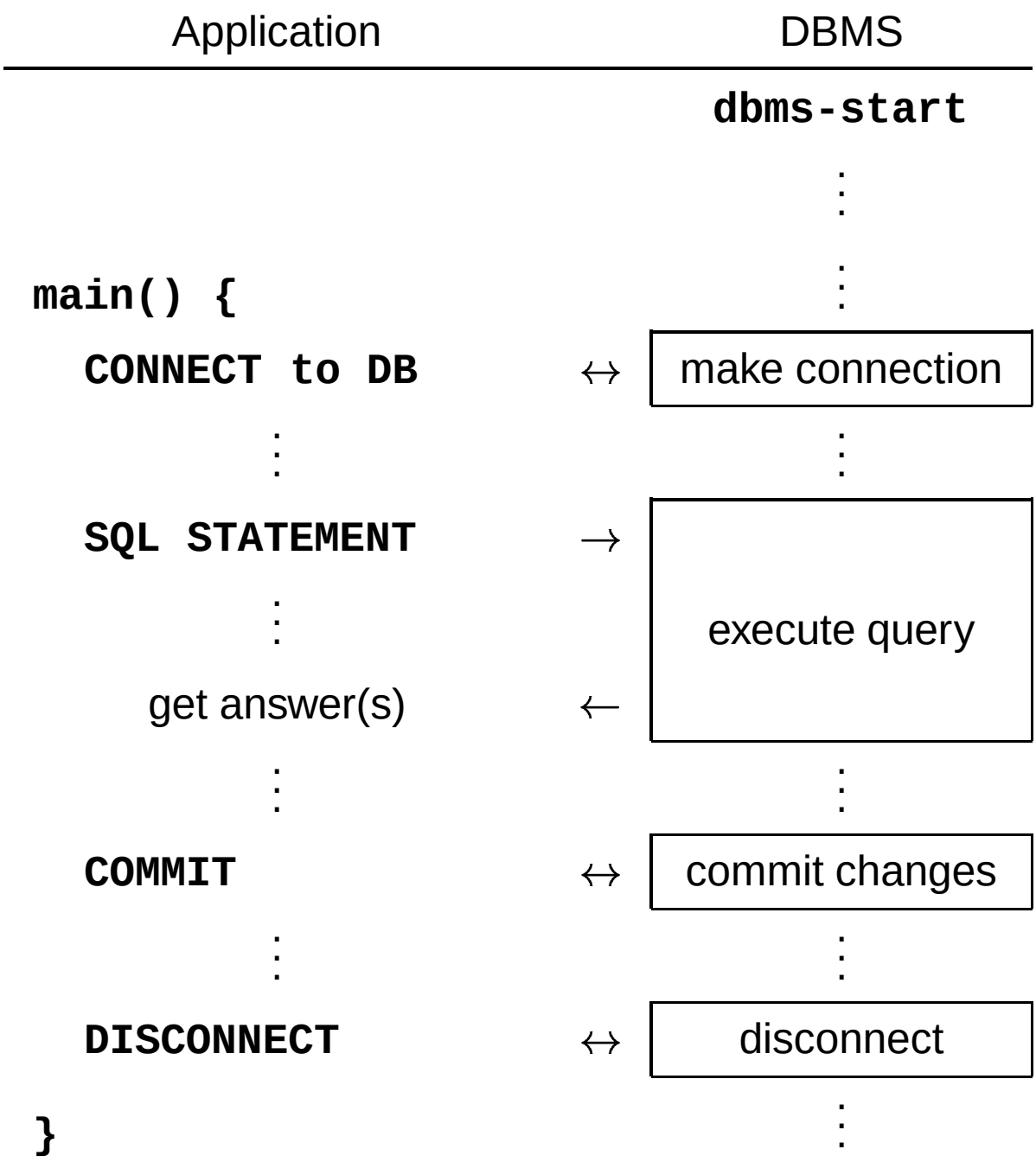
- Language considerations:

  $\Rightarrow$ Library calls (CLI/ODBC)
  $\Rightarrow$ Embedded SQL
  $\Rightarrow$ Advanced *persistent* PL (usually OO)

- Client-server:

  $\Rightarrow$ SQL runs on the server
  $\Rightarrow$ Application runs on the client

How does client/server work?



Embedded SQL

- SQL Statements are *embedded* into
  a *host language* (C, C++, FORTRAN, . . .)
- The application is *preprocessed*
  pure host language program + library calls

  $\Rightarrow$ Advantages:

  - Preprocessing of (static) parts of queries
  - MUCH easier to use

  $\Rightarrow$ Disadvantages:

  - Needs precompiler
  - Needs to be *bound* to a database

Embedded SQL (cont.)

- Considerations:

  $\Rightarrow$ How much can SQL be parameterized?

  * How to pass parameters into SQL?
  * How to get results?
  * Errors?

  $\Rightarrow$ Static vs. dynamic SQL statements.

- How much does the DBMS know about an application?

  $\Rightarrow$ precompiling: **`PREP`**
  $\Rightarrow$ binding: **`BIND`**

  in ORACLE both done using the **`proc`** tool

Application Structure

Include SQL support (SQLCA, SQLDA)

```
main(int argc, char **argv)
{
```

Declarations

Connect to Database

Do your work

Process errors

Commit/Abort and Disconnect

```
};
```

Declarations

- Include SQL communication area:

  `EXEC SQL  INCLUDE SQLCA;`

- it defines:

  $\Rightarrow$ the return code of SQL statements (sqlcode)
  $\Rightarrow$ the error messages (if any)
  $\Rightarrow$ . . . you can't live without it.

- SQL statements inserted using magic words

  `EXEC SQL <sql statement>`

Host Variables

. . . are used to pass values between a SQL statement and the rest of the program:

- parameters in SQL statements:

  communicate **single values**
  between SQL and the host language variable

- must be declared within SQL declare section:

  ```
  EXEC SQL  BEGIN DECLARE SECTION;
    declarations of variables to be used
    in SQL statements go here
  EXEC SQL  END DECLARE SECTION;
  ```

- can be used in the **`EXEC SQL`** statements:

  $\Rightarrow$ to distinguish them from SQL identifiers
  they are preceded by **`':'`** (colon)

Errors

What if a SQL statement fails?

- check **`sqlcode != 0`**
- use “exception” handling:

```
EXEC SQL WHENEVER SQLERROR   GO TO lbl;
EXEC SQL WHENEVER SQLWARNING GO TO lbl;
EXEC SQL WHENEVER NOT FOUND  GO TO lbl;
```

  $\Rightarrow$ designed for COBOL (lbl has to be in scope).

Dummy Application (DB2)

```
#include <stdio.h>
#include "util.h"

EXEC SQL INCLUDE SQLCA;

int main(int argc, char *argv[]) {

   EXEC SQL BEGIN DECLARE SECTION;
      char db[6] = "cs448";
   EXEC SQL END DECLARE SECTION;

   printf("Sample C program: CONNECT\n" );

   EXEC SQL WHENEVER SQLERROR  GO TO error;

   EXEC SQL CONNECT TO :db;

   printf("Connected to DB2\n");

   EXEC SQL COMMIT;
   EXEC SQL CONNECT reset;
   exit(0);

error:
   check_error("My error",&sqlca);
   EXEC SQL WHENEVER SQLERROR CONTINUE;
   EXEC SQL ROLLBACK;
   EXEC SQL CONNECT reset;
   exit(1);
}
```

Preparing your Application (DB2)

1. write the application in a file called **<name>.sqc**
2. preprocess the application:

   db2 prep <name>.sqc
3. compile the application:

   cc -c -O <name>.c
4. link with DB2 libraries:

   cc -o <name> <name.o> -L... -l...
5. run it:

   ./<name> [arguments]

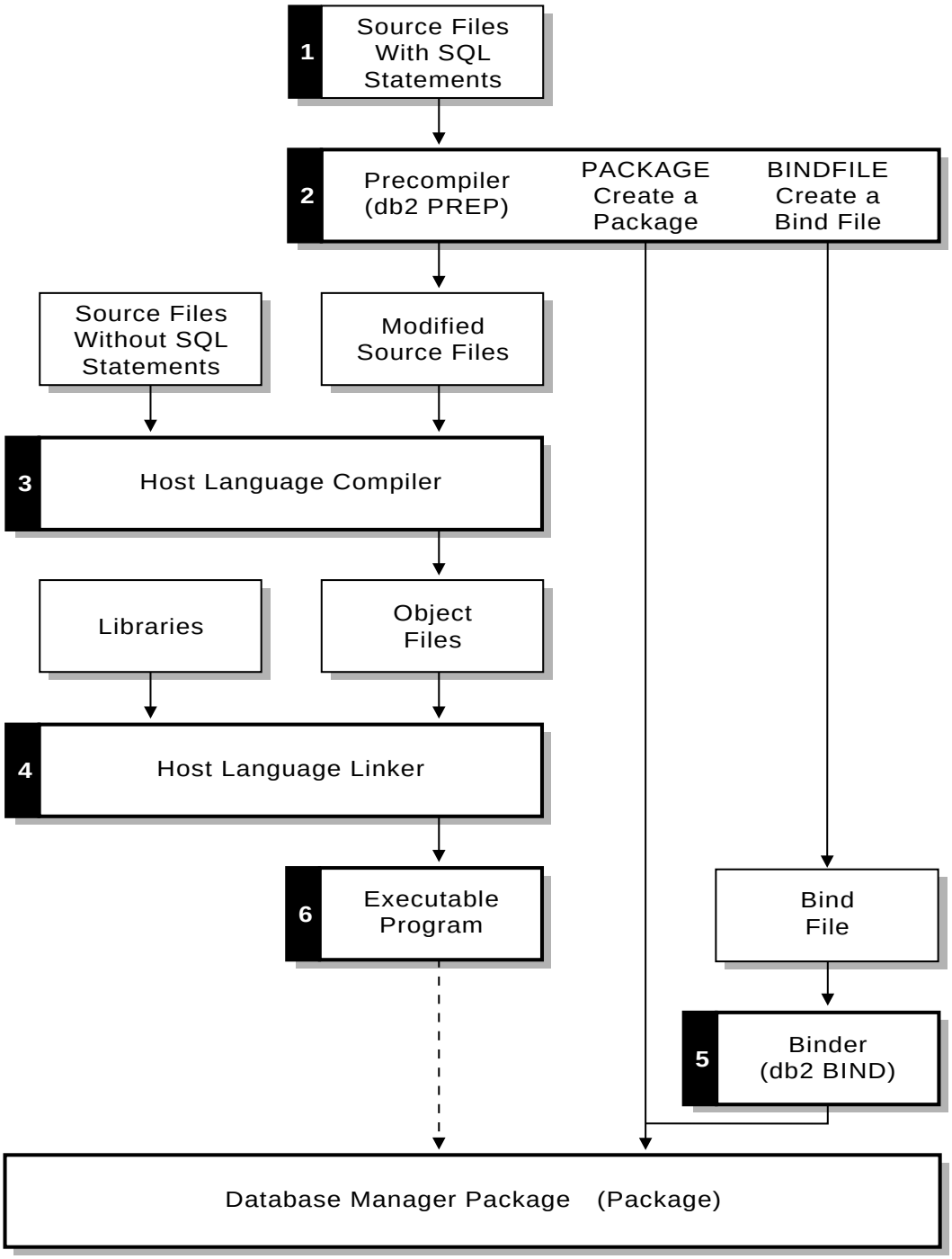
USE the provided Makefile

⇒ sets options
⇒ knows the path(s) and libraries

Example of a build (DB2)

```
bash$ make NAME=sample1
db2 connect to cs448

   Database Connection Information

 Database server        = DB2/SUN 6.1.0
 SQL authorization ID   = DAVID
 Local database alias   = CS448

db2 prep sample1.sqc bindfile

LINE    MESSAGES FOR sample1.sqc
------  ------------------------------------------------
        SQL0060W  The "C" precompiler is in progress.
        SQL0091W  Precompilation or binding was ended with
                  "0" errors and "0" warnings.
db2 bind sample1.bnd

LINE    MESSAGES FOR sample1.bnd
------  ------------------------------------------------
        SQL0061W  The binder is in progress.
        SQL0091N  Binding was ended with "0" errors and
                  "0" warnings.
db2 connect reset
DB20000I  The SQL command completed successfully.
cc -I/usr/db2/include -c sample1.c
cc -I/usr/db2/include -o sample1 sample1.o util.o
                -L/usr/db2/lib -R/usr/db2/lib -ldb2
```

Summary on Preparing an Application



“Real” SQL Statements

So far we introduced only the surounding infrastructure. Now for the real SQL statements:

- simple statements:

  $\Rightarrow$ “constant” statements
  $\Rightarrow$ statements with parameters
  $\Rightarrow$ statements returning a single tuple

- general queries with many answers
- dynamic queries

Simple Application

Write a program that for each publication id supplied as an argument prints out the title of the publication:

```
main(int argc, char *argv[]) {
   ...

   printf("Connected to Oracle\n");

   for (i=1; i<argc; i++) {
     strncpy(pubid,argv[i],8);

     EXEC SQL WHENEVER NOT FOUND GO TO nope;

     EXEC SQL SELECT title INTO :title
              FROM   publication
              WHERE  pubid = :pubid;

     printf("%10s: %s\n",pubid,title);
     continue;
   nope:
     printf("%10s: *** not found *** \n",pubid);
   };

   EXEC SQL COMMIT RELEASE;
   exit(0);

   ...
}
```

Simple Application (cont.)

```
bash$ ./sample2 ChTo98 nopubid
Sample C program: SAMPLE2
    ChTo98: Temporal Logic in Information Systems
   nopubid: *** not found ***
```

$\Rightarrow$ it is important that at most

one title is returned for each *pubid*.

NULLs and Indicator Variables

- what if a host variable is assigned a NULL?

  $\Rightarrow$ not a valid value in the datatype
  $\Rightarrow$ ESQL uses an extra *Indicator* variable, e.g.:

```
smallint ind;

SELECT firstname INTO :firstname
                 INDICATOR :ind
FROM   ...
```

  then if **`ind`** < 0 then **`firstname`** is NULL

- if the indicator variable is not provided and the result is a null we get an error

- the same applies for updates.

Impedance Mismatch

- What if we **`EXEC SQL`** a query and it **returns more than one tuple**?
- Solution: use a *cursor*:
  1. Declare a *cursor*:

```
EXEC SQL DECLARE <name> CURSOR
         FOR <query>;
```

  2. Iterate over it:

```
EXEC SQL OPEN <name>;
EXEC SQL WHENEVER NOT FOUND GO TO end;
for (;;) {
   <set up host parameters>
   EXEC SQL FETCH <name>
            INTO <host variables>;
   <process the fetched tuple>
 };
end:
 EXEC SQL CLOSE <name>;
```

Application with a Cursor

Write a program that lists all author names and publication titles where the author name matches a pattern given to the applications as an argument:

```
main(int argc, char *argv[]) {
   ...

   strncpy(apat,argv[1],8);

   EXEC SQL DECLARE author CURSOR
         FOR SELECT name, title
             FROM author , wrote, publication
             WHERE name LIKE :apat
               AND aid=author
               AND pubid=publication;

   EXEC SQL OPEN author;
   EXEC SQL WHENEVER NOT FOUND GO TO end;
   for (;;) {
     EXEC SQL FETCH author INTO :name, title;
     printf("%10s -> %20s: %s\n",apat,name,title);
   };
end:
   EXEC SQL COMMIT RELEASE;
   exit(0);

   ...
}
```

Application with a Cursor (cont.)

```
bash$ ./sample3 "%"
Sample C program: SAMPLE3
 % -> Toman, David  : Temporal Logic in Information
 % -> Toman, David  : Datalog with Integer Periodic
 % -> Toman, David  : Point-Based Temporal Extensio
 % -> Chomicki, Jan : Logics for Databases and Info
 % -> Chomicki, Jan : Datalog with Integer Periodic
 % -> Chomicki, Jan : Temporal Logic in Information
 % -> Saake, Gunter : Logics for Databases and Info
bash$ ./sample3 "T%"
Sample C program: SAMPLE3
T% -> Toman, David  : Temporal Logic in Information
T% -> Toman, David  : Datalog with Integer Periodic
T% -> Toman, David  : Point-Based Temporal Extensio
```

Cursors and Updates

- cursors iterate over tuples in the answer
- you can *change* the tuple the cursor points to
  $\Rightarrow$ remember updating views? (same rules here)
- the value to be changed has to be specified in the cursor is declaration:

```
EXEC SQL DECLARE <name> CURSOR
         FOR <query>
         FOR UPDATE [ OF <attribs> ];
```

- the actual change:

```
EXEC SQL FETCH <cursor> INTO <vars>;
if <cond on variables>
  EXEC SQL UPDATE <cursor> SET ...
           WHERE CURRENT OF <name>;
```

  $\Rightarrow$ the **UPDATE** must
  match the cursor declaration.

Example

```
main(int argc, char *argv[]) {
   ...
   EXEC SQL DECLARE author CURSOR
         FOR SELECT name
             FROM author
             WHERE url IS NULL
         FOR UPDATE OF url;

   EXEC SQL OPEN author;
   EXEC SQL WHENEVER NOT FOUND GO TO end;
   for (;;) {
     EXEC SQL FETCH author INTO :name;
     printf("Author '%s' has no URL\n", name);
     printf("Enter new URL to fix or <cr> to delete: ");
     gets(url);
     if (strcmp(url,"")==0) {
       printf("Deleting '%s'\n",name);
       EXEC SQL DELETE FROM author
                WHERE CURRENT OF author;
     } else {
       printf("Seting URL for '%s' to '%s'\n",name,url);
       EXEC SQL UPDATE author
                SET url = :url
                WHERE CURRENT OF author;
     }
   };
end:
  ...
}
```

Summary

- Declarations:

```
EXEC SQL INCLUDE SQLCA;
EXEC SQL BEGIN DECLARE SECTION;
   <host variables here>
EXEC SQL END DECLARE SECTION;
```

- Simple statements:

```
EXEC SQL <SQL statement>;
```

- Queries (with multiple answers)

```
EXEC SQL DECLARE <id> CURSOR FOR <qry>;
EXEC SQL OPEN <id>;
do {
  EXEC SQL FETCH <id> INTO <vars>;
} while (SQLCODE == 0);
EXEC SQL CLOSE <id>;
```

- Don’t forget to check errors!!