Capturing bugs in extreme stress testing:
Improving software quality in SAP HANA with Undo

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SAP

Undo

The challenge:
Stress Testing for SAP HANA

Problem Setup

- **SAP HANA as an enterprise-class, in-memory database management system**
  - OLTP and OLAP, relational and noSQL functionality in a single system
  - Complex codebase
- **Very strict quality and governance processes**
  - Sophisticated continuous integration platform
  - Large functional and performance test harness (see Rehmann@RDSS 2014)
- **„Regular“ tests plus highly parallel, multi-user stress tests (PMUT)**
  - Arbitrary database operations (DML, DDL, etc) in parallel
  - High amount of stress for system resources
  - Complements other tests with explorative/non-deterministic testing
  - Similar approaches with other systems („chaos monkey“)

Problem Statement

- Good: PMUT captures sporadic problems not detected by other tests
  - Improves software quality by finding bugs early
- Bad: Non-deterministic nature makes reasoning very hard
  - PMUT workload is highly parallel and (pseudo-) randomized
- Ugly: Developers spend days/weeks to resolve underlying root cause
  - Challenge: Problem reproduction is extremely time consuming
  - Fixing often is trivial afterwards

- **Goal: Avoid overhead for scenario/problem reproduction**

The solution:
Live Recorder from Undo

CCTV for program execution

Record program's execution

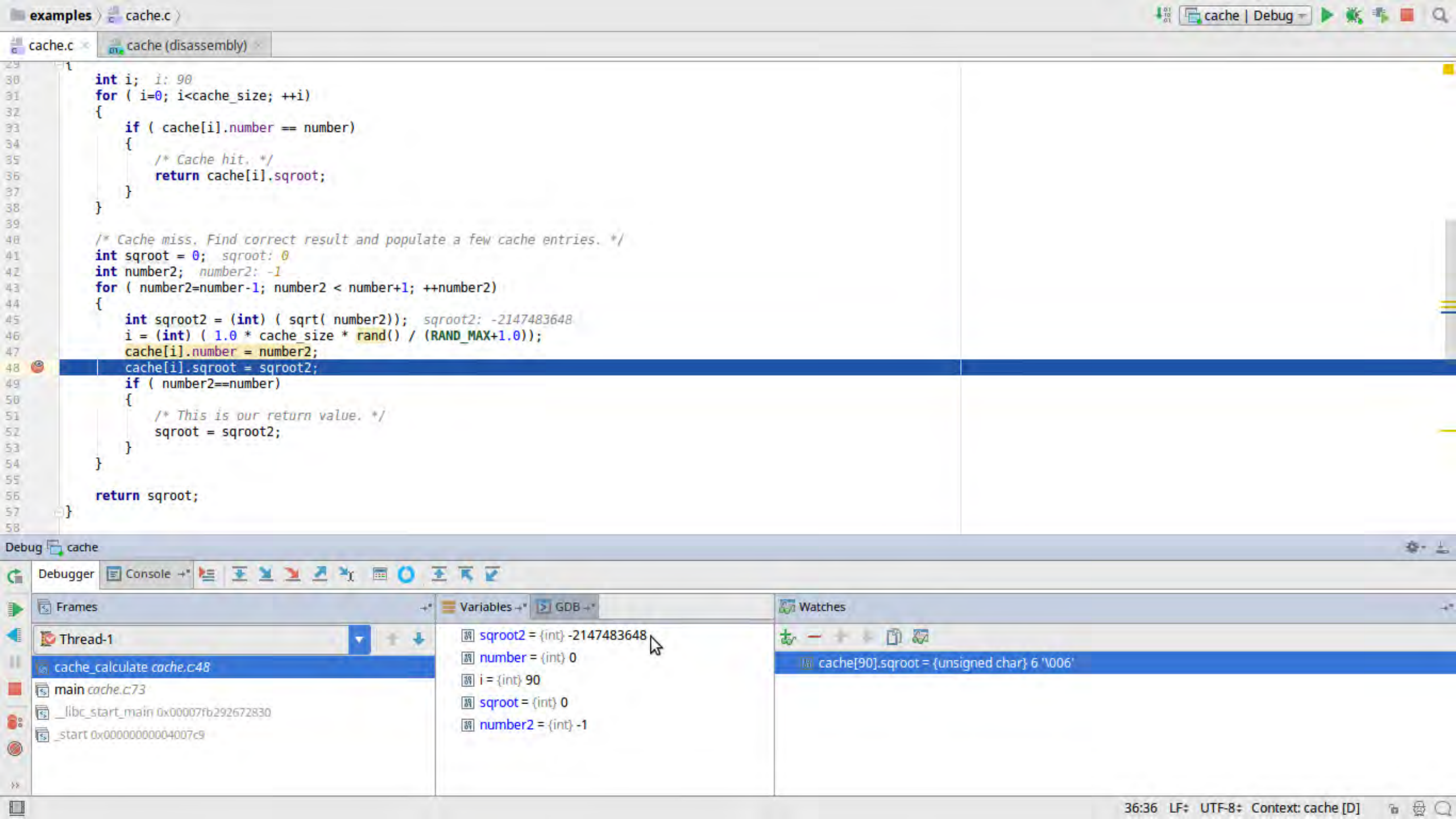
Replay at any time

Freeze-frame

Single-step backwards

Single-step forwards

Find out why the program made the decisions it did


examples
cache.c
cache | Debug
cache.c
cache (disassembly)
int i; i: 90
for (i=0; i<cache_size; ++i)
{
if (cache[i].number == number)
{
/* Cache hit. */
return cache[i].sqroot;
}
}
/* Cache miss. Find correct result and populate a few cache entries. */
int sqroot = 0; sqroot: 0
int number2; number2: -1
for (number2=number-1; number2 < number+1; ++number2)
{
int sqroot2 = (int) (sqrt(number2)); sqroot2: -2147483648
i = (int) (1.0 * cache_size * rand() / (RAND_MAX+1.0));
cache[i].number = number2;
cache[i].sqroot = sqroot2;
if (number2==number)
{
/* This is our return value. */
sqroot = sqroot2;
}
}
return sqroot;
}
Debug cache
Debugger
Console
Frames
Thread-1
cache_calculate cache.c:48
main cache.c:73
__libc_start_main 0x00007fb292672830
_start 0x00000000004007c9
Variables
GDB
sqroot2 = {int} -2147483648
number = {int} 0
i = {int} 90
sqroot = {int} 0
number2 = {int} -1
Watches
cache[90].sqroot = {unsigned char} 6 '\006'
36:36
LF
UTF-8
Context: cache [D]

The solution

- SAP uses Live Recorder from Undo to record multi-user stress test (PMUT) runs
- When a failure occurs the recording is kept and handed over to developers to diagnose
- Turns the sporadic problem into a 100% reproducible
- SAP developers use Undo's interactive reversible debugger – UndoDB – on the recording to diagnose the root cause of the problem

Some in-production defects captured in test using Live Recorder and diagnosed using UndoDB

- A number of sporadic memory leaks and memory corruption defects
- Several issues in the networking code, including the incorrect flushing of a receive buffer and sporadically releasing channels in cases of timeout, resulted in queries incorrectly aborting
- Incorrect parallel access to a shared data-structure which resulted in very subtle sporadic problems which were hard to reproduce
- A race condition in SAP HANA's transaction management cache with the potential of incorrectly reusing cached session data
- Very sporadic race condition in SAP HANA's asynchronous garbage collection for in memory table structures during table unloads under heavy system load

Wider perspective

- This isn’t just about test
- This isn’t just about SAP HANA
- Existing approaches are not good enough
- Recording program execution is a new approach
- Getting a recording of your test run enables new ways of investigating how your code is behaving

Thank you.

See us at booth 6 during the coffee break or after the workshops

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