HOW TO MIGRATE FROM POSTGRESQL TO HDF5 AND LIVE HAPPILY EVER AFTER

Michele Simionato @ **GEM Foundation**

legacy code warrior

The story of a *successful* software rewriting

WHERE I COME FROM

- Ph. D. in Theoretical Physics (yep, I understand gravitational waves)
- contributed to Python with article/docs, author of the decorator module
- worked a couple of years as consultant (Zope/Plone + other stuff)
- worked 7 years in a Finance firm (mostly database and web programming)
- arrived at GEM in October 2012
- in charge of the earthquake simulation engine from September 2014

- I spent 15 years doing Physics and 14 years programming
- I am still more interested in solving the scientific problems than the technological problems
- lots of experience with programming in the large
- know all about code maintenance, dependencies management, product documentation, automatic tests, continuous integration, code reviews, ...
- SQL lover and generally old school boy
- still using Emacs in the 21th century
- *I don't throw away old code just because it is old*

WHAT I AM GOING TO TALK ABOUT

- "big" numerical simulations for earthquakes
- lots of floating point outputs with geospatial data
- why storing them in Postgres/PostGIS did not work
- what to do when you have a *huge* architectural problem
- technical and political issues faced
- how the migration PostGIS -> HDF5 was done
- lessons learned

NUMBER CHRUNCHING WITH A RELATIONAL DATABASE??

- yep, seriosly
- after a few weeks on the new job I had already realized that the architecture was completely wrong
- everything was structured like a Django application without being a web application
- there was an insane mix of Django objects and arrays
- large numpy arrays were stored in the database as pickled objects

- there were absurd things like doing the aggregation on the database with locks
- there were hundreds of workers writing concurrently on the same table
- the database logic was *hopelessly* coupled with the scientific logic
- strangely enough, the architecture was totally wrong but the code base pretty good

Then rewrite everything?

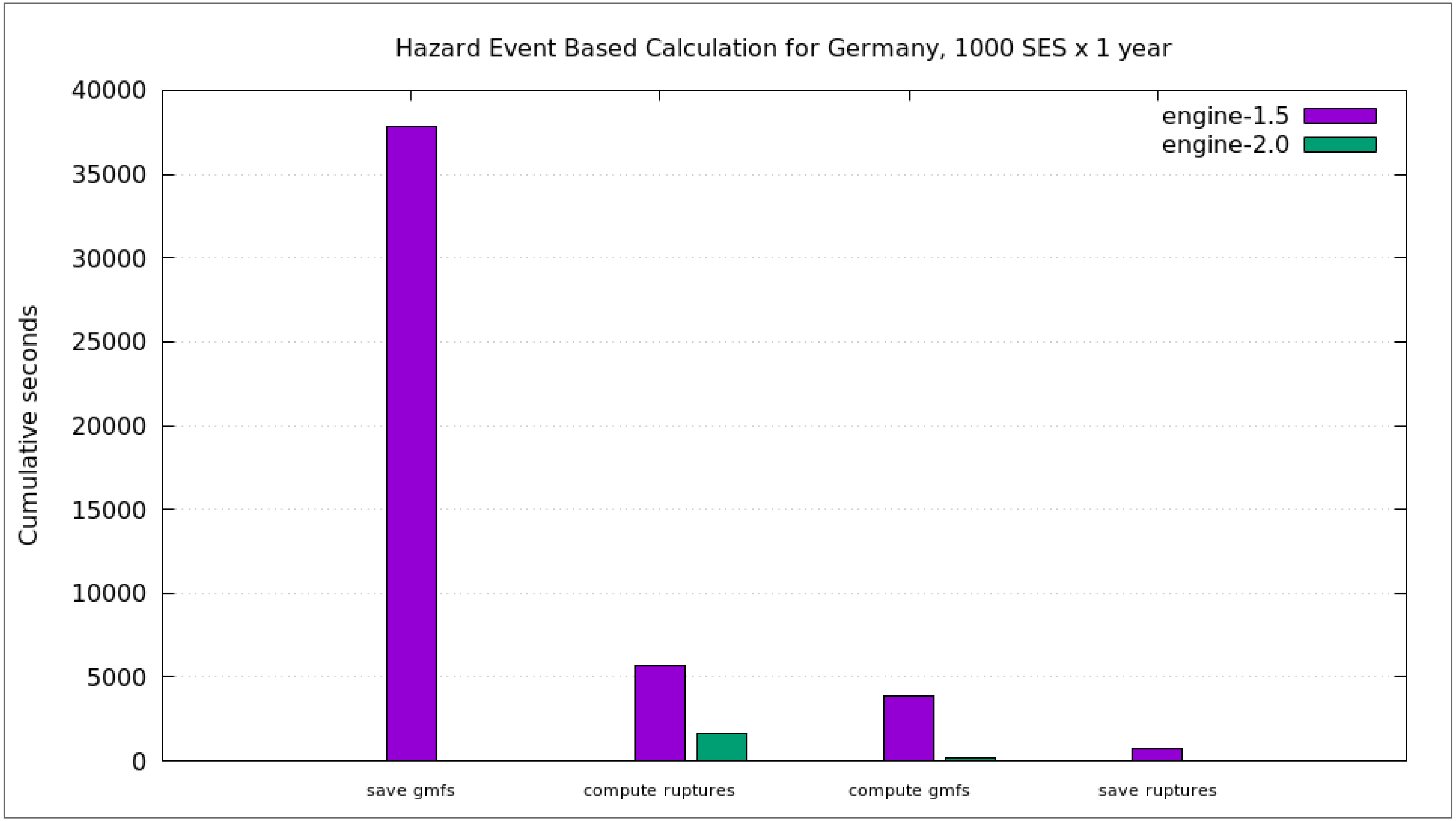
THE FIRST LAW OF SOFTWARE REWRITING

Rewriting a project takes *always* longer than writing it in the first place

(as we seasoned developers know)

I did not want to embark myself in such an adventure

but sometimes there is no choice :-(


Hazard Event Based Calculation for Germany, 1000 SES x 1 year
Cumulative seconds
40000
35000
30000
25000
20000
15000
10000
5000
0
engine-1.5
engine-2.0
save gmfs
compute ruptures
compute gmfs
save ruptures

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WHAT *FIVE* ORDERS OF MAGNITUDE MEAN

- 1 day -> less than 1 second
- 1 year -> 5 minutes

I *measured* a speedup exceeding 200,000x

(+ memory gain of 1-2 orders of magnitude)

BLOCKED BY POLITICAL ISSUES

- the architecture of the application had been just rewritten (more than an year of effort, it was ported from Redis to PostgreSQL)
- a younger collegue of mine had already written a criticizing mail went in the wrong hands
- the official release of version 1.0 had to be ready in six months
- there was a team friction between Zurich and Pavia
- there was an artificial division between hazard code and risk code making it impossible to fix the risk code

DOING NOTHING FOR 8 MONTHS

- sometimes doing nothing is the best choice
- study the codebase, maintain the old code
- let the frustration grow
- *(a good thing, if limited in time)*
- getting new case studies and adding new tests
- improve where you can (monitoring, XML parsing, concurrency, ...)

WAITING PAYS OFF

- the Zurich team evaporated
- we took change of both hazard and risk in Pavia
- we started removing old cruft (10,000+ lines of code)
- we decided on a conservative strategy: keep Postgres, rewrite the relational schema and the slow queries

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13 MORE MONTHS FIGHTING POSTGRESQL

- implemented a migration mechanism
- changed most of the tables
- changed the critical queries several times
- improvements by several orders of magnitude
- still, it was not enough, as realized in the summer of 2014
- but we kept the users and scientists happy

THE DECISION TO DROP POSTGRESQL

- started the oq-lite project with the *excuse* of the Windows porting, September 2014
- ported the simplest calculators to the new architecture
- removed gradually the geospatial queries
- kept in parallel both versions, with the same functional tests
- removed a lot of annoying unittests
- built expertise with HDF5

OTHER ARCHITECTURAL CHANGES

- all the concurrency is managed by a pure *map-reduce*
- made the concurrency layer independent from the low level parallelization technology
- changed from *everybody read/write on the database* to *only the controller node can read/write*
- all scientific data are now in the datastore (one .hdf5 file per calculation)
- all the metadata (i.e. start/stop time of the calculation, description, logs, performance information, output information) are in SQLite

- the workers do not write anything on the filesystem and they do not communicate at all with the master, except via the map-reduce (shared nothing)
- totally decoupled the database from the calculation logic
- added a DbServer in Python serializing the access to the database (needed for the WebUI)
- removed the ORM layer (thanks to Martin Blais dbapiext)

EVEN MORE CHANGES

- removed completely the need for XMLSchema, doing the validation entirely at the Python level
- implemented a generic serializer Python <-> XML instead of dozens of different serializers, one per class
- added CSV exports with the final goals of removing XML exports
- implemented a serialization protocol Python <-> hdf5 with methods `__toh5__` and `__fromh5__`
- supported both single user mode and multiple user mode
- ported the engine to Windows and Mac OS X
- modernized the code to Python 3

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ALL WENT SURPRISINGLY WELL!?

THINGS THAT I ALREADY KNEW, REINFORCED

- monitoring the running system for speed and memory allocation is *essential*
- if testing is difficult, the architecture is bad
- unittests are bad, functional tests are good
- if you want performance, replace Python objects and dictionaries with numpy.arrays
- no ORM please

MY TECHNICAL ADVICE

- follow a principle of simplicity/cleanness: 95 % of the speedups and memory saving came for free after *removing* code
- invest your time in solving the real problem, not in complicating your technological stack (so I did not spend time on numbas, GPUs, Intel compiler, etc etc)
- always challenge the underlying assumptions
- take the most difficult problem *that you can solve* and solve it first
- most of all, be patient

POLITICAL ADVICE

- don't be confrontational with your boss
- it is his job to be conservative
- take the slow way and make sure that at every little step you have a *measureable* improvement to show off
- performance is a good *excuse* for change
- you can raise your voice once or two in four years
- it takes time to build trust

THINGS I DISCOVERED ALONG

- using a database + ORM requires a *LOT* more memory than you think
- it is sometimes best to use all of the available memory
- sometimes it is better to run out of memory early
- the data transfer is really important
- a story about parsing XML: lxml -> ElementTree -> expat
- the migration to Python 3 had several surprises

LESSONS ABOUT TECHNOLOGIES

- concurrent.futures is just fine
- Travis is good
- wheels are great
- h5py is ultra-fast but can bite you

REGRETS

- nearly two years "lost" (from October 2012 to August 2014)
- I was too conservative and I should have cut more stuff/tests
- I should have investigated better what features were really important

(but removing 50,000+ lines of code feels really great!)

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THE END: SECOND LAW OF SOFTWARE REWRITING

Software rewriting takes *always* longer than you think

But sometimes it is worth it :-)

https://github.com/gem/oq-engine