Improvement of the Oracle Setup and Database Design at the Heidelberg Ion Therapy Center

K. Höppner, Th. Haberer, J. M. Mosthaf, A. Peters
HIT, Heidelberg Ion Therapy Center, University Hospital, Heidelberg, Germany
M. Thomas, A. Welde
Eckelmann AG, Wiesbaden, Germany
G. Fröhlich, S. Jülicher, V. R. W. Schaa, W. Schiebel, S. Steinmetz
GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

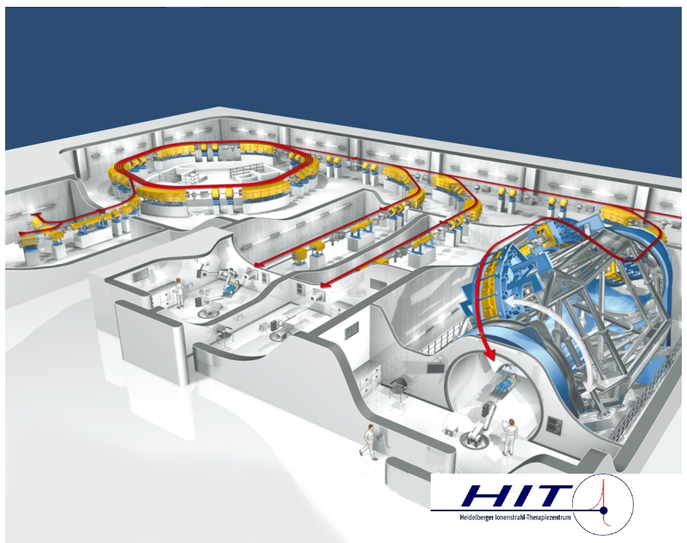
Abstract

The HIT (Heidelberg Ion Therapy) center is an accelerator facility for cancer therapy using both carbon ions and protons, located at the university hospital in Heidelberg. It provides three therapy treatment rooms: two with fixed beam exit (both in clinical use), and a unique gantry with a rotating beam head, currently under commissioning. The backbone of the proprietary accelerator control system consists of an Oracle database running on a Windows server, storing and delivering data of beam cycles, error logging, measured values, and the device parameters and beam settings for about 100,000 combinations of energy, beam size and particle rate used in treatment plans. Since going operational, we found some performance problems with the current database setup. Thus, we started an analysis in cooperation with the industrial supplier of the control system (Eckelmann AG) and the GSI Helmholtzzentrum für Schwerionenforschung. It focused on the following topics: hardware resources of the DB server, configuration of the Oracle instance, and a review of the database design that underwent several changes since its original design. The analysis revealed issues on all fields. The outdated server will be replaced by a state-of-the-art machine soon. We will present improvements of the Oracle configuration, the optimization of SQL statements, and the performance tuning of database design by adding new indexes which proved directly visible in accelerator operation, while data integrity was improved by additional foreign key constraints.

The HIT Medical Accelerator

First dedicated accelerator facility for cancer therapy with carbon ions and protons:

- Two sources
- Two treatment rooms with fixed beam exit (operational since 2009)
- Rotatable heavy ion gantry (under commissioning)
- Experimental area



Particle energy, beam size and intensity may be chosen from a catalogue of so-called MEFI values:

- 2×10^6–5×10^8 carbon ions per second, energy range 88–430 MeV/u
- 8×10^7–2×10^{10} protons per second, energy range 48–220 MeV/u

Database

Oracle database:

- Storing beam cycle data, measured values
- List of devices, definitions of beamlines
- Device settings per MEFI (as blobs)
- Alarms, log messages

Previous Oracle Setup

- Oracle 9i on Windows 2003 server (dual core Intel Xeon, 2 GB RAM), backup by daily tablespace export.
- ☛ Performance problems in accelerator operation, both during therapy (check integrity of device blob against database on any beam request) and accelerator adjustment (generating, downloading, flashing device blobs).
- ☛ Workgroup established
  - HIT accelerator controls group,
  - Eckelmann AG (supplier of accelerator control system),
  - GSI database experts,

  aiming on issues of hardware, Oracle setup, and structural database design.

Hardware

Upgrade to a blade center, cf. poster of J. M. Mosthaf, MOMMU009.

Changes in Oracle Setup

Upgrade to Oracle 11g, running on a dedicated blade with Windows 2008 Server (64bit), using

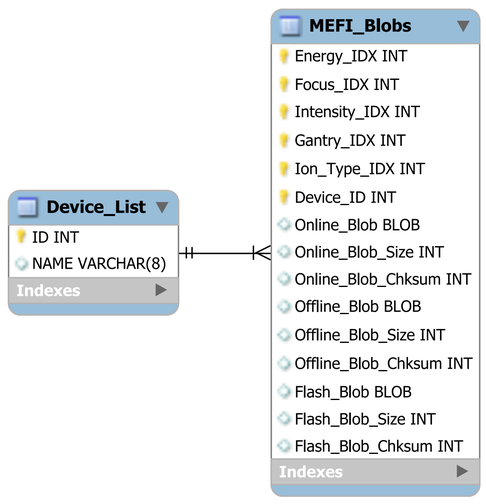
- Oracle's Automatic Storage Manager (ASM), file system optimized for Oracle DB,
- RMAN as backup manager.

Database Design

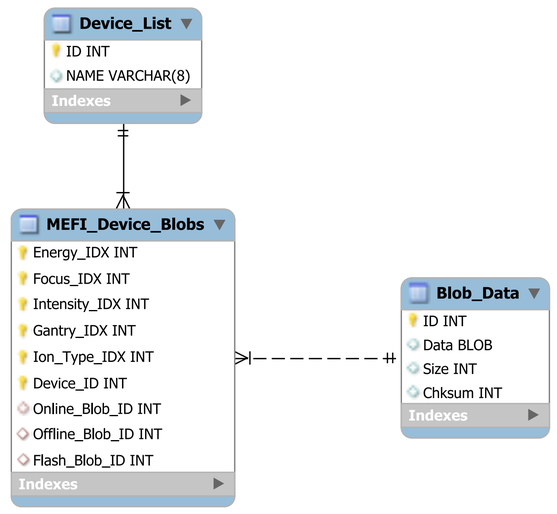
Recommendations were:

- reduce commit rate (20 commits per second!)
- separate tablespaces for rather static configuration and volatile measured data
- avoid to mix columns with static and volatile data in tables,
- define proper relations between tables by adding foreign key constraints where missing,
- add indexes to optimize database queries,
- redesign "wide" tables to achieve a better in-memory-caching of data records within the Oracle database instance.

Example: Table with device blobs per MEFI keeps 3 blobs per DB record: flash blob for therapy, online (RAM) blob for accelerator adjustment, offline blob for saved settings.



The amount of data that have to be loaded and cached by Oracle can be reduced by replacing the three blob columns by reference to another table.



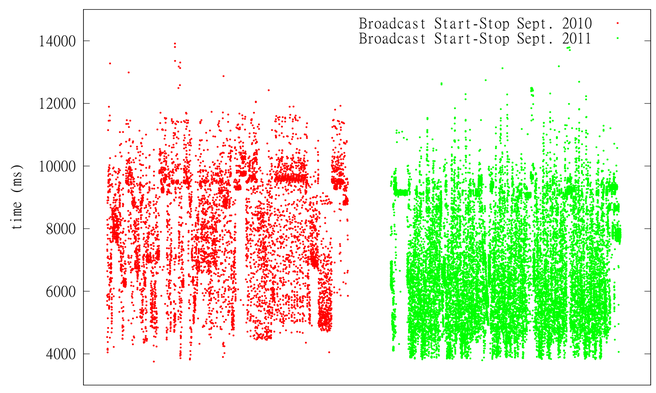
Current Status

- ✔ Hardware upgrade,
- ✔ Oracle upgrade and configuration,
- ✔ tablespace separation,
- ✍ index reorganisation, foreign key constrains in progress (≈ 75 % completed),
- ☞ table redesign, planned for end of 2011.

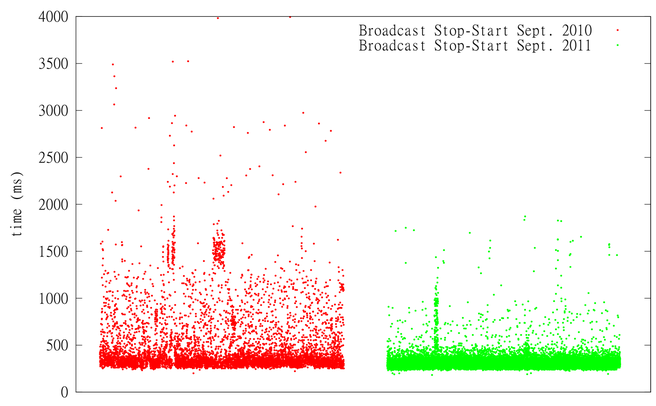
First Results

Comparison of beam cycle lengths (with up to 5 seconds radiation of tumor) and dead time between cycles (needed for preparation of the upcoming cycle), respectively, for one week in September 2010 (red) and September 2011 (green).

Pulse length:



Dead time between beam pulses:



Better performance immediately visible during accelerator adjustment: generating device blobs (interpolation over full MEFI range) for beam to gantry takes 1.5 hours instead of 4 hours before!

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