



Let your PostgreSQL data  
travel back in time

French acronym for  
"***E**nregistrement des **M**ises **A** **J**our*"  
*i.e. "updates recording"*

## *E-Maj, what is it for?*

- E-Maj allows the data content to **travel back in time**, with a table level granularity
- By recording updates on sets of application tables, it is possible to
  - **Count** them (statistic function),
  - Easily **view** them (audit function),
  - **Revert** them ("rollback" function),
  - **Replay** them (script generation, or revert a revert...)
- Usable with
  - applications in test or in production
  - databases of all sizes

## *The gains*

- In **test** environment
  - Helps the application tests management by providing a quick way to
    - Examine updates generated by the application, for debugging purpose
    - Cancel updates generated by the application in order to easily repeat tests
- In **production** environment
  - Allows to cancel processings
    - Without being obliged to save and restore the instance by `pg_dump/pg_restore` or by physical copy
    - With a finer granularity
  - Avoids to loose entire batch processing nights by helping the recovery after failure
  - Very interesting with large tables and few updates

## The components

- **E-Maj**, the heart
  - A PostgreSQL extension
  - Open Source, under GPL licence
  - Download from [pgxn.org](https://pgxn.org/dist/e-maj/) - <https://pgxn.org/dist/e-maj/>
  - Sources available on [github.com](https://github.com/dalibo/emaj) - <https://github.com/dalibo/emaj>
- **Emaj\_web**
  - A web client - [https://github.com/dalibo/emaj\\_web](https://github.com/dalibo/emaj_web)
- The online **documentation**
  - In English (or French) - <https://emaj.readthedocs.io/en/latest/>



## *The characteristics which drove the design*

- **Reliability**
  - Absolute data integrity after updates cancellation
  - Management of all usual objects (tables, sequences, constraints,...)
- **Ease of use** for DBAs, production people, application developers and testers,...
  - Easy to understand and use
  - Easy to integrate into an automatized production (thus scriptable)
- **Performance**
  - Limited log overhead
  - Acceptable “rollback” duration
- **Security**
- **Maintainability**

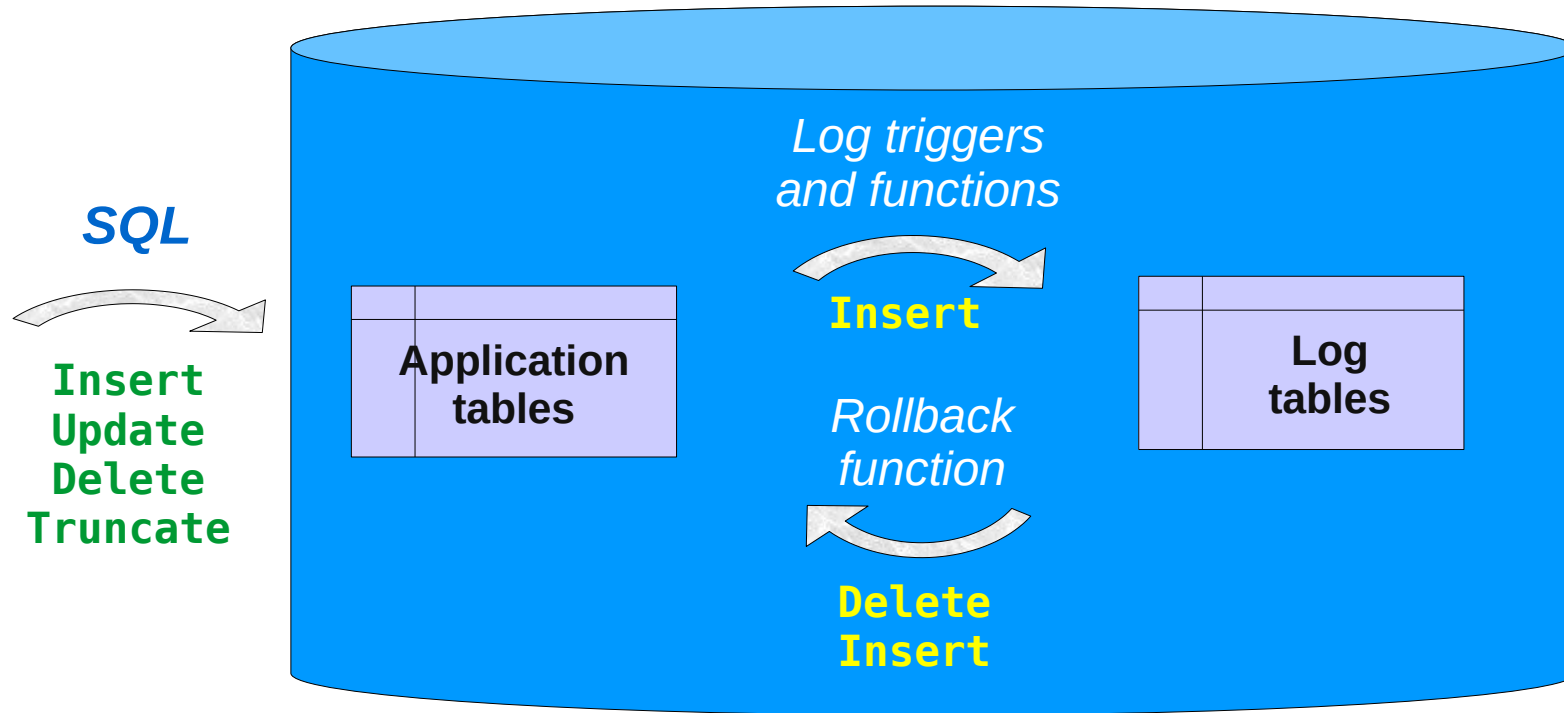
## Concepts

- **Tables Group** = a set of tables and/or sequences belonging to one or several schemas and having the same life cycle ; it's the only object manipulated by users
- **Mark** = stable point in the life of a tables group, whose state can be set back ; identified by a name
- **E-Maj Rollback** = positioning of a tables group at a previously set mark state
  - NB: this concept is different from the transaction rollbacks performed by the RDBMS
    - a “RDBMS-rollback” cancels the current transaction
    - a “E-Maj rollback” cancels updates from several committed transactions

## Concepts (2)

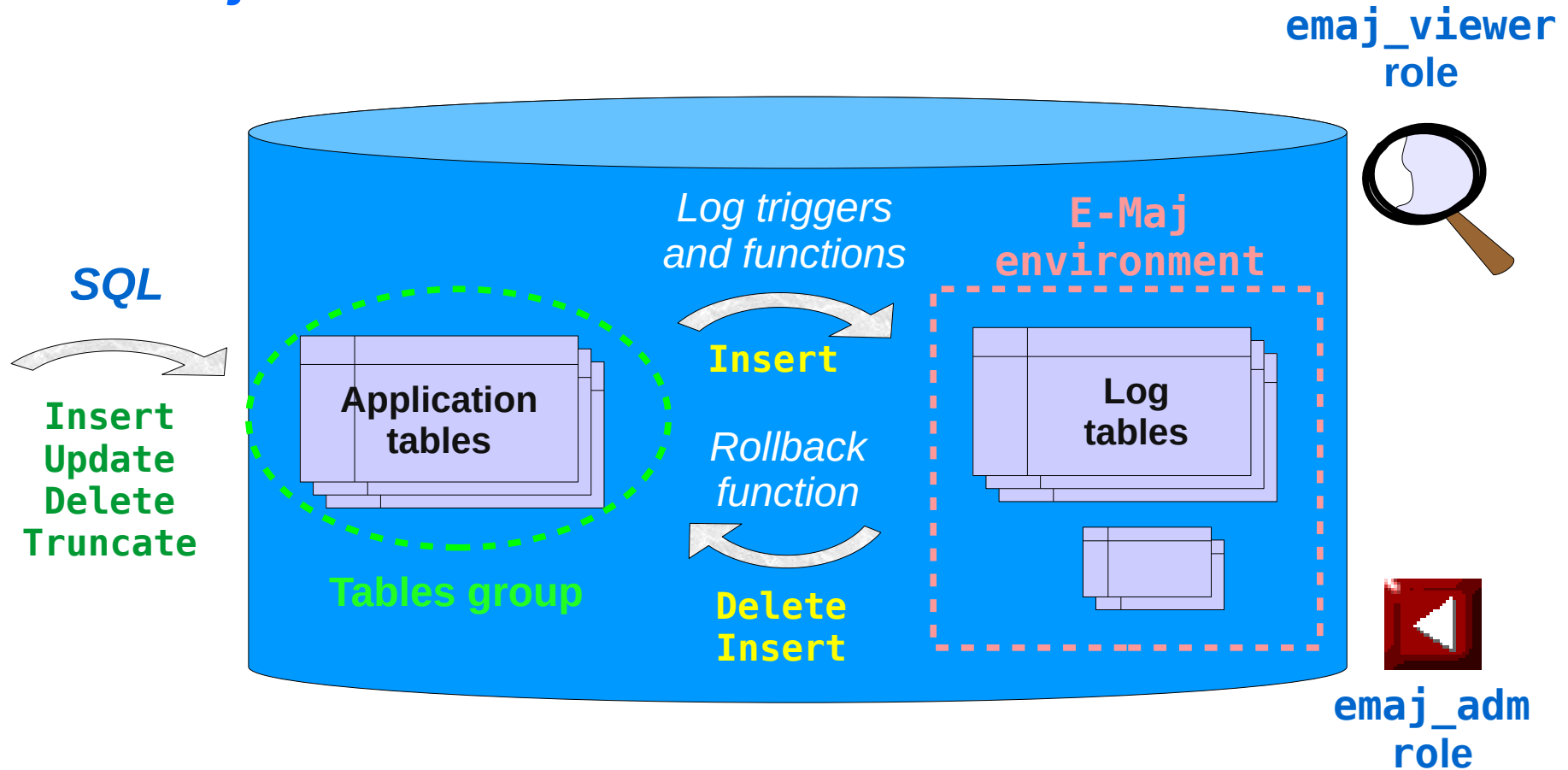
- By default, a tables group is created as **rollbackable**
- A tables group may be created as **audit-only**
  - E-Maj rollbacks are not possible
  - Useful to capture data changes for tables without PRIMARY KEY or of type UNLOGGED
- **Log session** = time interval when a tables group capture data changes ; it is bounded by the tables group **start** and **stop** actions.

## *An updates recording based on triggers*





## Main objects



## *Management of application sequences*

- Sequence increments are not individually recorded
- At set mark time
  - The state of each sequence of the group is stored into an internal table
- At E-Maj rollback time
  - Each sequence is reset to its state recorded at the targeted mark

## Install E-Maj

- Standart install
  - `pgxn install E-Maj --sudo`
  - Log on the target database as super-user and execute
    - `CREATE EXTENSION emaj CASCADE;`
- Install on DBaaS cloud environment
  - Download from [pgxn.org](http://pgxn.org) and unzip the extension
  - `psql ... -f sql/emaj-<version>.sql`
- This adds to the database
  - the extensions `dblink` et `btree_gist` if needed
  - 1 schema, named 'emaj', with about 190 functions, 19 technical tables, 12 types, 1 view, 1 sequence, 3 event triggers
  - 2 roles

## Initialization

- For each group:
  - 1) Create an empty group  
`SELECT emaj_create_group (group, is_rollbackable [,comment]);`
  - 2) Add tables and sequences  
`SELECT emaj_assign_tables (schema, inclusion regexp, exclusion regexp, group);`  
`SELECT emaj_assign_sequences (schema, inclusion regexp, exclusion regexp, group);`
    - Ex: all tables of a schema except those suffixed by sav:  
`'.*', 'sav$'`
    - Create for each application table: 1 log table, 1 log sequence, 1 log trigger and its function
- NB: `SELECT emaj_drop_group (group)`
  - ... drop an existing group

## *The 3 main functions to manage groups*

- “Starting” a group
  - `emaj_start_group (group, mark)`  
activates the log triggers and sets a first mark
- Setting a mark
  - `emaj_set_mark_group (group, mark [,comment])`  
sets an intermediate mark
- “Stopping” a group
  - `emaj_stop_group (group [,mark])`  
deactivates the log triggers => a rollback is not possible anymore
- The % character in a mark name represents the current date and time

## Examine logs

- Examining log tables may largely help the application debugging
- Each application table has its own log table
  - `emaj_<schema>.<table>_log`
- A log table contains
  - The same columns as its related application table
  - And some technical columns
- A single row change in an application table generates
  - 1 log row for an INSERT (image of the new row)
  - 1 log row for a DELETE or a TRUNCATE (image of the old row)
  - 2 log rows for an UPDATE (image of the old and the new rows)
- A TRUNCATE generates also a single log row

## *Log tables technical columns*

- 6 technical columns at the end of each log row
  - `emaj_verb` : SQL statement type - INS/UPD/DEL/TRU
  - `emaj_tuple` : row type - OLD/NEW
  - `emaj_gid` : internal sequence number
  - `emaj_changed` : time of the update - `clock_timestamp()`
  - `emaj_txid` : transaction identifier - `txid_current()`
  - `emaj_user` : connection role of the client - `session_user`
- ... and some others can be added
- It is possible to identify clients and transactions, and analyze the timing of the program execution

## Generated columns on application tables (*GENERATED ALWAYS AS expression*)

Type	Physical (STORED)	Virtual
Minimum Postgres version	12	18
Structure in log table	A standart column	
Content in log table	Expression result	NULL
SQL visualisation of the changes impact	Direct examination of the log table column	Use the expression
Expression change ( <i>ALTER TABLE ... ALTER COLUMN ... SET EXPRESSION ...</i> )	Blocked by E-Maj (*)	Possible
Expression drop ( <i>ALTER TABLE ... ALTER COLUMN ... DROP EXPRESSION</i> )	Possible, but risky for data integrity at subsequent E-Maj rollback operations	Not applicable (forbidden by PostgreSQL)
Column transformation: generated $\leftrightarrow$ standart ( <i>ALTER TABLE ... DROP COLUMN ..., ADD COLUMN ...</i> )	Detected by E-Maj at mark set and rollback attempts (*)	

(\*) the table must be temporarily removed from its group



## Counting recorded data changes

- 3 statistical functions, at **tables group** level and for a given marks interval
  - `emaj_log_stat_group (group, start_mark, end_mark)`  
quickly returns an estimate of recorded changes per table
  - `emaj_detailed_log_stat_group (group, start_mark, end_mark)`  
scans log tables and returns precise statistics on their content, per table, statement type (INSERT / UPDATE / DELETE / TRUNCATE) and ROLE
  - `emaj_sequence_stat_group (group, start_mark, end_mark)`  
returns the number of increments per sequence

## Counting recorded data changes (2)

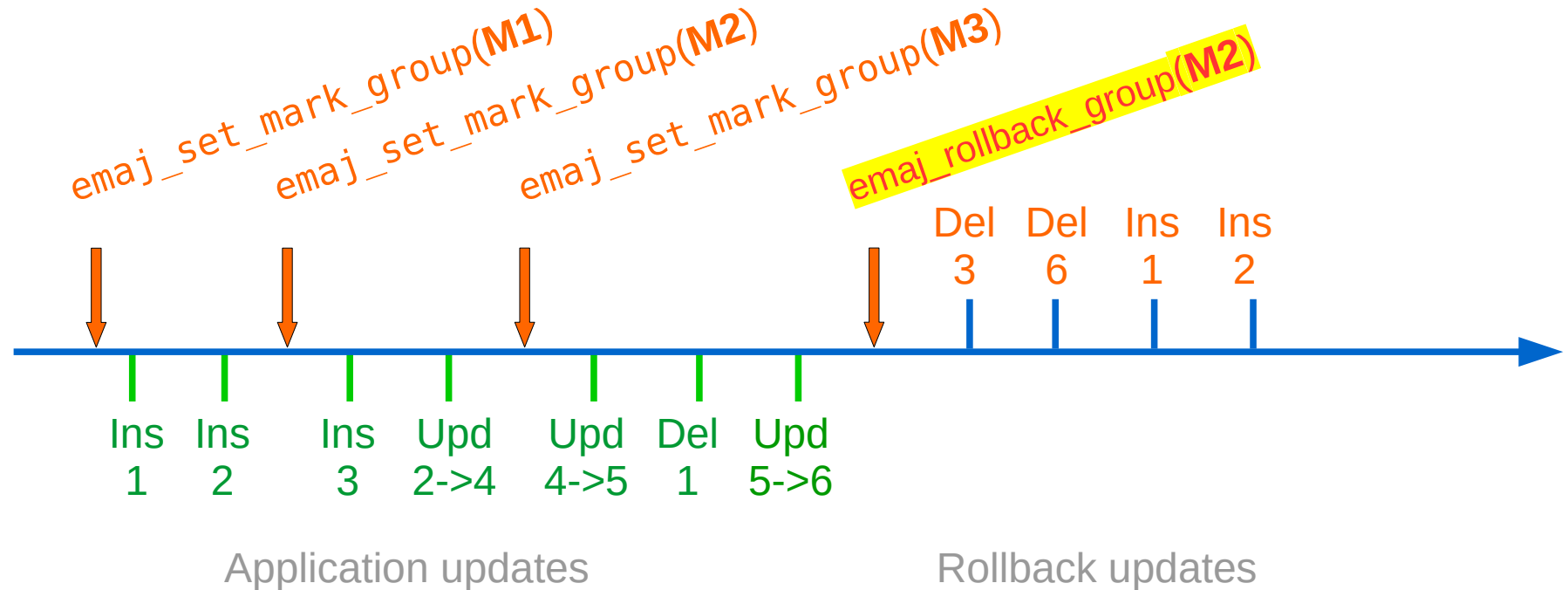
- 2 functions quickly return an estimate of recorded changes for **one table** for each elementary marks interval on a given time frame
  - `emaj_log_stat_table (schema, table, start_date_time, end_date_time)`
  - `emaj_log_stat_table (schema, table, start_group, start_mark, end_group, end_mark)`
- 2 functions return the number of increments for **one sequence** for each elementary marks interval on a given time frame
  - `emaj_log_stat_sequence (schema, sequence, start_date_time, end_date_time)`
  - `emaj_log_stat_sequence (schema, sequence, start_group, start_mark, end_group, end_mark)`

## Cancel updates : the “simple” rollback

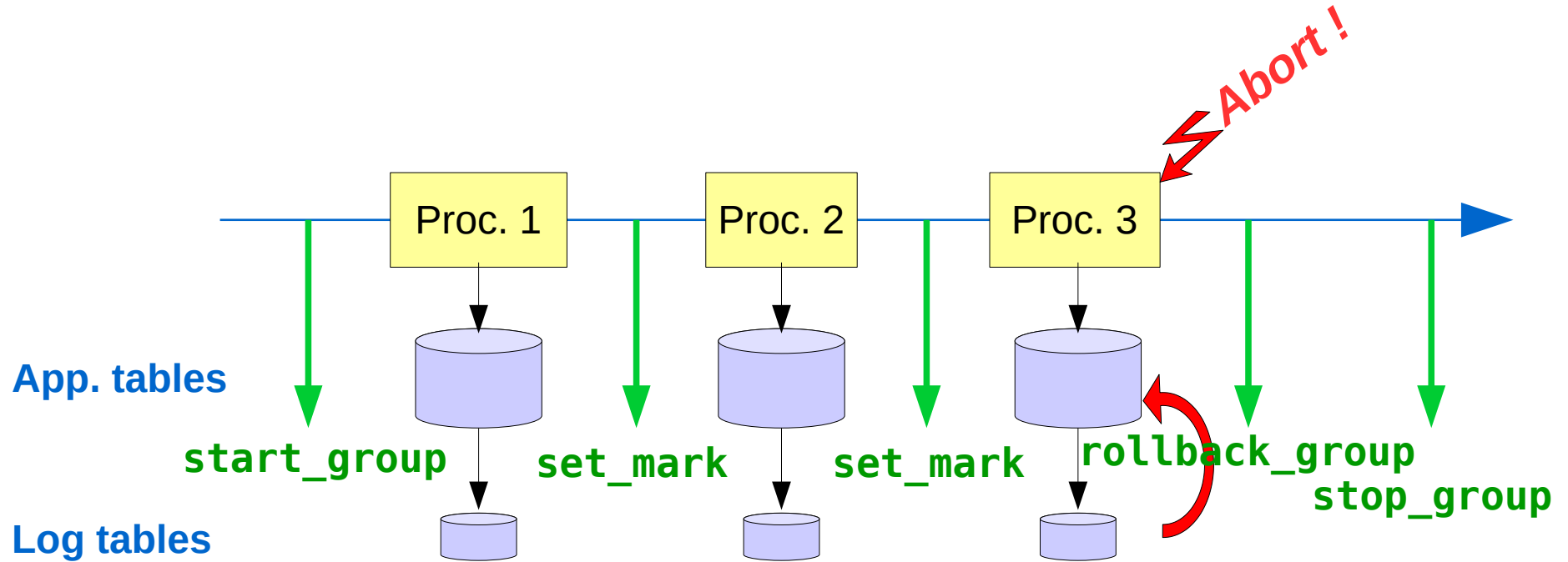
- A “rollback” function allows to reset a tables group in the state it had at a given mark
  - `emaj_rollback_group (group, mark [, false [, comment]])`
- How this works
  - Log triggers are deactivated during the operation
  - Each table is reset to its mark state using an optimised algorithm
  - Application sequences are reset to their mark state
  - Takes into account the foreign keys, if any
  - The canceled logs and marks are deleted
    - => all what is after the rollback mark is forgotten

## An optimised rollback algorithm

- It processes each primary key value only once



## *A typical E-Maj usage (production batch processing)*

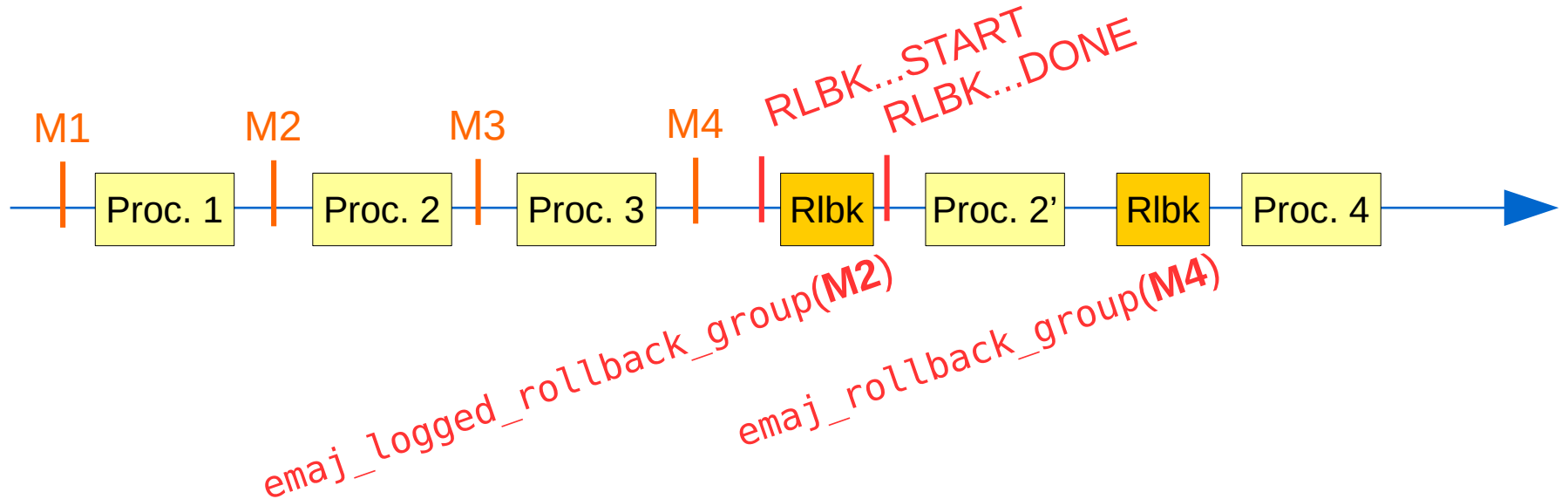


## Cancelling updates : the “logged” rollback

- `emaj_logged_rollback_group (group, mark[, false [, comment]])`
- Different from the “simple” rollback
  - Log triggers are NOT deactivated during the operation  
=> the updates generated by the rollback are recorded
  - Cancelled logs et marks are NOT deleted
- So we can revert an E-Maj rollback ! And more generally let a tables group travel back and forth in time !
- 2 marks are automatically set before and after the rollback
  - `RLBK_<rollback id>_START` and `RLBK_<rollback id>_DONE`
- During the rollback, tables remain accessible in read mode

## *A typical E-Maj usage in test environment*

- 4 processings to test in sequence
- After test 3, a new version of processing 2 must be re-tested
- Then perform the remaining tests



## *Estimating an E-Maj rollback duration*

- In order to know if we have enough time to perform the operation or if another way to recover would be more efficient
- A function estimates the time needed to rollback a group to a given mark
  - `emaj_estimate_rollback_group (group, mark)`



## *Executing a parallel E-Maj rollback*

- A perl client performs rollbacks with parallelism
  - `emajParallelRollback.pl -d <database> -h <host> -p <port> -U <user> -W <password> -g <group_name or groups_list> -m <mark> -s <nb_sessions> [-l] [-c comment>]`
- Automatically spreads the tables to process into a given number of parallel sessions
- All sessions belong to a single transaction (2PC)
  - => `max_prepared_transactions` >= nb sessions
- Needs perl software with its PostgreSQL extension

## *Monitoring E-Maj rollbacks in execution*

- A function
  - `SELECT * FROM emaj.emaj_rollback_activity ();`
  - returns
    - The characteristics of rollbacks (group, mark...)
    - Their state
    - Their current duration
    - An estimate of the remaining duration and the already executed %
- Needs to setup the value of the “`dblink_user_password`” parameter in the `emaj_param` table

## Monitoring E-Maj rollbacks

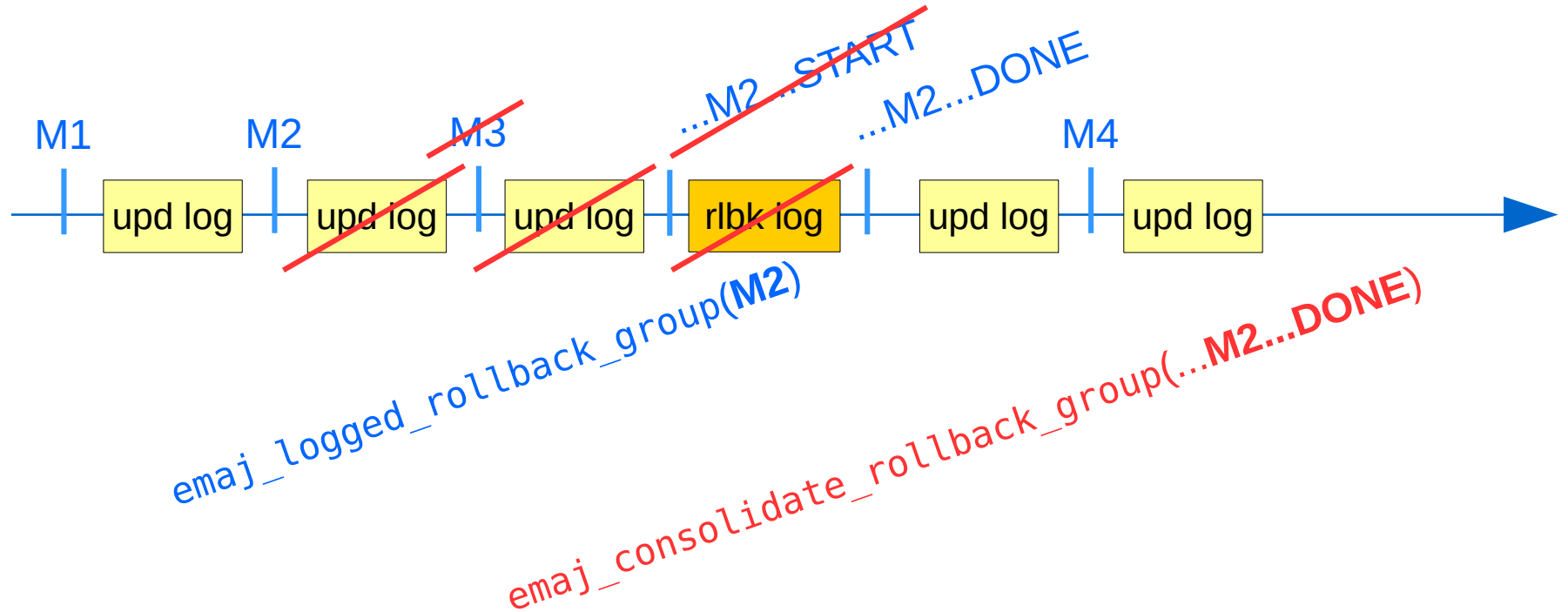
- A perl client to monitor the executing or completed rollbacks
  - `emajRollbackMonitor.pl -d <database> -h <host> -p <port> -U <user> -W <password> -n <nb_iterations> -i <refresh_rate_in_seconds> -l <nb_completed rollbacks> -a <completed_rollbacks_history_depth_in_hours>`

```
E-Maj (version 4.2.0) - Monitoring rollbacks activity
-----
21/03/2023 - 08:31:23
** rollback 34 started at 2023-03-21 08:31:16.777887+01 for groups {myGroup1}
   status: COMMITTED ; ended at 2023-03-21 08:31:16.9553+01
** rollback 35 started at 2023-03-21 08:31:17.180421+01 for groups {myGroup1}
   status: COMMITTED ; ended at 2023-03-21 08:31:17.480194+01
-> rollback 36 started at 2023-03-21 08:29:26.003502+01 for groups {group20101}
   status: EXECUTING ; completion 85 %; 00:00:20 remaining
```

## Consolidate a “logged” rollback

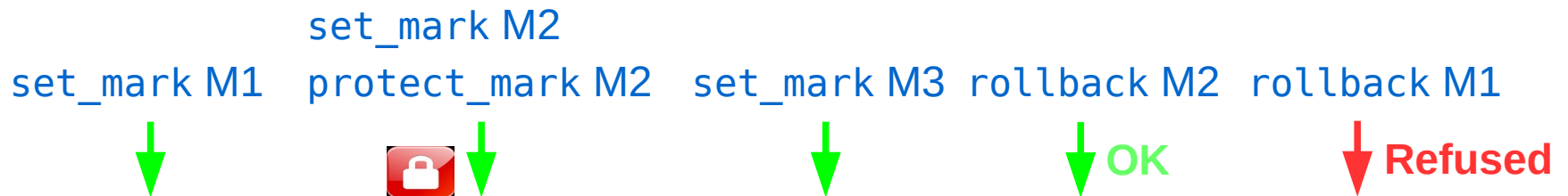
- “Consolidate” a rollback means transform a “logged rollback” into a “simple rollback”
- Intermediate logs and marks are deleted, recovering some place in the logs
  - `emaj_consolidate_rollback_group (groups, end_rollback_mark)`
- Tables can be updated during the consolidation
- A function returns the list of consolidable rollbacks
  - `emaj_get_consolidable_rollbacks ()`

## Example of E-Maj rollback consolidation



## Being protected against unattended E-Maj rollbacks

- 2 functions to manage the protection of a tables group
  - `emaj_protect_group (group)`
  - `emaj_unprotect_group (group)`
- 2 functions to manage the protection of a mark
  - `emaj_protect_mark_group (group, mark)` blocks any attempt to rollback to a mark prior the protected mark
  - `emaj_unprotect_mark_group (group, mark)`



## The emajStat client to monitor changes recording

- A perl client to count changes on tables and sequences since the latest mark of their group and since the previous display, in absolute value and changes per second
- Many options to filter groups, tables and sequences, define the refresh parameters, ...
  - For the details: `emajStat.pl --help`

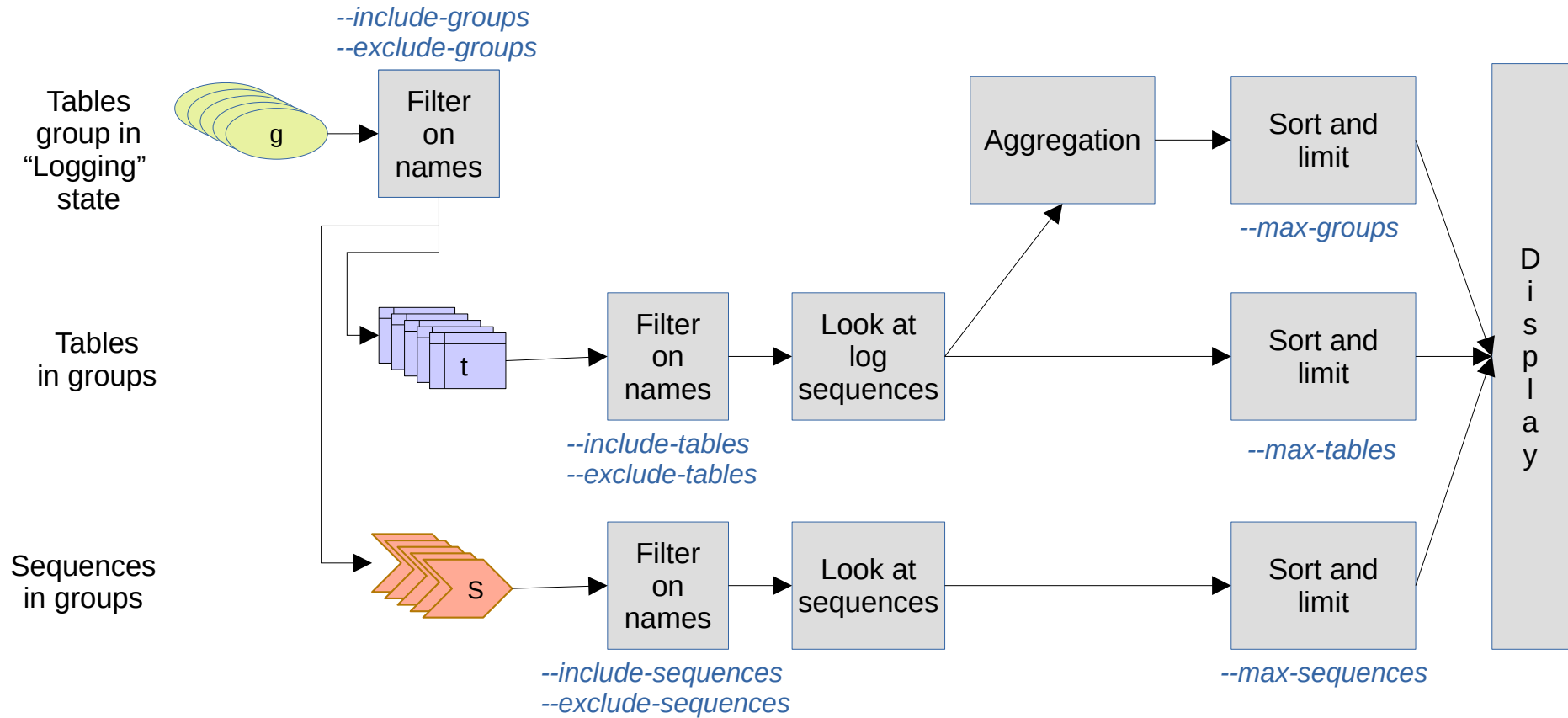
```
E-Maj (version 4.5.0) - Monitoring logged changes on database regression (@127.0.0.1:5412)
-----
2024/08/15 08:12:59 - Logging: groups=2/3 tables=11/11 sequences=4/4 - Changes since 1.004 sec: 0 (0.000 c/s)

Group name + Latest mark + Changes since mark + Changes since prev.
myGroup1 | Multi-1 (2024/08/15 08:12:38) | 359 (17.045 c/s) | 0 (0.000 c/s)

Table name + Group + Changes since mark + Changes since prev.
myschema1.mytbl1 | myGroup1 | 211 (10.018 c/s) | 0 (0.000 c/s)
myschema1.mytbl3 | myGroup1 | 60 ( 2.849 c/s) | 0 (0.000 c/s)
myschema1.mytbl2b | myGroup1 | 52 ( 2.469 c/s) | 0 (0.000 c/s)
myschema1.mytbl2 | myGroup1 | 27 ( 1.282 c/s) | 0 (0.000 c/s)
myschema1.mytbl4 | myGroup1 | 9 ( 0.427 c/s) | 0 (0.000 c/s)

Sequence name + Group + Changes since mark + Changes since prev.
myschema1.mytbl2b_col20_seq | myGroup1 | -5 (-0.237 c/s) | 0 (0.000 c/s)
myschema1.mytbl3_col31_seq | myGroup1 | -20 (-0.950 c/s) | 0 (0.000 c/s)
```

## emajStat logic and parameters





## Analyse recorded data changes

- Dump on files, by COPY, in a given directory, a log tables extracts and sequences of a group
  - `emaj_dump_changes_group (group, start_mark, end_mark, options_list, tables/seq_array, directory)`
- Generate SQL to extract recorded changes between 2 marks for all or some tables or sequences of a group
  - In the instance disk space :  
`emaj_gen_sql_dump_changes_group (group, start_mark, end_mark, options_list, tables/seq_array, file)`
  - In an `emaj_temp_sql` temporary table, for any use by any client :  
`emaj_gen_sql_dump_changes_group (group, start_mark, end_mark, options_list, tables/seq_array)`

## Analyse data changes: the options

- Common to `emaj_dump_changes_group()` and `emaj_gen_sql_dump_changes_group()`
  - **CONSOLIDATION** = NONE (default) | PARTIAL | FULL
  - **EMAJ\_COLUMNS** = ALL | MIN | (list) : selects E-Maj technical columns
  - **COLS\_ORDER** = LOG\_TABLE | PK : sets the order of delivered columns
  - **ORDER\_BY** = PK | TIME : sets the order of delivered rows, by PK or emaj\_gid
  - **SEQUENCES\_ONLY** : excludes tables
  - **TABLES\_ONLY** : excludes sequences
- For `emaj_dump_changes_group()`
  - **COPY\_OPTIONS** = (options list) : for the COPY TO generation
  - **NO\_EMPTY\_FILES** : removes empty files (tables without changes)
- For `emaj_gen_sql_dump_changes_group()`
  - **PSQL\_COPY\_DIR** = directory : generates a \copy for each statement, with this directory
  - **PSQL\_COPY\_OPTIONS** = (liste options) : sets the \copy options
  - **SQL\_FORMAT** = RAW | PRETTY : formats each statement on 1 or several lines

## Analyse data changes: the consolidated vision of changes

- The consolidated vision of changes provides a net outcome of recorded changes, for a given time range and for each primary key
  - At most: 1 “OLD” row (the initial state) and 1 “NEW” row (the final state)
  - Ex: if UPDATE ‘A’ → ‘B’ then UPDATE ‘B’ → ‘C’, row OLD = ‘A’ and row NEW = ‘C’
- Therefore each examined table must have an explicit PK
- 2 consolidation kinds
  - “Partial consolidation”: without taking into account the columns content
  - “Full consolidation”: examining the changed data
    - For a given PK, no change is reported if all columns of both “OLD” and “NEW” rows are equal
    - Ex: no change reported for a given PK if UPDATE ‘A’ → ‘B’ then UPDATE ‘B’ → ‘A’, or if INSERT then DELETE
- Sequences
  - 1 “OLD” row and 1 “NEW” row for the initial and final sequence’s characteristics
  - In “Full consolidation” mode, no row is returned if the sequence has not been changed

## Analyse data changes: emaj\_temp\_sql temporary table structure

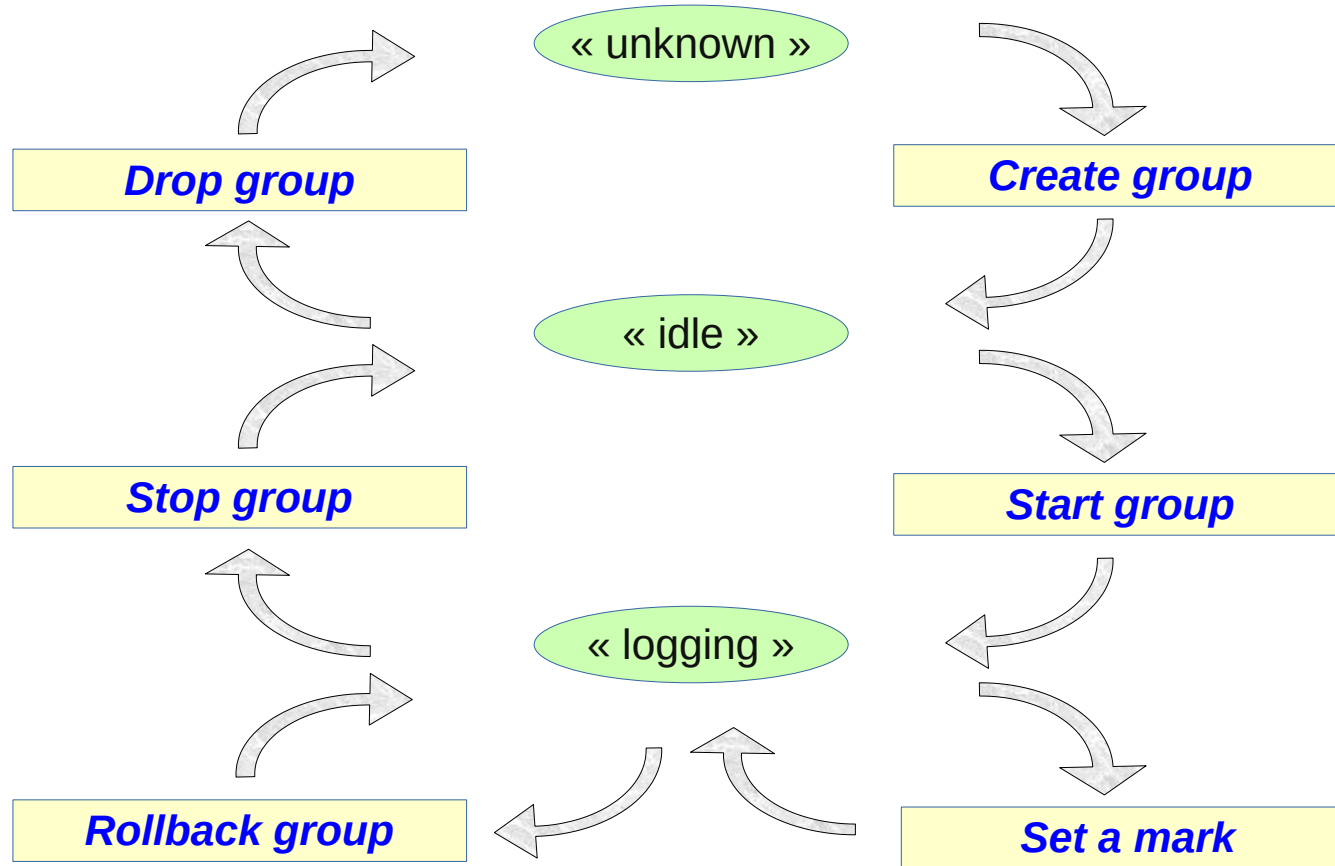
```
CREATE TEMP TABLE emaj_temp_sql (  
    sql_stmt_number      INT,          -- Statement number  
                                   -- (0 for the initial comment)  
    sql_line_number      INT,          -- Line number within the statement  
                                   -- (0 for the initial comment of the statement)  
    sql_rel_kind         TEXT,         -- Relation kind: "table" or "sequence"  
    sql_schema           TEXT,         -- Schema name  
    sql_tblseq           TEXT,         -- Table or sequence name  
    sql_first_mark       TEXT,         -- First mark name (for the table/sequence)  
    sql_last_mark        TEXT,         -- Last mark name (for the table/sequence)  
    sql_group            TEXT,         -- Tables group owning the relation  
    sql_nb_changes        BIGINT,      -- Estimated number of changes to process  
    sql_file_name_suffix TEXT,         -- File name suffix  
    sql_text             TEXT,         -- SQL statement text  
    sql_result           BIGINT        -- Column dedicated to the caller for its operations  
                                   -- (some other can be added with ALTER TABLE)  
);
```

An index on the 2 first columns

## Replay data changes

- Generate a sql script replaying the elementary recorded changes between 2 marks, for some or all tables and sequences of a group
  - In the instance disk space:  
`emaj_gen_sql_group (group, start_mark, end_mark, dest_file [,tables/seq_list])`
  - Anywhere, with psql:  
`SELECT emaj_gen_sql_group (group, start_mark, end_mark, NULL [,tables/seq_list])  
\copy (SELECT * FROM emaj_sql_script) TO 'dest_file'`
- Useful in test environment to “replicate” the changes produced by a processing

## The tables group life cycle



## *Tables groups dynamic adjustment*

- To add one or several tables
  - `emaj_assign_table(schema, table, group, properties [, mark])`
  - `emaj_assign_tables(schema, tables list, group, properties [, mark])`
  - `emaj_assign_tables(schema, selection filter, exclusion filter, group, properties [, mark])`
- Properties:
  - JSON format
  - To define the priority and the tablespaces for log data and index
- Selection and exclusion filters: RegExp

## *Tables groups dynamic adjustment*

- Example

- `emaj_assign_tables('myschema', 'tbl.*', '_sav$', 'mygroup',  
'{"priority":1}':::json)`

assigns to the group 'mygroup' and with the priority 1 all tables of the schema 'myschema' whose name starts with 'tbl' and doesn't end with '\_sav'



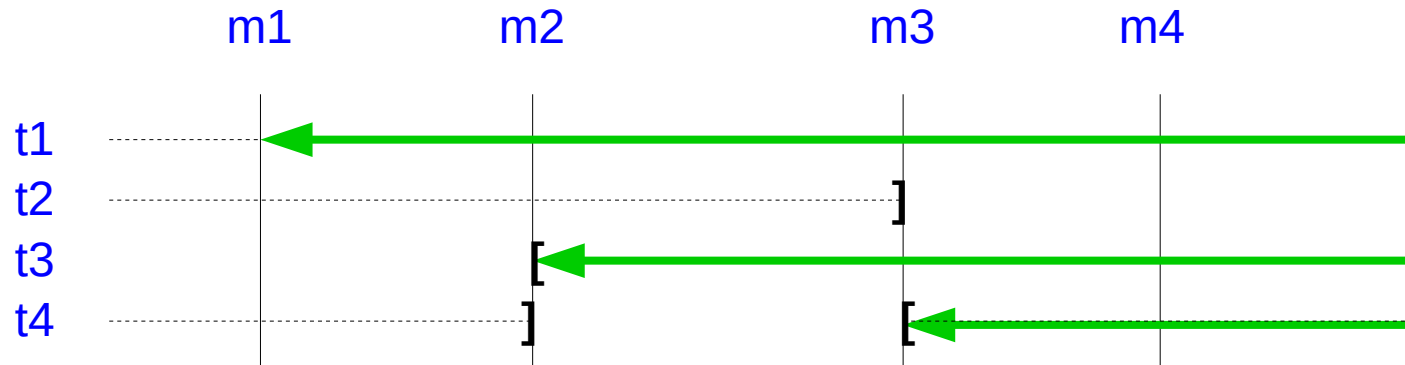
## *Tables groups dynamic adjustment*

- Similarly:
  - `emaj_assign_sequence()` and `emaj_assign_sequences()`
  - `emaj_modify_table()` and `emaj_modify_tables()`
  - `emaj_move_table()` and `emaj_move_tables()`
  - `emaj_move_sequence()` and `emaj_move_sequences()`
  - `emaj_remove_table()` and `emaj_remove_tables()`
  - `emaj_remove_sequence()` and `emaj_remove_sequences()`

## Impact of logging group structure changes on rollbacks

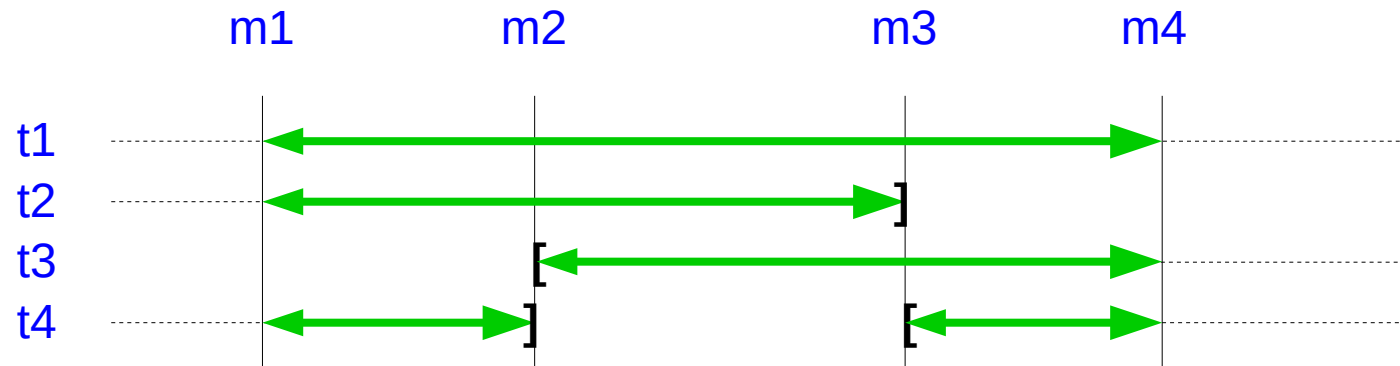
Table t2 removed at mark m3, t3 added at m2, t4 removed at m2 and added at m3

`emaj_rollback_group(<groupe>,'m1', true)` would pr



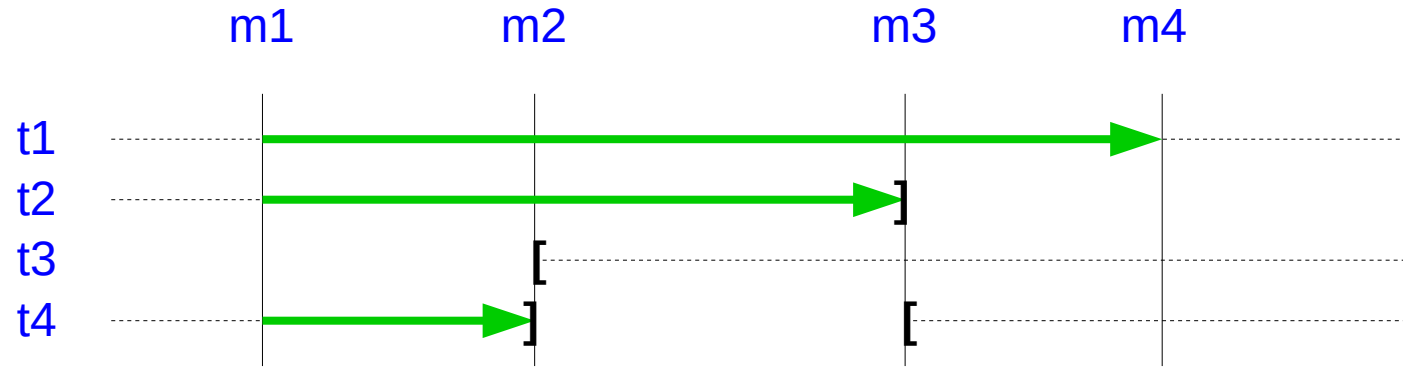
## Impact of logging group structure changes on statistics and content changes extracts

`emaj_log_stat_group(<groupe>,'m1','m4')` and  
`emaj_dump_changes_group(<groupe>,'m1','m4',...)` would report:



## Impact of logging group structure changes on the SQL scripts generation

`emaj_gen_sql_group(<group>,'m1','m4')` would process:



## *Modify the structure of a table in a LOGGING group*

- For actions like: rename the table, change its schema, add/drop/rename a column, change a column type
- The log table structure is impacted
- 3 steps
  - Remove the table from its tables group
  - ALTER TABLE
  - Add the table into its tables group
- Constraint: an E-Maj rollback to a prior mark will not be able to go beyond the structure change
- Idem to rename a sequence or change its schema

## *Processing several groups in a single operation*

- Some “multi-groups” variants of functions
  - `emaj_start_groups (groups_array, ... )`
  - `emaj_stop_groups (groups_array, ... )`
  - `emaj_set_mark_groups (groups_array, ... )`
  - `emaj_rollback_groups (groups_array, ... )`
  - `emaj_logged_rollback_groups (groups_array, ... )`
  - `emaj_log_stat_groups (groups_array, ... )`
  - `emaj_gen_sql_groups (groups_array, ... )`
- Allows to get marks shared by several groups
- Both PostgreSQL syntaxes for groups arrays
  - `ARRAY['group 1', 'group 2', ... ]`
  - `'{"group 1", "group 2", ... }'`

## Managing marks

- Comment a mark for a group (add/modify/suppress)
  - `emaj_comment_mark_group (group, mark, comment)`
- Rename a mark
  - `emaj_rename_mark_group (group, old_name, new_name)`
- Delete a mark
  - `emaj_delete_mark_group (group, mark)`
  - If the deleted mark is the first one, logs prior the second one are deleted
- Delete all marks prior a given mark
  - `emaj_delete_before_mark_group (group, mark)`
  - Deletes logs prior the mark (it may take a long time...)

## Managing mark (2)

- Search for marks
  - `emaj_find_previous_mark_group (group, date-time)` returns the mark immediately preceeding a given date and time
  - `emaj_find_previous_mark_group (group, mark)` returns the mark immediately preceeding a given mark
- “`EMAJ_LAST_MARK`” represents the last set mark for a group
  - Usable for all parameters defining an existing mark



## Other actions on groups

- Comment a group (add/modify/suppress)
  - `emaj_comment_group (group, comment)`
- Purge log tables of a stopped group (anticipating its next restart)
  - `emaj_reset_group (group)`
- Export / import tables groups configurations
  - `emaj_export_groups_configuration ()`
  - `emaj_import_groups_configuration ()`
- Force a group stop (in case of problem with the normal stop function)
  - `emaj_force_stop_group (group)`

## *Other actions on groups*

- Snap on files in a given directory, by COPY, all tables and sequences of a group
  - `emaj_snap_group (group, directory, copy_options)`
- 3 useful functions to write idempotent scripts to
  - create/drop a tables group
    - `emaj_does_exist_group (group)`
  - start/stop a tables group
    - `emaj_is_logging_group (group)`
  - Set a mark
    - `emaj_does_exist_mark_group (group, mark)`
- Erase histories about a dropped tables group
  - `emaj_forget_group (group)`

## Other actions

- Get the current emaj extension version or drop the extension
  - `emaj_get_version ()`
  - `emaj_drop_extension ()`
- Verify the good health of the E-Maj installation
  - `emaj_verify_all ()`
- Get the current log table of a given application table
  - `emaj_get_current_log_table ()`
- Manualy purge obsoletes traces
  - `emaj_purge_histories ()`
- Create/modify/delete a comment on a rollback
  - `emaj_comment_rollback ()`
- Export or import parameters configuration
  - `emaj_export_parameters_configuration ()`
  - `emaj_import_parameters_configuration ()`

## Temporary or permanent logging?

- **Temporary logging** = steps like
    - `emaj_start_group()`
    - repeat
      - processing
      - `emaj_set_mark()`
    - `emaj_stop_group()`
  - At next start, old logs are purged
  - But stops and starts set very heavy locks
- **Permanent logging** = no repeated group stop/restart
    - Obsolete data in log tables must be regularly deleted, using the `emaj_delete_before_mark()` function
  - The deletion can be costly if the volume of log to delete is big

## *For large databases...*

- Log tables and indexes can be stored into **tablespaces**
  - 2 optional properties set when assigning tables to groups

## *To ensure the reliability*

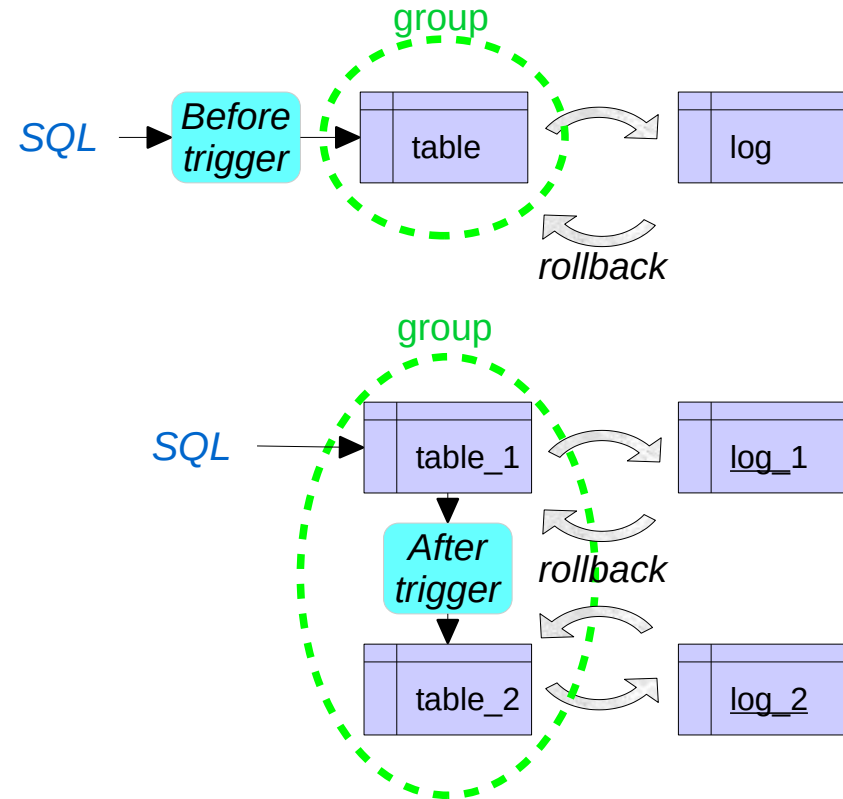
- No change in the PostgreSQL engine
- Many systematic **checks**, in particular at group start, mark set or rollback times:
  - Do all required tables, sequences, functions and triggers exist?
  - Consistency of columns between the application tables and the related log tables (existence, type)?
- Heavy **locks** on tables at **start\_group**, **set\_mark\_group** and **rollback\_group**, to be sure that no transaction is currently updating application tables
  - The order of lock setting can be influence by a priority level defined for each table
- Rollback all tables and sequences by a single **transaction**

## *To ensure the reliability (2)*

- “**event triggers**” block unintentional drops or some component changes (tables, sequences, functions...)
  - 2 functions to deactivate/reactivate the lock-in
  - `emaj_disable_protection_by_event_triggers ()`
  - `emaj_enable_protection_by_event_triggers ()`

## Impact of application triggers on E-Maj rollbacks

- Triggers of type *BEFORE* on a table belonging to a tables group
  - Values really inserted into the database are recorded into the log
  - => to be disabled at E-Maj rollback
- Triggers of type *AFTER* updating a table belonging to the same tables group
  - The rollback will reset both tables with the right content
  - => to be disabled at E-Maj rollback
- Other cases : study the impacts





## *Impact of application triggers on E-Maj rollbacks*

- By default, application triggers are automatically disabled by E-Maj rollbacks
- A trigger may be left in its state at rollback time if it is registered as is
- 2 properties for `emaj_assign_table()`, `emaj_assign_tables()`, `emaj_modify_table()` and `emaj_modify_tables()` functions to specify the triggers that must be ignored by the E-Maj rollback processing
  - `"ignored_triggers": ["trg1","trg2",...]` lists trigger names
  - `"ignored_triggers_profiles": ["regexp1","regexp2",...]` lists regular expressions that select trigger names

## *To contribute to the security*

- 2 NOLOGIN roles whose rights may be granted:
  - `emaj_adm` for the E-Maj administration
  - `emaj_viewer` to just look at E-Maj objects (logs, marks, statistics)
- E-Maj objects are only created and handled by a super-user or a member of the `emaj_adm` role
- No other right has to be granted on E-Maj schemas, tables and functions
- Log triggers are created with the “SECURITY DEFINER” attribute
- No need to give additional rights to application tables or sequences

## Performances

- Log overhead
  - Highly depends on hardware and on the application read/write SQL ratio
  - Typically a few % on elapse times
  - But can be much higher on pure data loading
- Rollback duration
  - Of course depends on the number of updates to cancel
  - Also highly depends on
    - The hardware configuration
    - Tables structure (row sizes, indexes, foreign keys, other constraints...)
  - But almost always shorter than a logical restore

## Emaj\_web

- For administrators and users
- All E-Maj objects (groups, marks...) and their attributes
- (almost) all possible actions on E-Maj objects

Connection: localhost:5415 - role "postgres" SQL | History | Logout English

Emaj\_web > Pg 15 > postgres

Groups Schemas Triggers E-Maj Rollbacks E-Maj

### Tables groups in "LOGGING" state

	Group	Created at	Tables	Sequences	Type	Marks	Actions	Comment
<input type="checkbox"/>	myGroup1	12 Apr 2024 15:51:04	5	1		3		Useless comm...
<input type="checkbox"/>	myGroup2	12 Apr 2024 15:51:04	4	2		4		

Select Actions on objects (0)

All / Visible / None / Invert

### Tables groups in "IDLE" state

	Group	Created at	Tables	Sequences	Type	Marks	Actions	Comment
<input type="checkbox"/>	phil's group#3	12 Apr 2024 15:51:04	2	1		0		

Select Actions on objects (0)

All / Visible / None / Invert

New group Export Import

### Old dropped tables groups

No old dropped tables groups.

Tables groups list

## Emaj\_web : tables group details

Connection: localhost:5415 - role "postgres" SQL | History | Logout English

Emaj\_web > Pg 15 > postgres > myGroup1

Properties Changes statistics Content History

### Tables group "myGroup1" properties

Created at	Type	Tables	Sequences	State	Started at	Marks	Log size
12 Apr 2024 15:51:04		5	1		12 Apr 2024 15:51:05	3	144 kB

Comment: Useless comment!

Set a mark Protect Stop Set a comment

### Tables group "myGroup1" marks

		Mark	State	Set at	Row changes	Cumulated changes	Actions	Comment
<input type="checkbox"/>		MARK3		Fri 12 Apr 15:51:05	0	0		
<input type="checkbox"/>		MARK2		Fri 12 Apr 15:51:05	7	7		End of 1st prog...
<input type="checkbox"/>		MARK1		Fri 12 Apr 15:51:05	19	26		

Select Actions on objects (0)

All / Visible / None / Invert

## *Current limitations*

- Minimum PostgreSQL version = **12**
- Every application table belonging to a rollbackable group needs a **PRIMARY KEY**
- **DDL** statements cannot be logged or cancelled by E-Maj
  - Changing a table's structure requires to temporarily remove the table from its group
- **FOREIGN KEYs** defined on **partitionned tables** are incompatible with E-Maj rollbacks
  - => define them on each partition

## *To conclude...*

- Many more **informations** in
  - the documentation:  
<https://emaj.readthedocs.io/en/latest/index.html>
  - the README et CHANGES files
- Many thanks to all contributors and users
- Feel free to give any **feedback** through github or email (phb.emaj@free.fr)