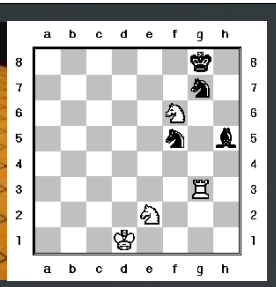
Towards Real-Time, Many Task Applications on Large Distributed Systems

- focusing on the implementation of RT-BOINC

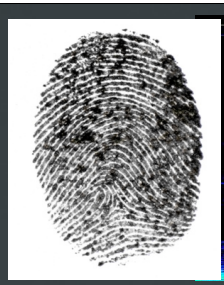
Sangho Yi (sangho.yi@inria.fr)

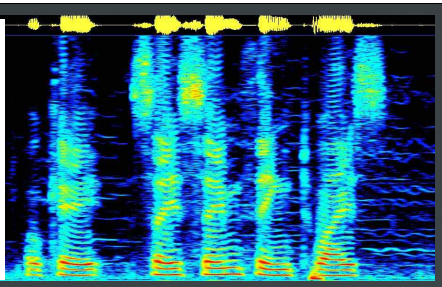
Content

- Motivation and Background
- **RT-BOINC** in a nutshell
  - Internal structures
  - Design & implementation
- Conclusions and future work



Motivation





- Demands for computing large-scale real-time(RT) tasks increased in distributed computing environment
  - Chess, Game of Go
  - Real-time Forensic Analysis
  - Ultra HD-level Real-time Multimedia Processing
  - …
- Lack of support for RT in existing Desktop Grids, and Volunteer Computing environment

About BOINC

- BOINC is tailored for maximizing task throughput, not minimizing latency on the order of seconds.
  - XtreemWeb and Condor have similar characteristics.
- A BOINC project has
  - A BOINC server (web, storage, database, ...)
  - Multiple BOINC clients
  - Network connection between server - clients

BOINC Projects

- Normally perform a few transactions in 1 sec with host clients.
  - **1~50 transactions in 1 sec** (ref. http://boincstats.com)
- Send large chunk of computation to the host clients.
  - a couple of **hours**, or even **days** of computation
- Does not have RT guarantee
  - Because it is tailored for maximizing total amount of computation.

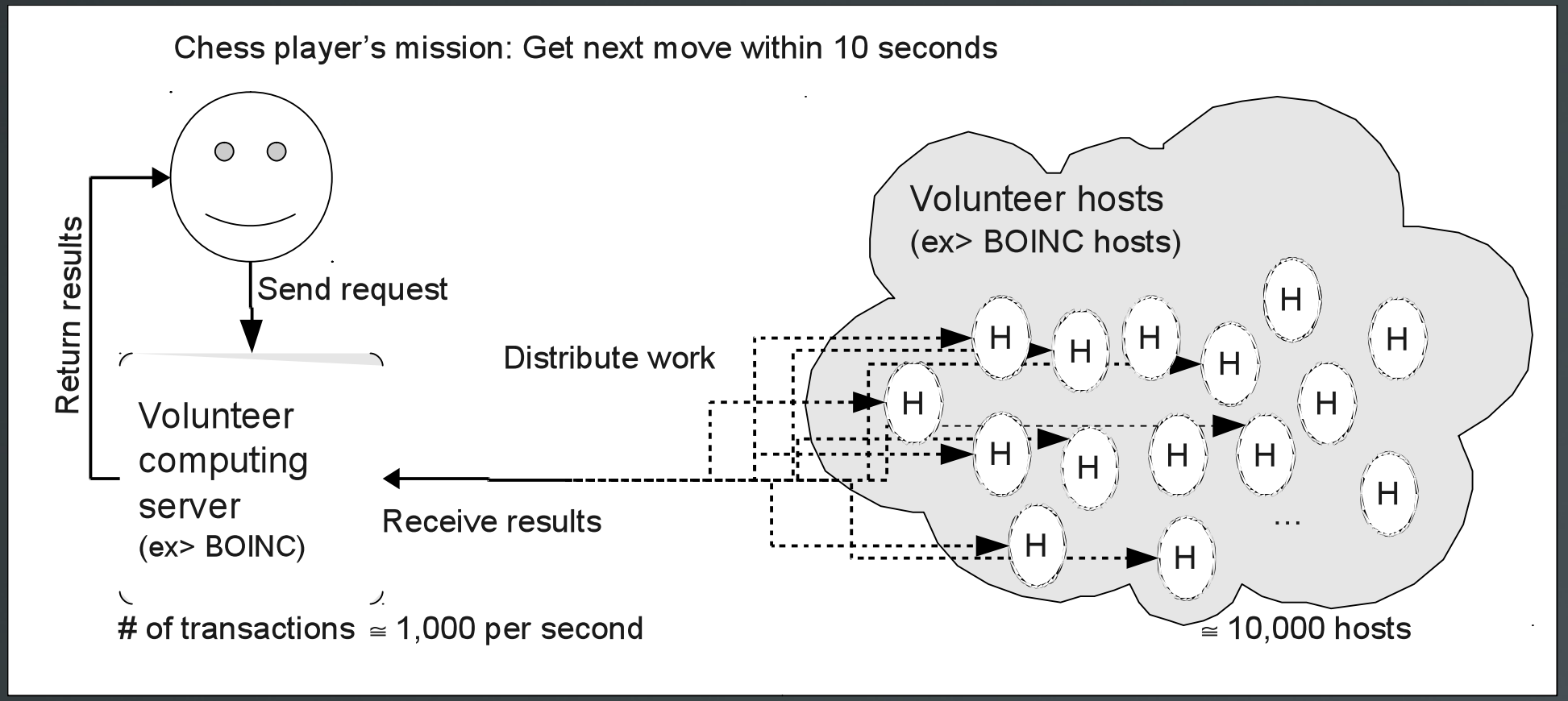
Significant Gaps here...

- ”I need a 10-second-car.” - in the movie ”Fast & Furious”

Vin diesel –
the main actor in the movie

Significant Gaps here...

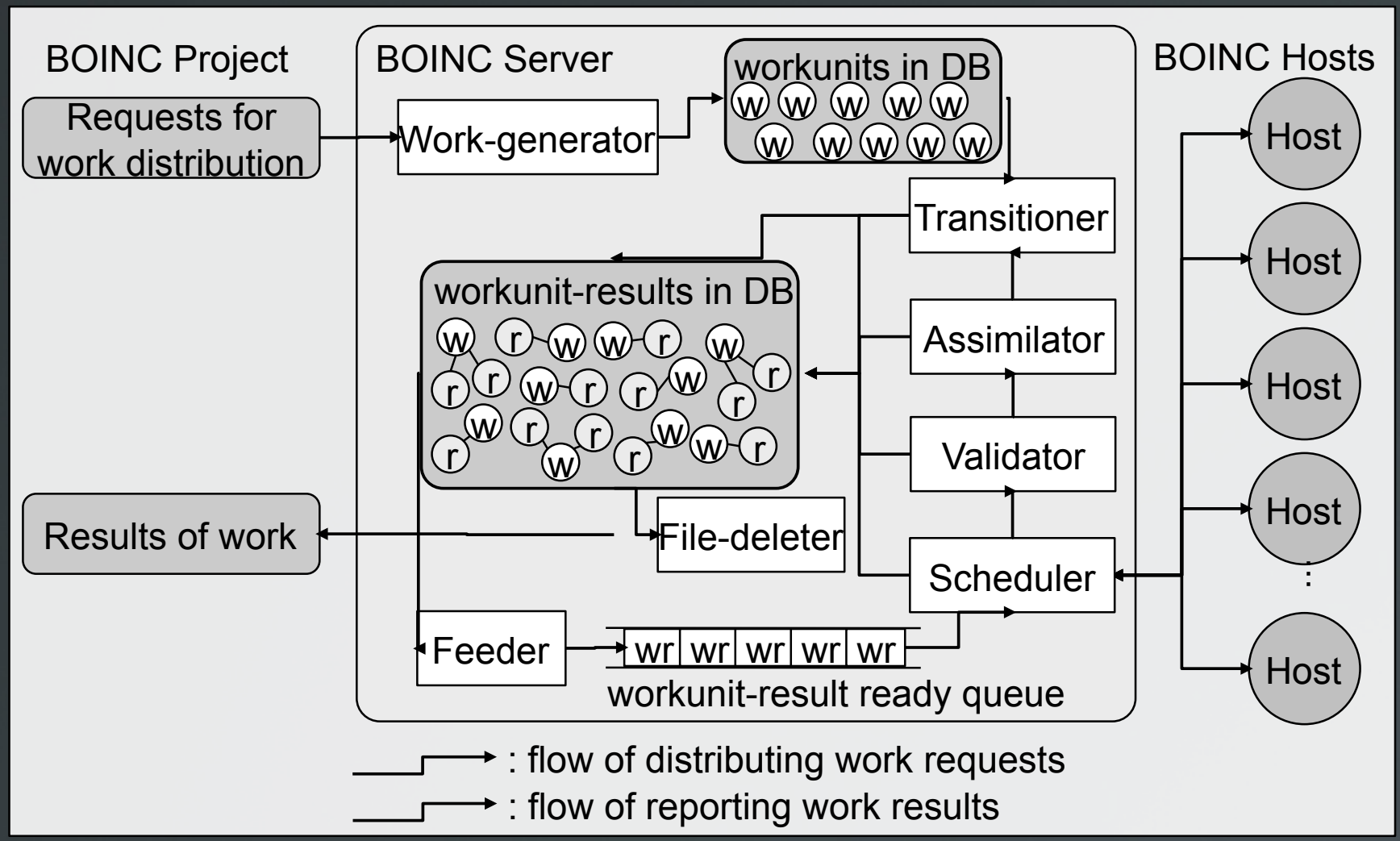
- ”We need a 10-second-completion.” - in a ”Chess game”



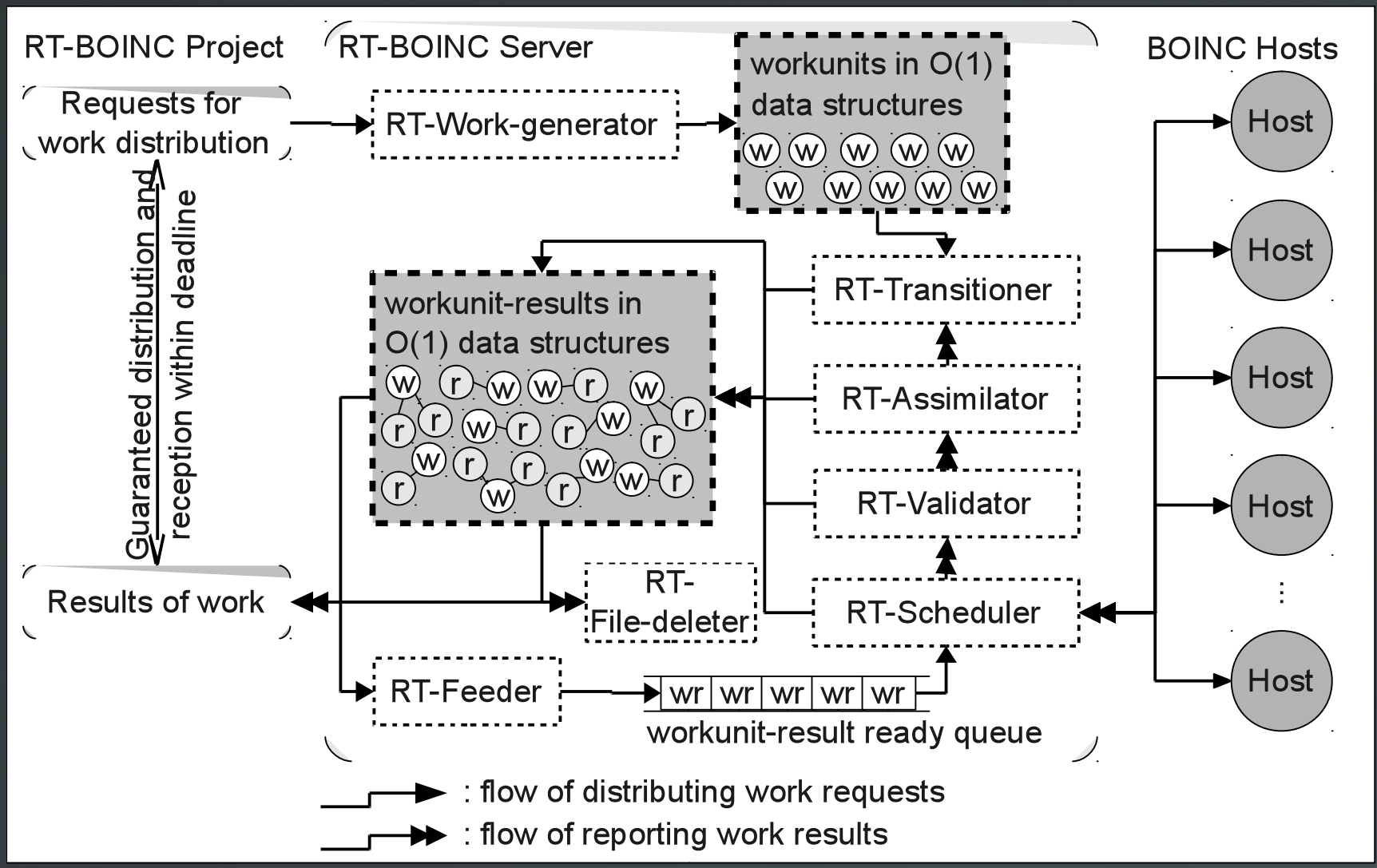
RT-BOINC in a Nutshell

- RT-BOINC features
  - Providing low WCET (worst-case execution time) for all components
  - No database operations at run-time
  - O(1) interfaces for data structures
  - Reduced complexity for server daemons
    - Almost O(1)

Original BOINC Internal

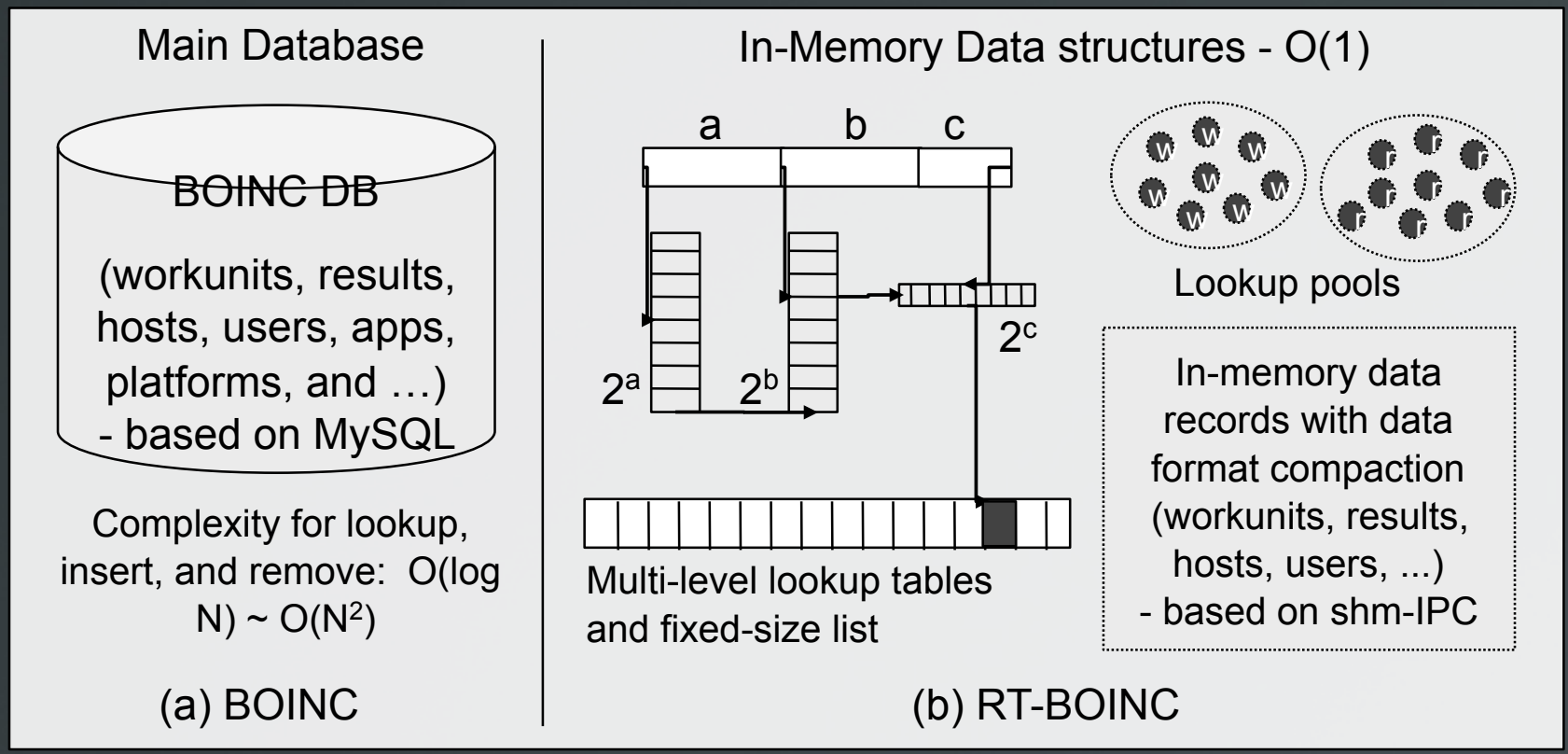


RT-BOINC Internal



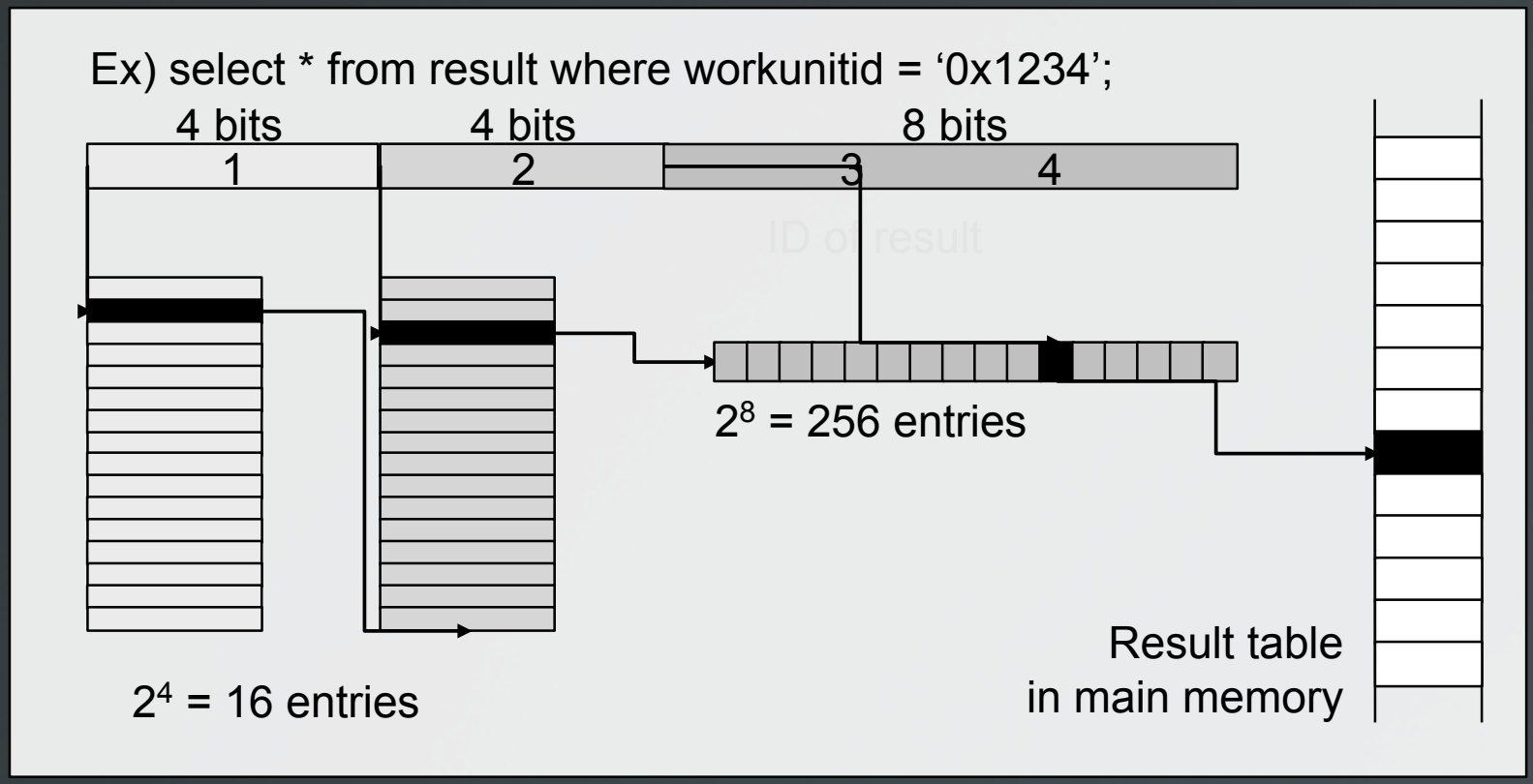
Data management

- MySQL Database vs. In-memory data structures



Example 1) select from where;

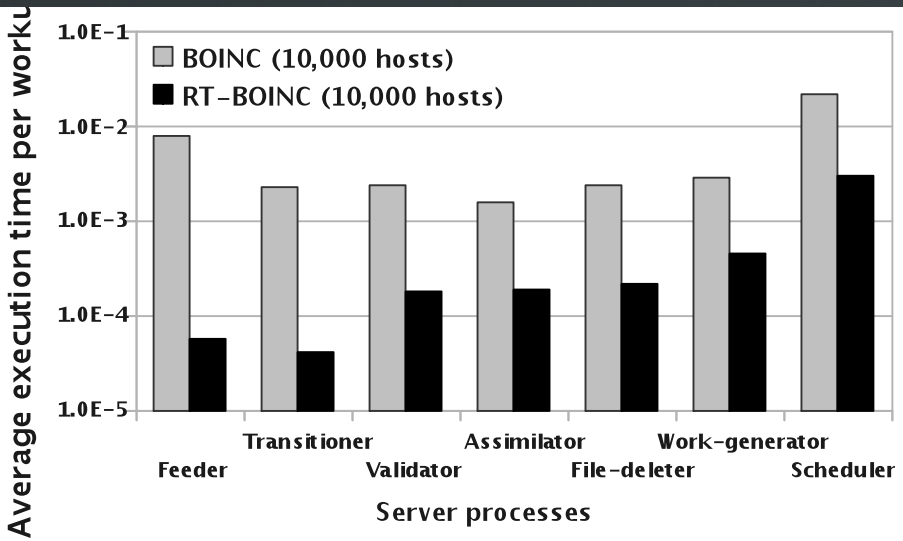
- Retrieving RESULT from the O(1) data structure

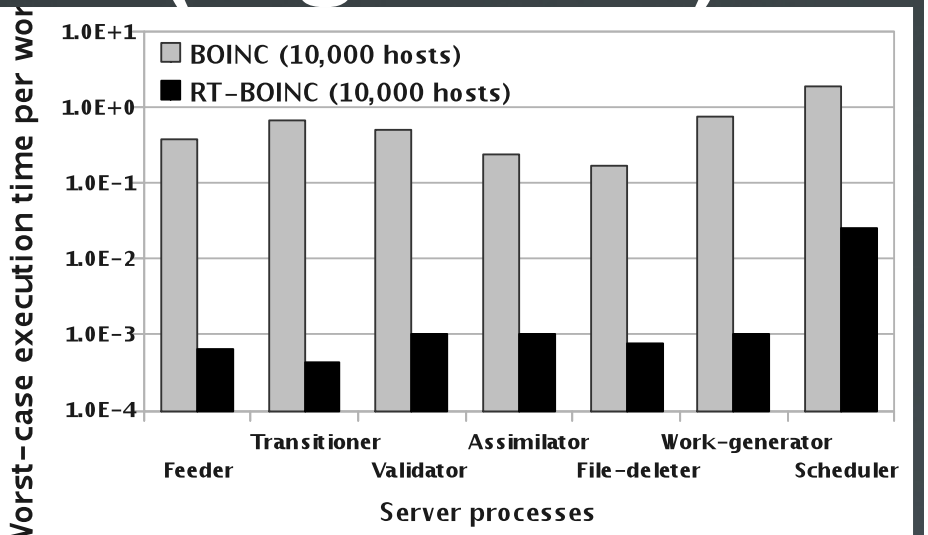


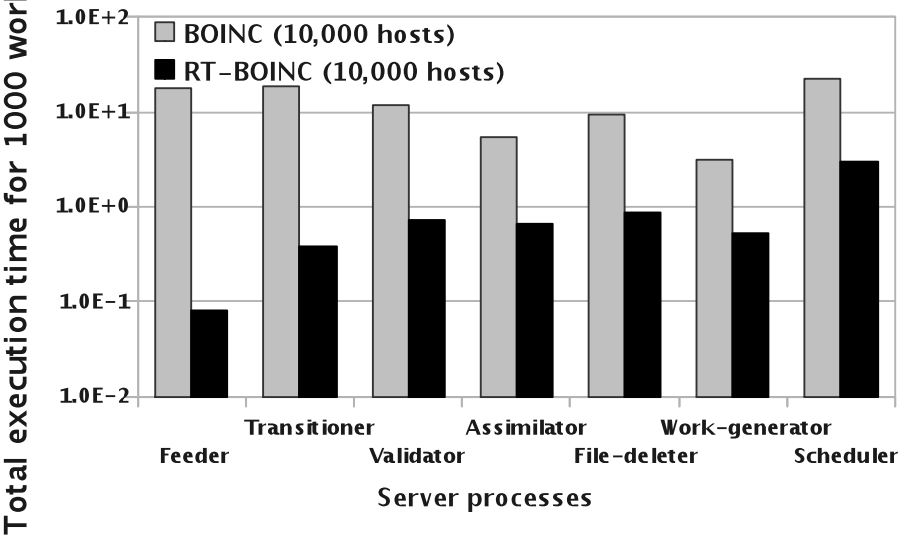
Performance Evaluation

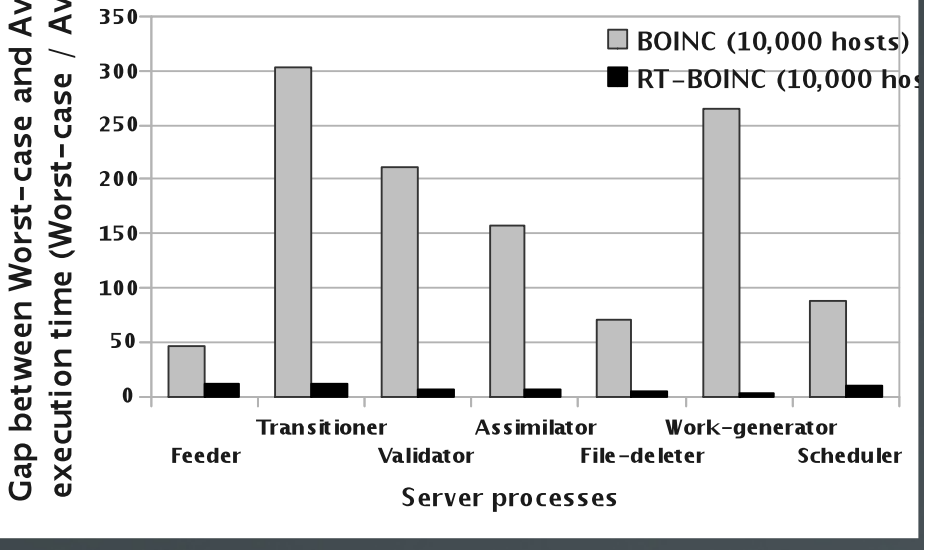
- 1) Micro and Macro Benchmarks
  - Based on dummy server load
- 2) Case Studies
  - Game of Go AI, (and Chess AI – soon)

Macro-benchmarks (high load)









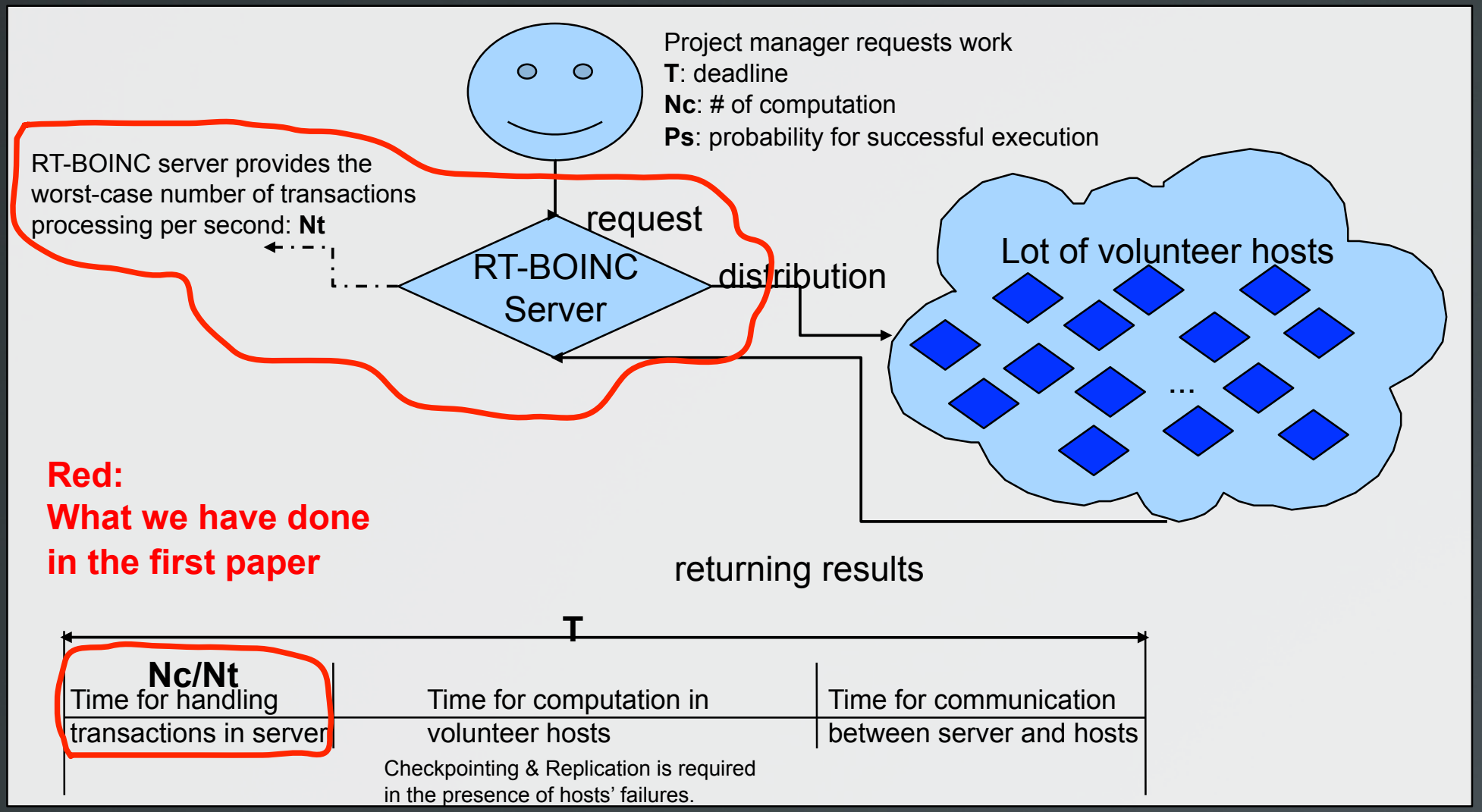
Performance Evaluation - #2

- Case Studies
  - Game of Go - 9x9 board (currently working)
    - FueGo - a monte-carlo-based AI
    - GTP protocol (go text protocol)
    - KGS Go Server - can play with AI and human
  - Chess (developing with Emmanuel Jeannot)
    - Distributed depth-first-search-based AI
    - UCI protocol (universal chess interface)

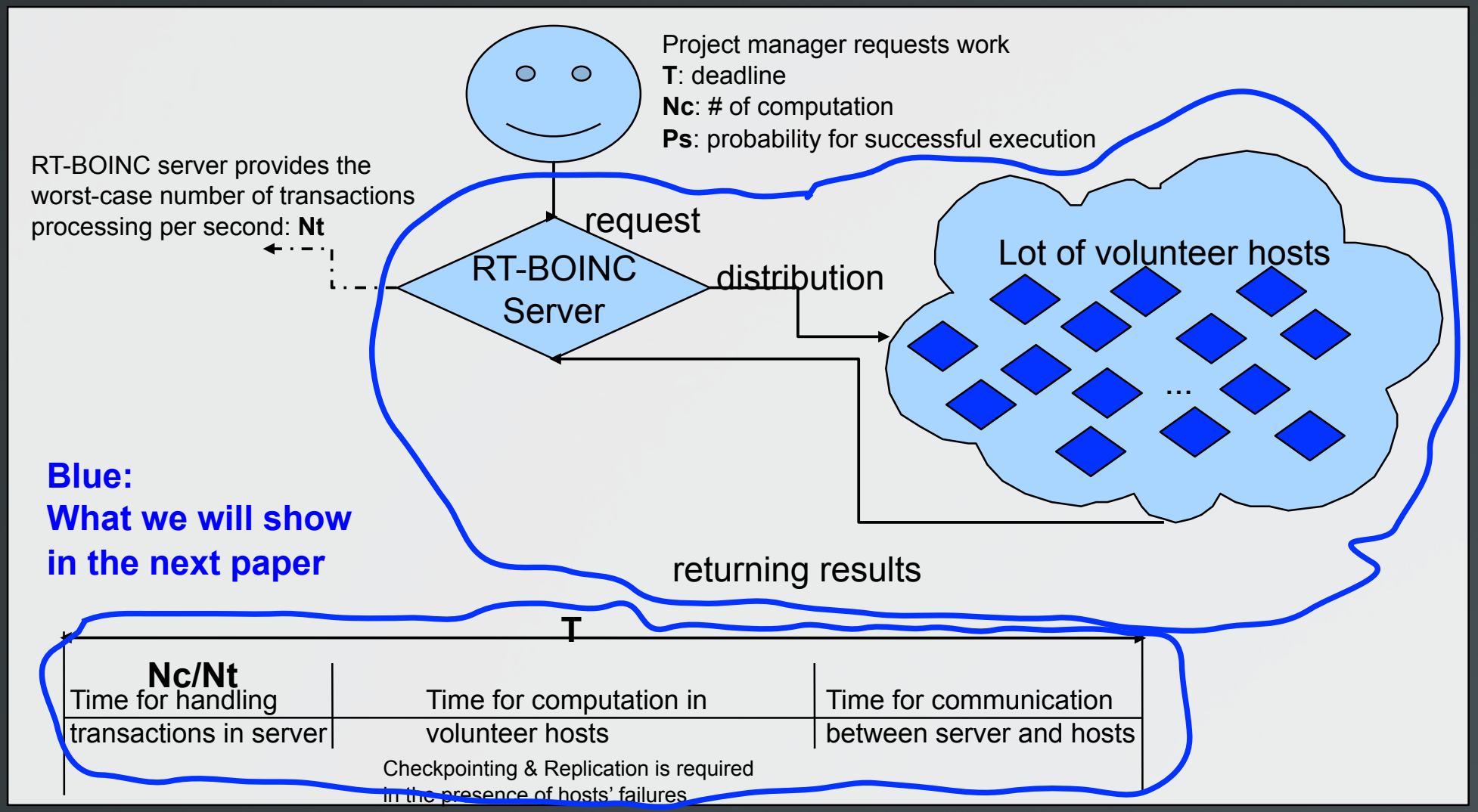
Summary

- RT-BOINC provides...
  - Faster response time and real-time performance than BOINC.
  - 300~1,000 times lower WCET(worst-case execution time) for each server-side operation.
  - less difference between the average and the worst-case performance.
  - less difference between low and high load conditions.

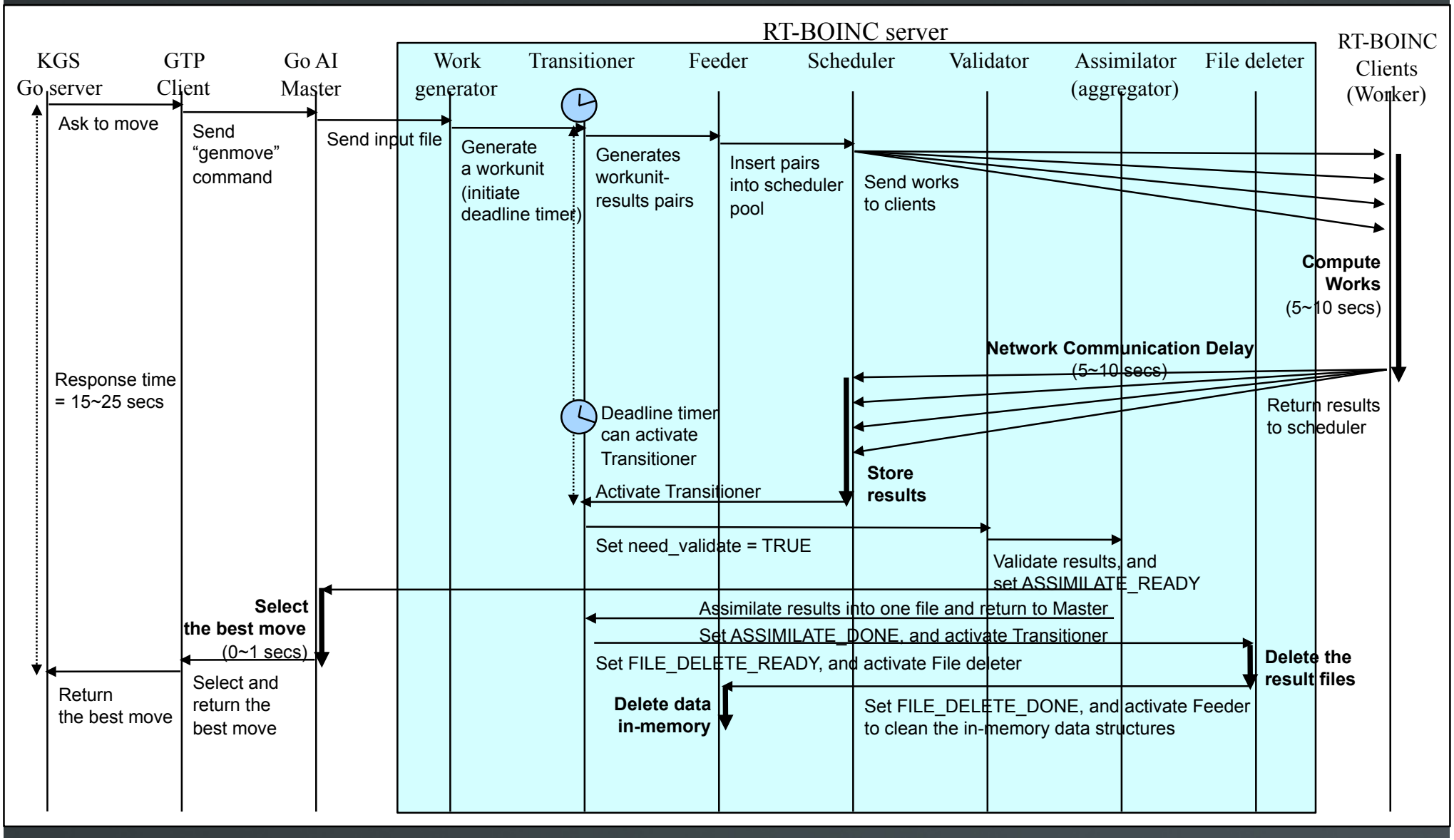
Future work (The rest part)



Future work (The rest part)



Go AI on RT-BOINC



Experimental Setup (1)

- We used a little bit fast machine, but used only 2 cores for this experiements.
  - We'll extend the scale of experiments when we have greater # of volunteers.

Component	Description	Notes
Processor	2.00 Ghz (Dual-Quad)	Intel Xeon E5504
Main Memory	32GB	(1,000 Mhz)
Secondary Storage	HDD	- sorry for lack of info :')
Operating System	Ubuntu 9.10 (karmic)	Linux Kernel 2.6.31-19

Experimental Setup (2)

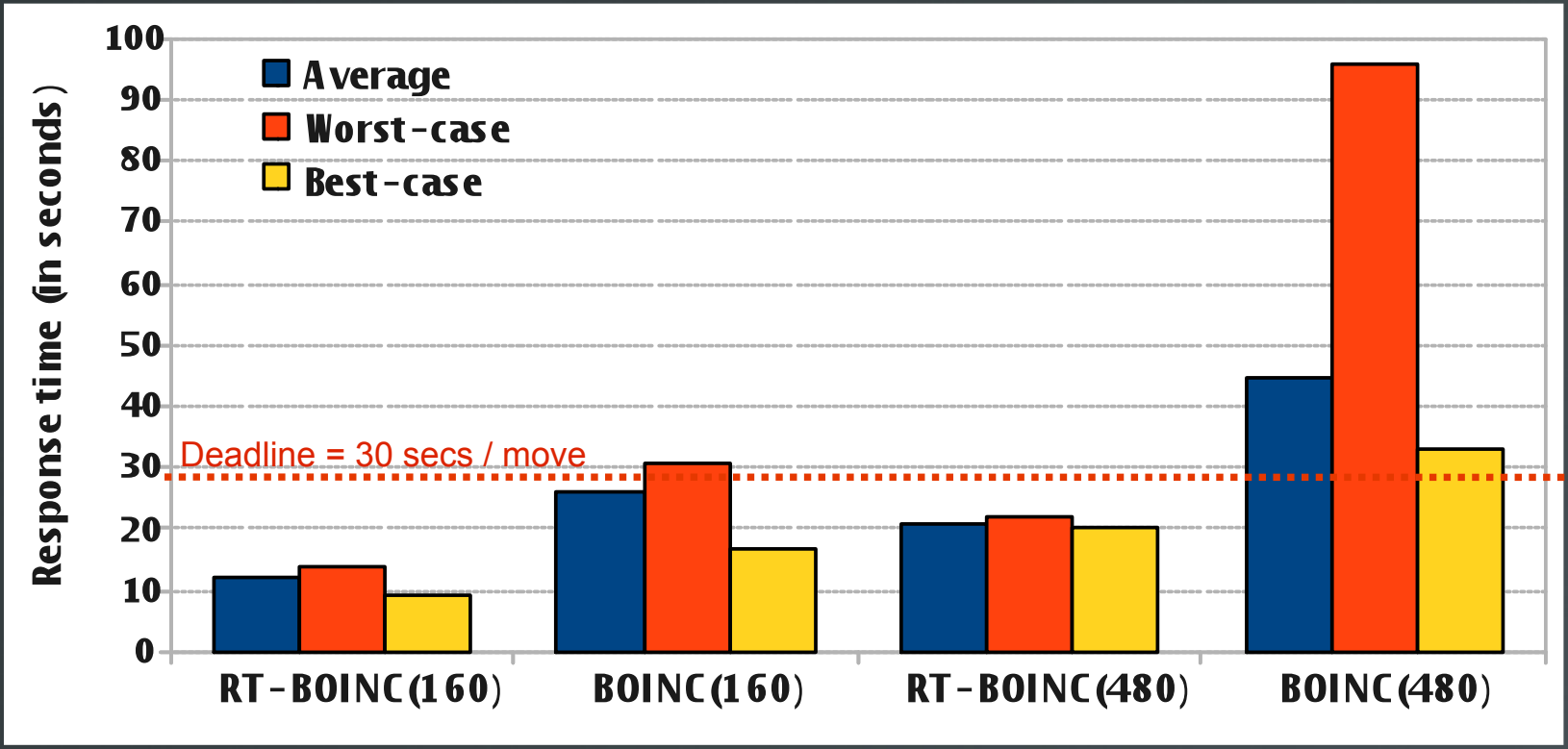
- RT-BOINC
  - Up to 50k active wu, result, host, users
  - 3.9GBs of memory usage on a 64bit machine
    - 1.9GBs of memory usage for O(1) data structures (49.5 % of total)
- BOINC
  - Recent server-stable version (Jun. 2010)

Minor Things for Experiments

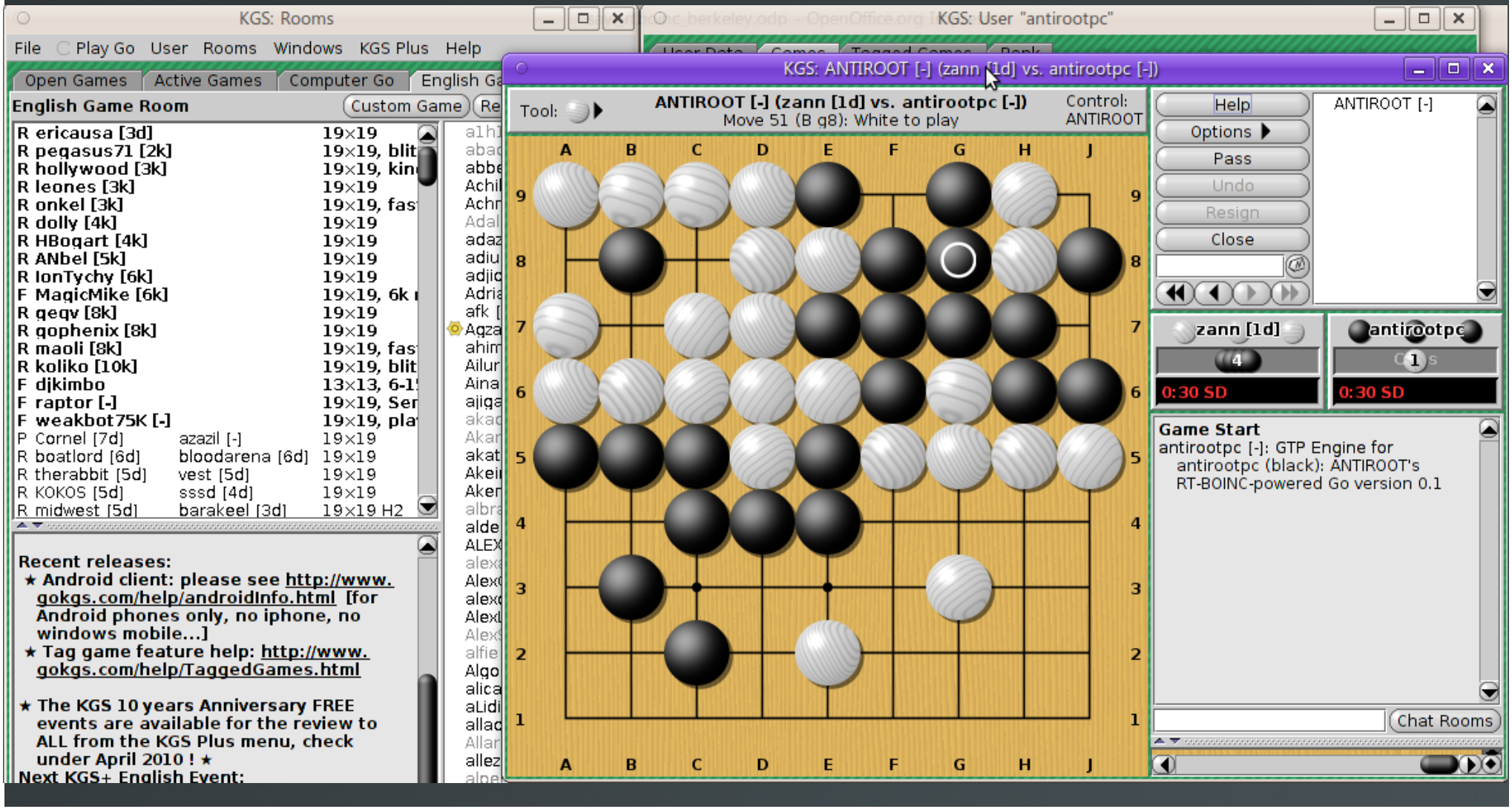
- Apache & MySQL
  - Max # of connections (default is 100~256)
- Need 2 identical (physical) servers
  - For BOINC vs. RT-BOINC testing

Preliminary Results (Go AI)

- Only preliminary results are available now.
  - Two cases: 160, and 480 cores (of volunteers)

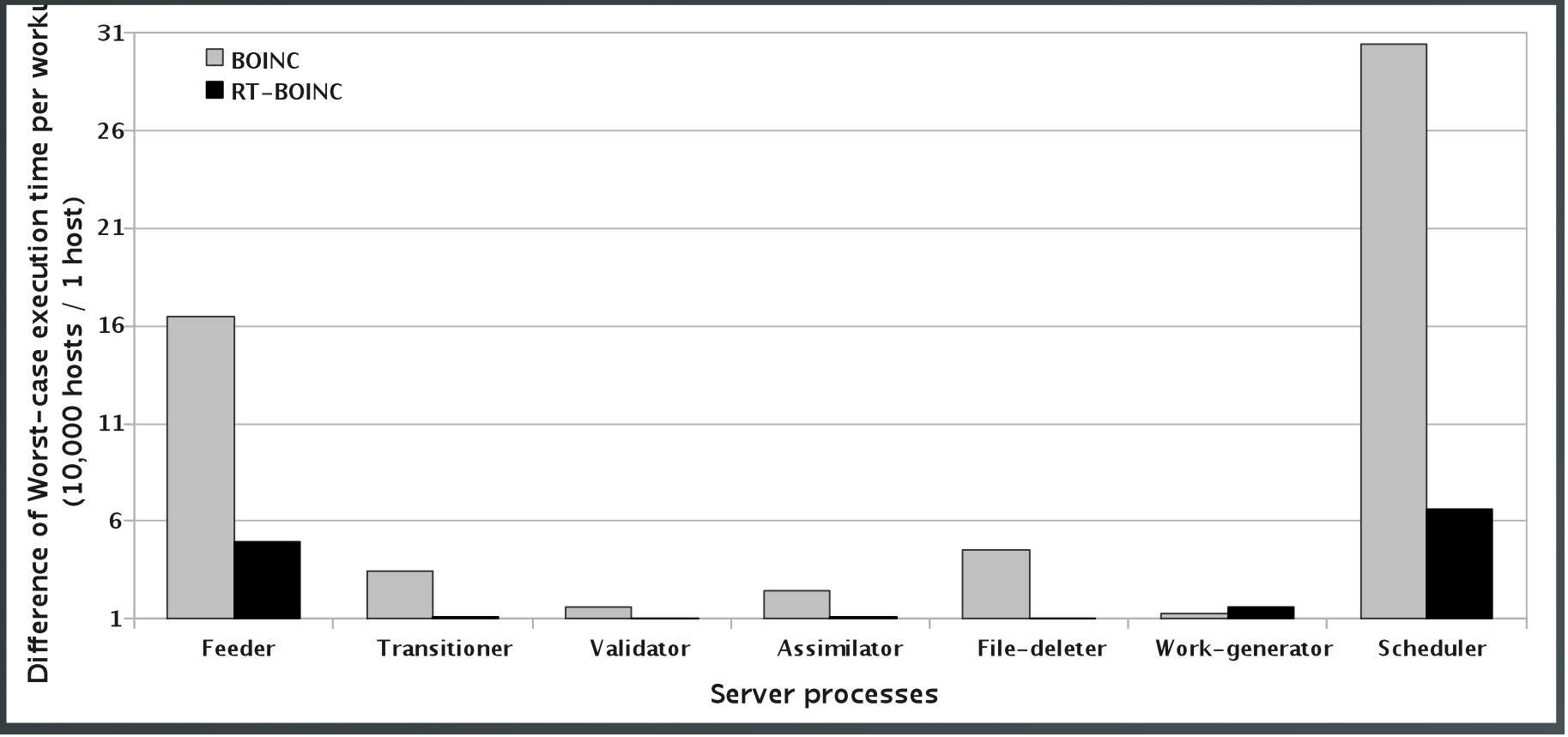


Screen Shot on KGS



Macro-benchmarks

- Difference of worst-case performance between low and high load condition



Performance Evaluation - #1

- Purpose: to measure real-time performance of **BOINC** and **RT-BOINC**
- Criteria: the worst-case and the average execution time
- Method: micro and macro benchmarks
  - Micro-benchmark: for each primary operation related to server process
  - Macro-benchmark: for each server process (including feeder, scheduler, transitioner, work-generator, assimilator, validator, and file-deleter)

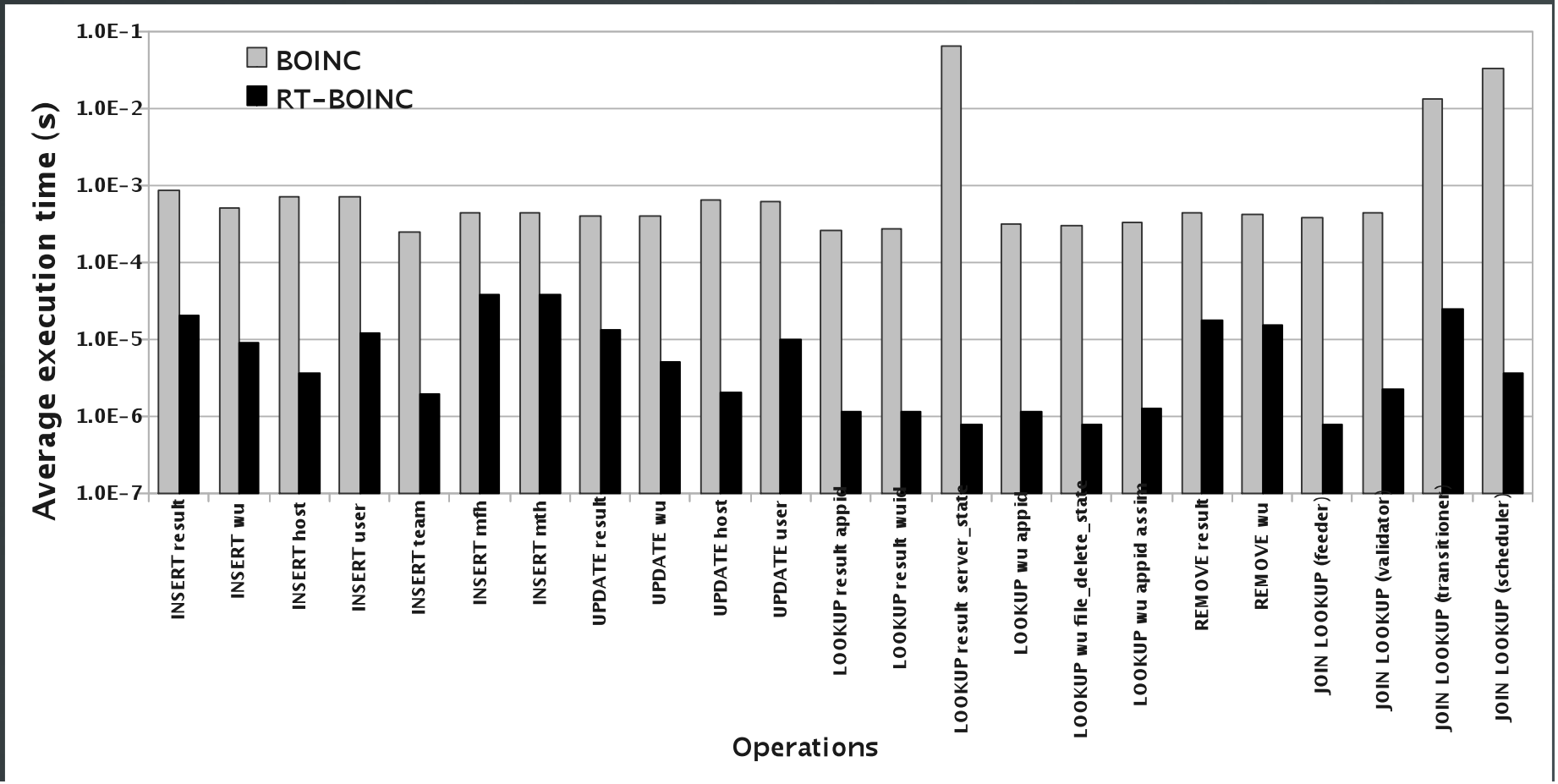
Experimental Environment

- We used a little bit slow, common-off-the-shelf system. ;-)
  - For ease of reproduction of the results

Component	Description	Notes
Processor	1.60GHz, 3MB L2 cache	Intel Core 2 Duo
Main Memory	3GB (800 Mhz)	Dual-channel DDR3
Secondary Storage	Solid State Drive	SLC Type
Operating System	Ubuntu 9.10 (karmic)	Linux Kernel 2.6.31-19
BOINC version	Server stable version	Nov. 11, 2009 (from SVN)

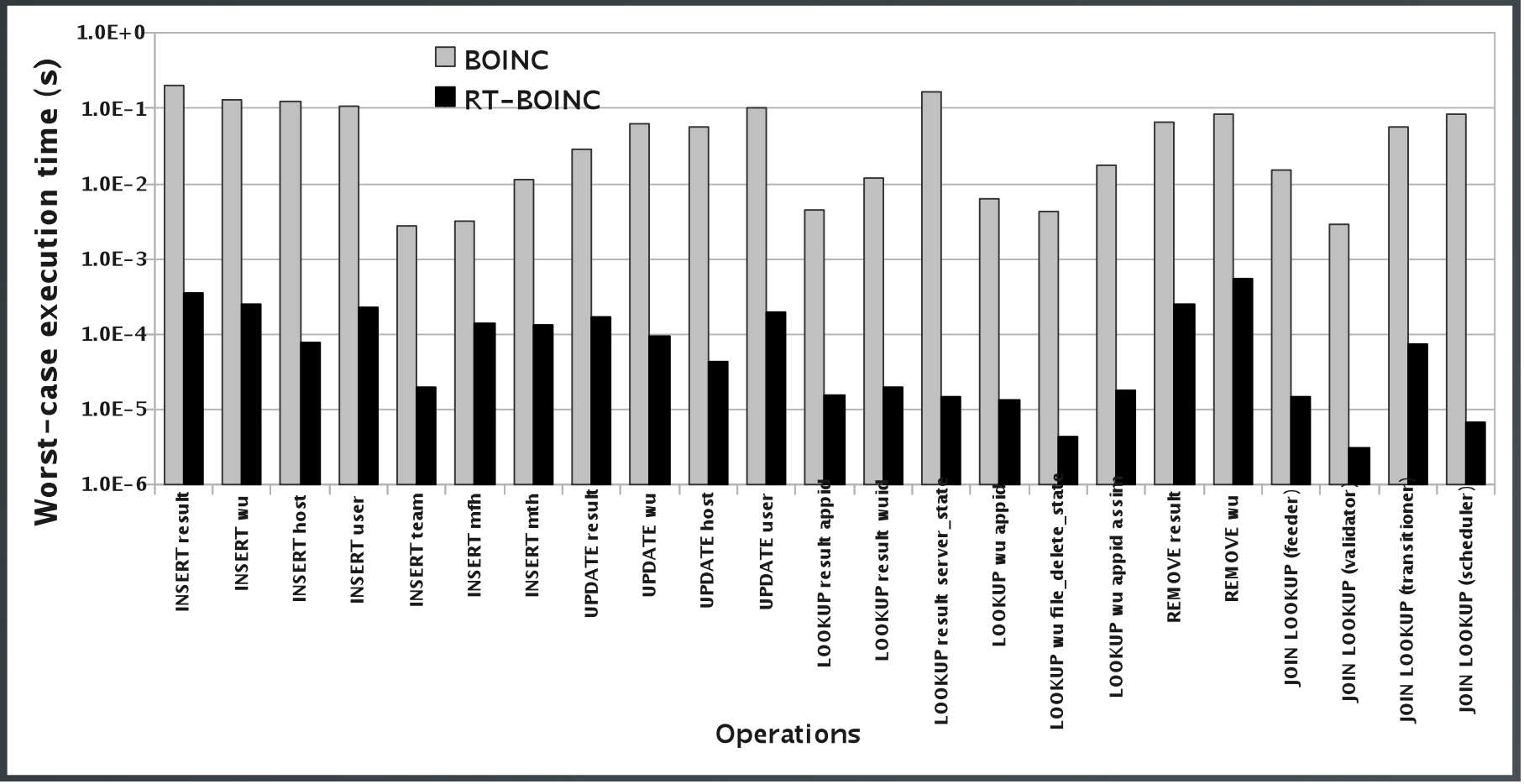
Micro-benchmarks

- Average execution time (in seconds)



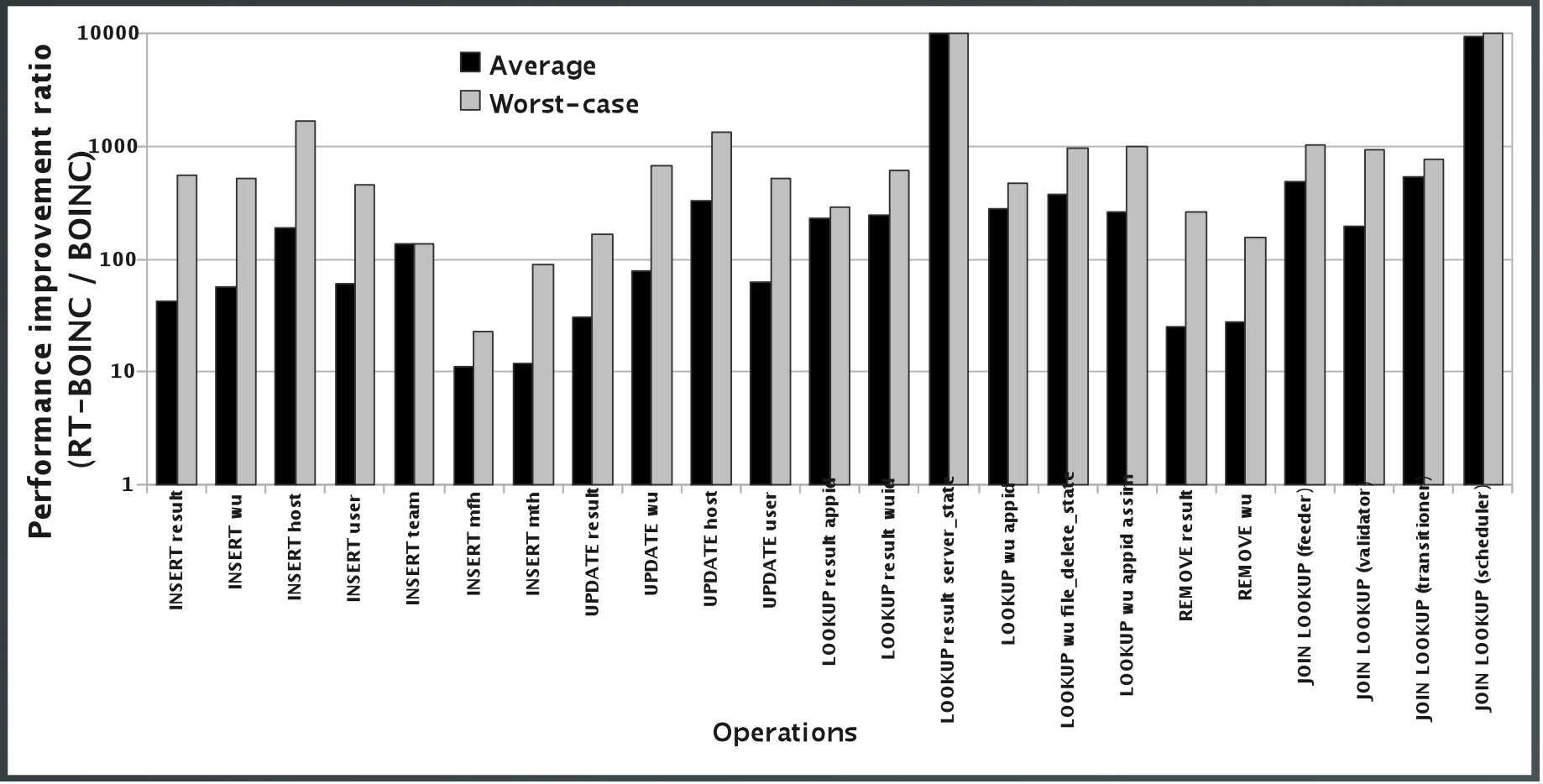
Micro-benchmarks

- Worst-case execution time (in seconds)



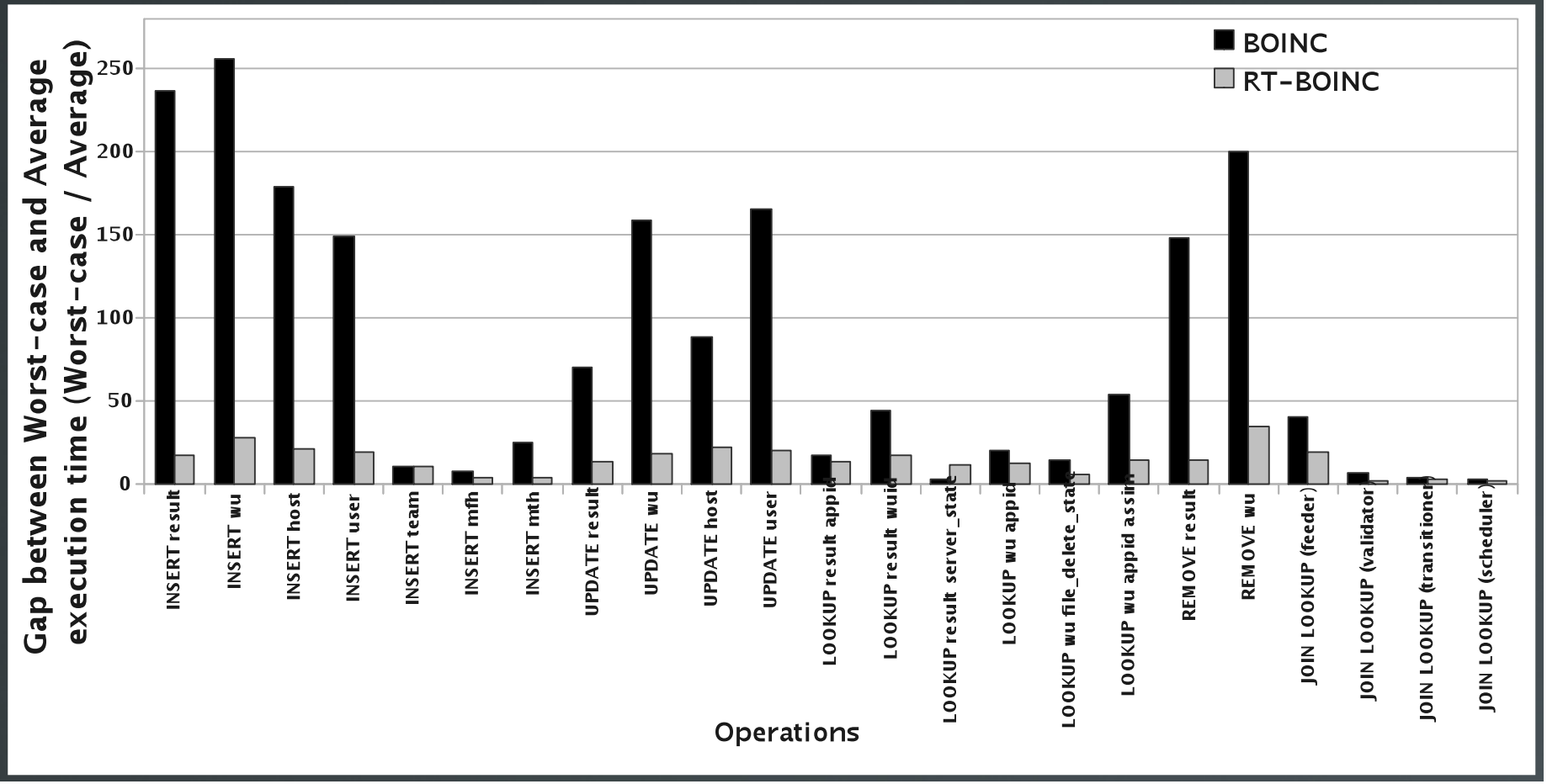
Micro-benchmarks

- Performance improvement ratio (RT-BOINC / BOINC)

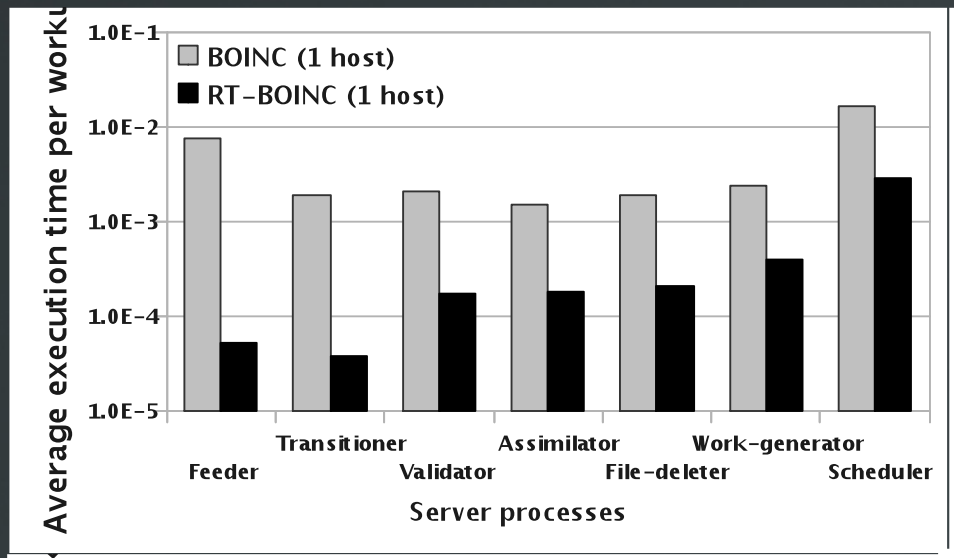


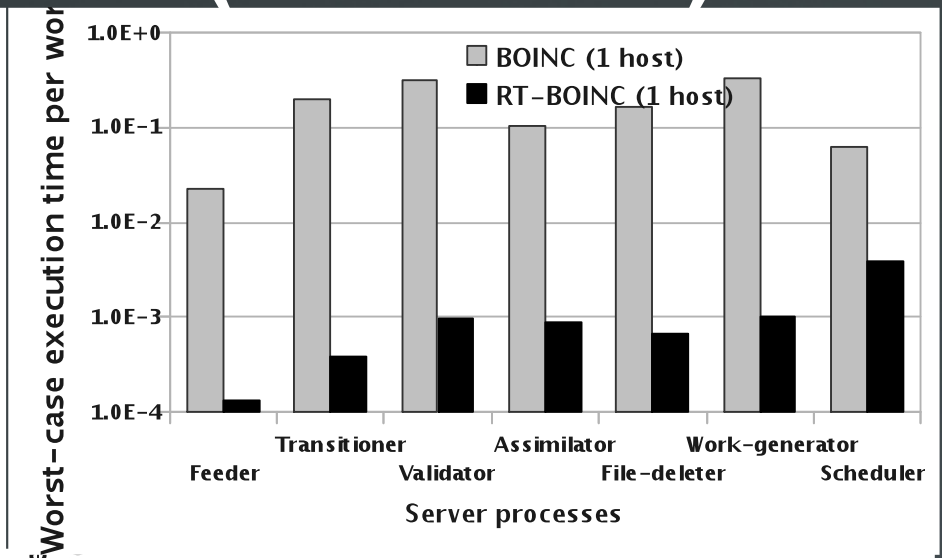
Micro-benchmarks

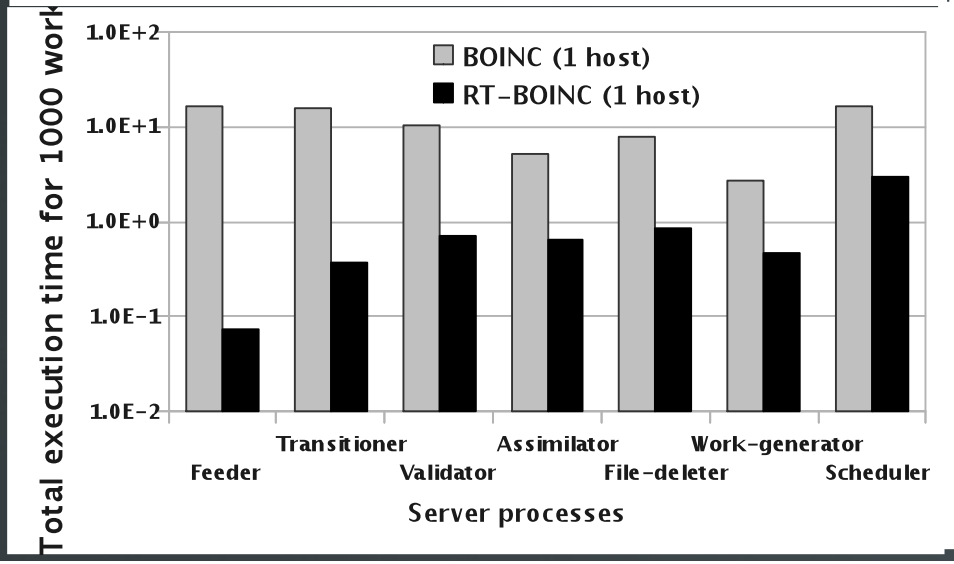
- Performance gap between worst-case and average

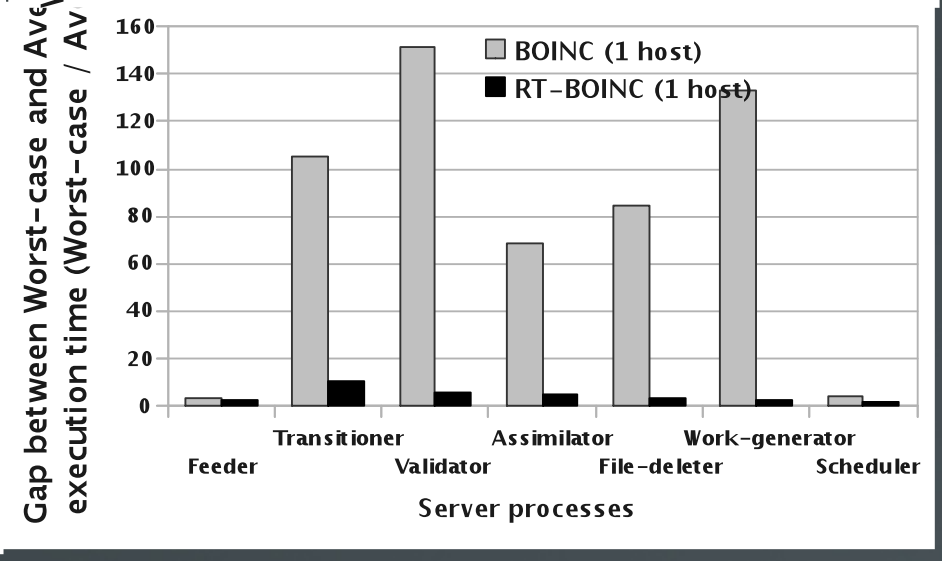


Macro-benchmarks (low load)



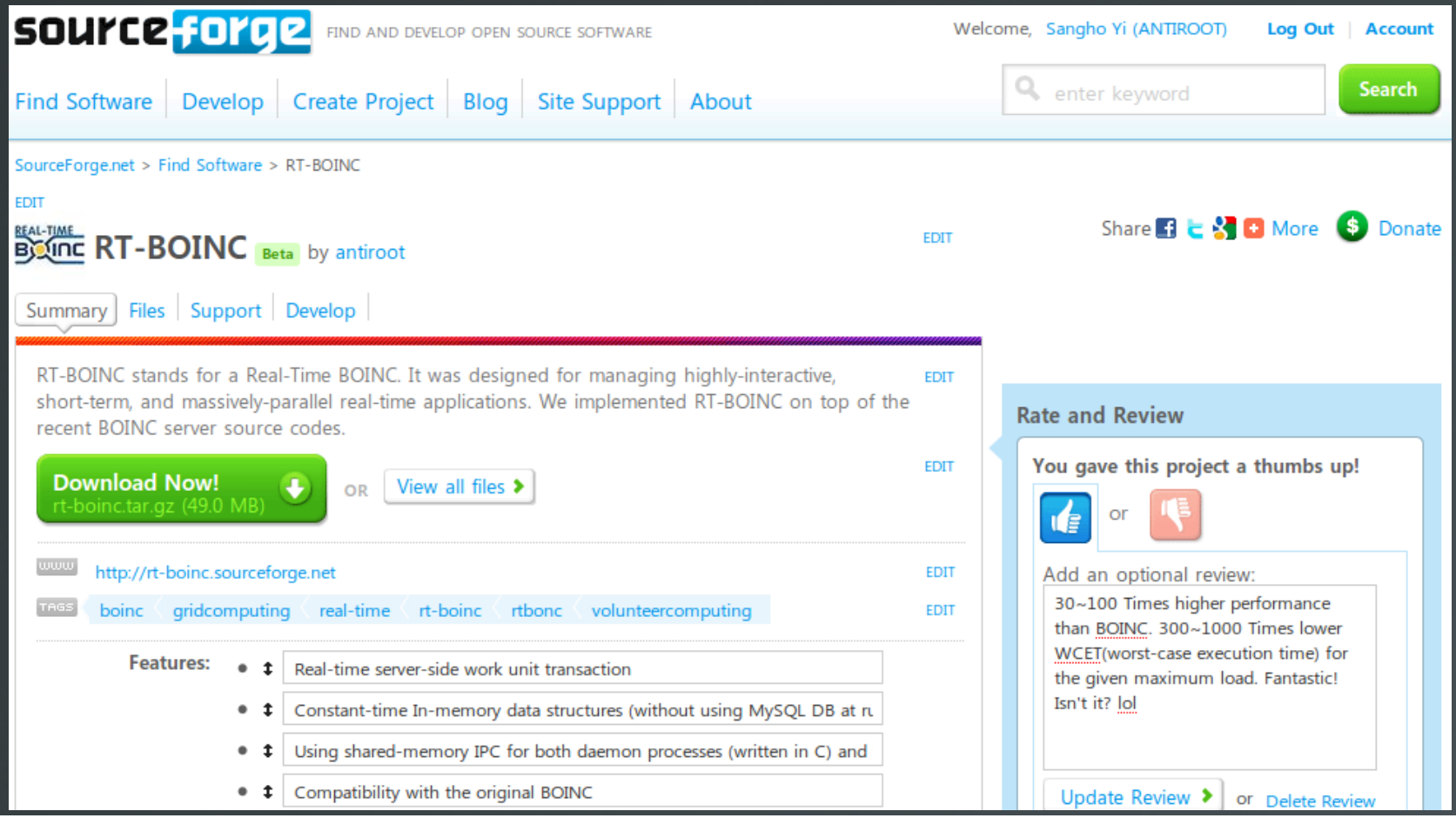






Source code on the Web

- http://sourceforge.net/projects/rt-boinc



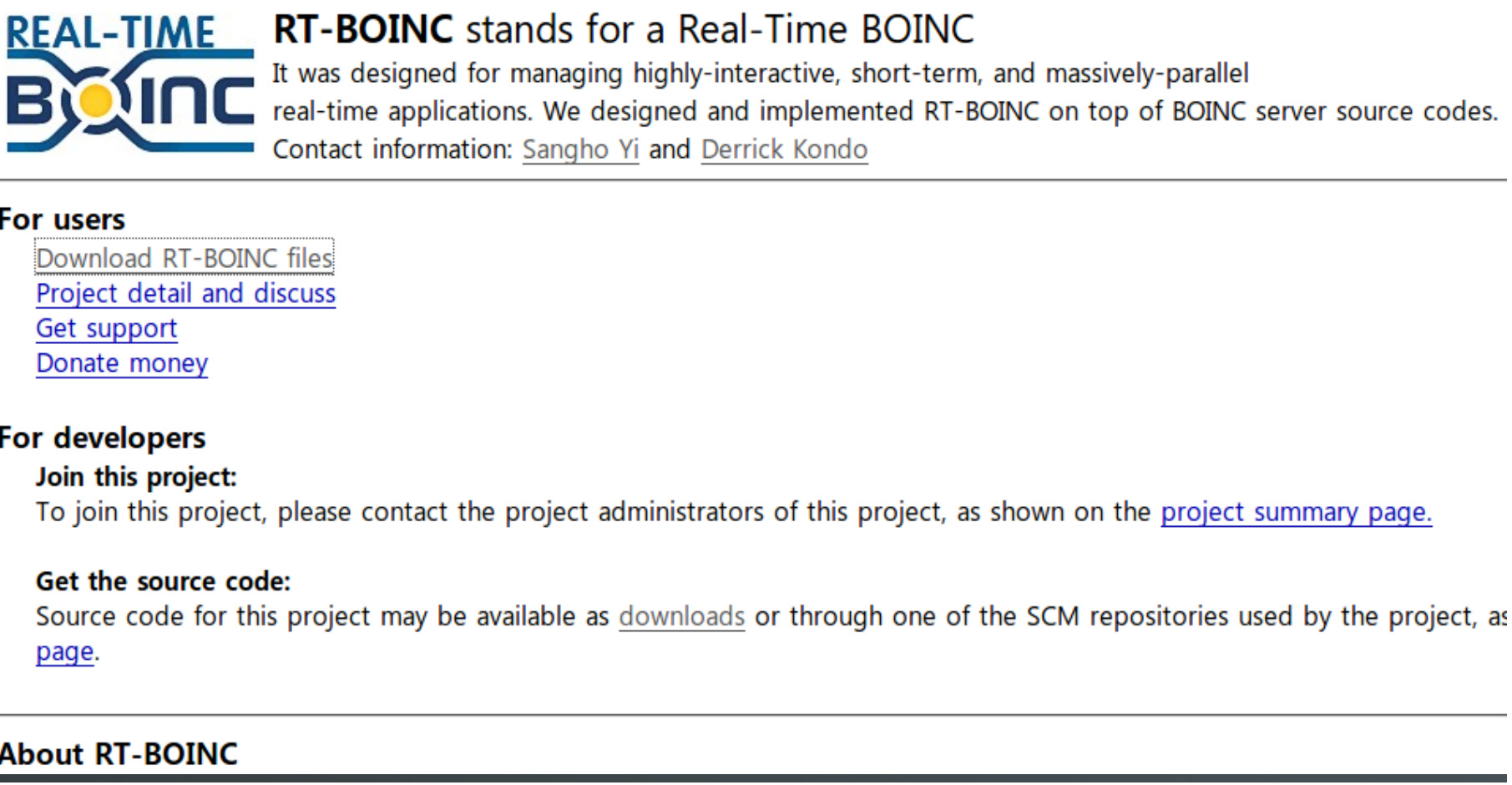
Size of Data Structures

- RT-BOINC uses the 'shared memory segment' IPC between server daemon processes to share the data structures.

- For 10,000 entries of hosts, results, workunits, it consumes totally **1.09GB** in main memory.
  - Memory overhead for O(1) data structures is **38.6%** of the total usage.
  - Using **1GB** memory is reasonable on the common-off-the-shelf 64-bit hardware platforms.

Detailed information on the Web

- http://rt-boinc.sourceforge.net



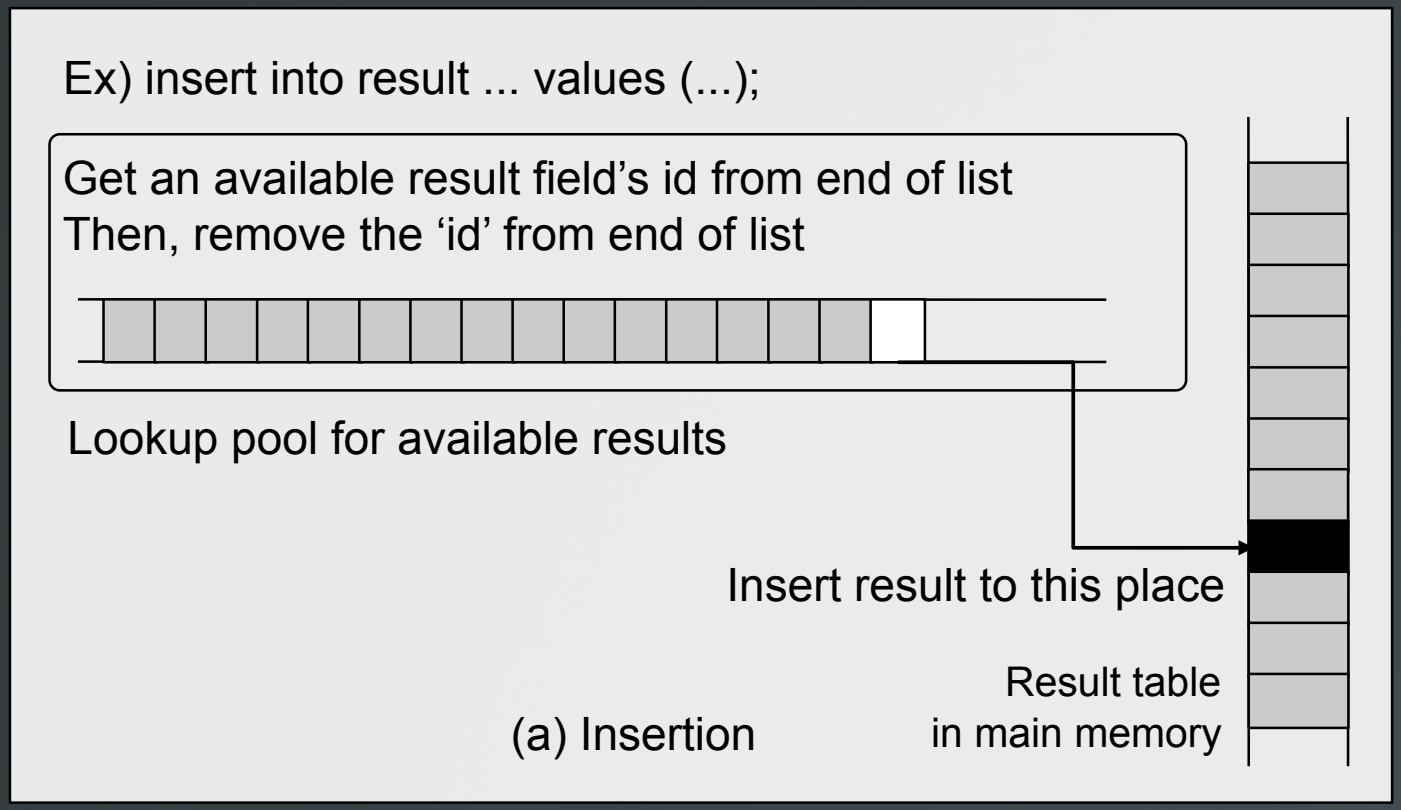
Future work (Remaining issues)

- Providing ’dynamic shared-memory management’ to reduce memory usage
- Studying trade-offs between execution time and memory usage
- Studying better data structure management for O(1) response
- Finding better task deployment policy to
  - Reduce server-side load and latency
  - Improve real-time performance

Thanks! / Questions?

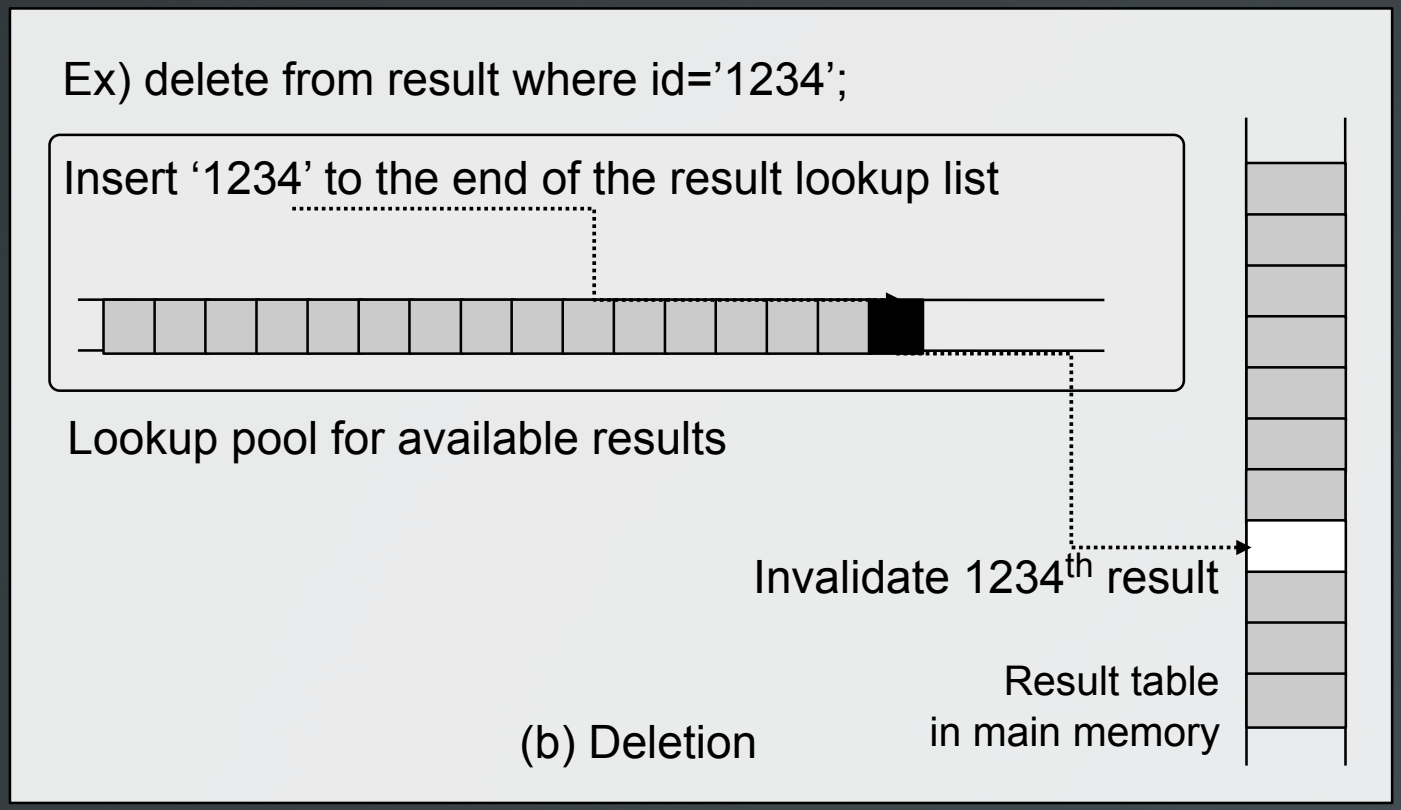
Example 2) insert into values(...);

- Inserting RESULT to the O(1) data structure



Example 3) delete from where;

- Deleting RESULT from the O(1) data structure



Prototype Implementation

- Additional information
  - Compaction of BOINC's data format
  - Modification of PHP codes
  - Trade-offs between memory usage and WCET
    - Statically adjustable with parameters
  - Compatibility with BOINC
    - The rest parts are still compatible with BOINC.