Precise WCET Analysis in the Presence of Dynamic Memory Allocation

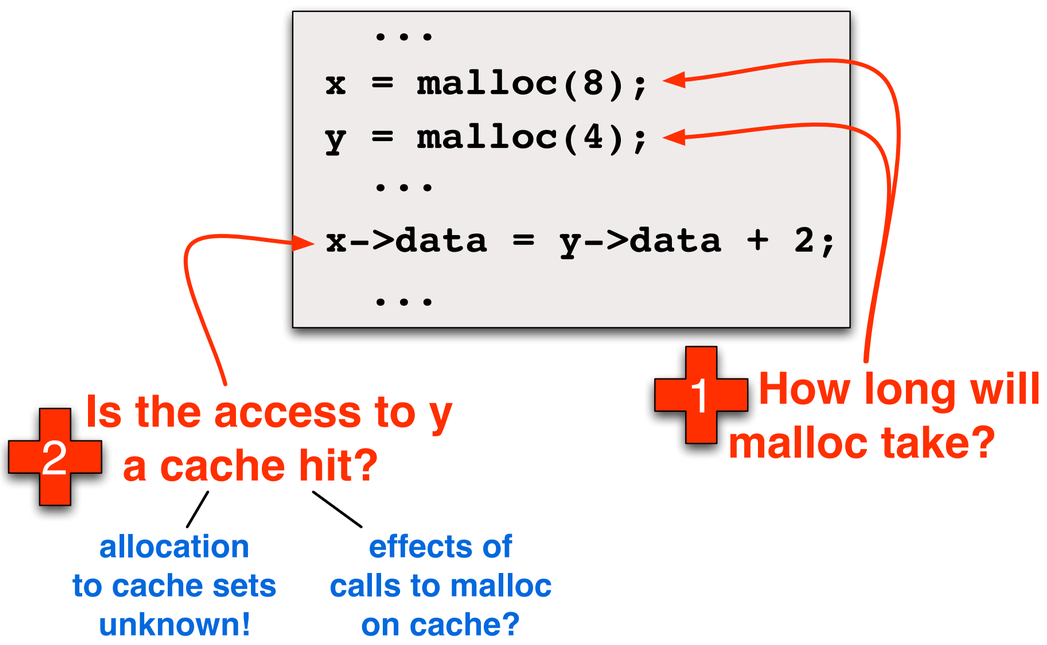
Jörg Herter
Department of Computer Science, Saarland University

Current Situation

What we have ...
Worst-case execution time (WCET) analysis in the presence of static memory allocation only

What we would like to have ...
WCET analysis in the presence of dynamic memory allocation

Problems with Dynamic Memory Allocation



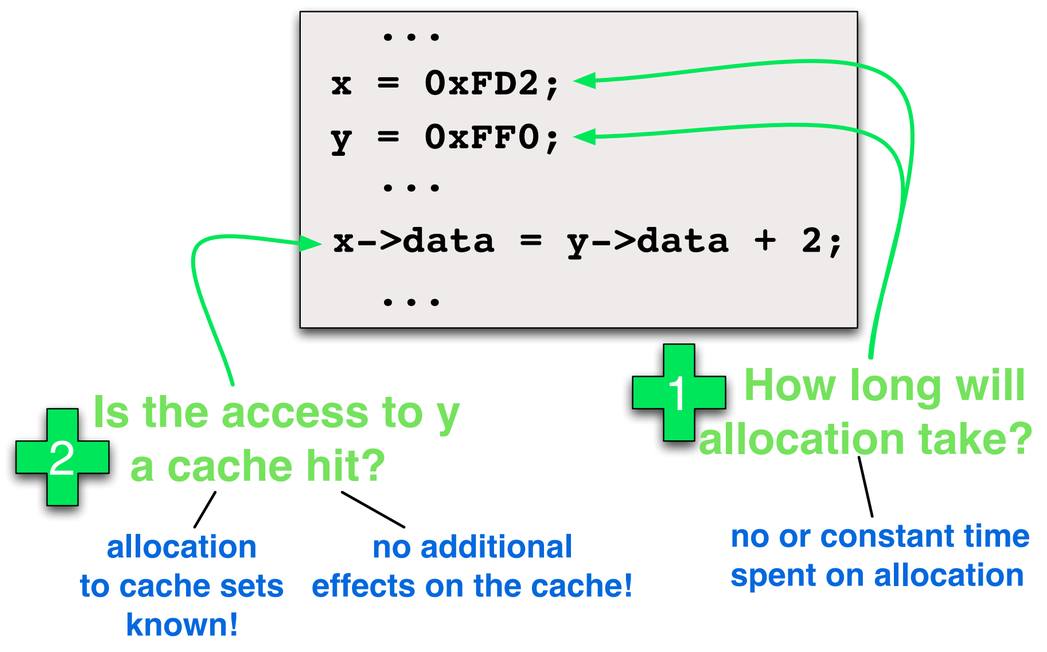
Approach 1: "Making Dynamic Allocation Static"

Idea: Replace dynamic memory allocation by *good* static allocation!

- Statically compute suitable memory addresses for allocated blocks.
- Can use information about the program required by the WCET analysis for the address computation.
- Optimal mappings minimize the WCET bound

$$\min_{\substack{\text{address}\\\text{mappings}}} \max_{\substack{\text{execution}\\\text{paths}}} \sum_{b \in \mathcal{B}} \text{WCET}(b) \cdot \text{Frequency}(b)$$

  where $\mathcal{B}$ is the set of basic blocks of the program.
  As a secondary objective the memory consumption is minimized.
- Combination of simulated annealing/hill climbing algorithms and ILPs is used to approximate optimal mappings.



Discussion

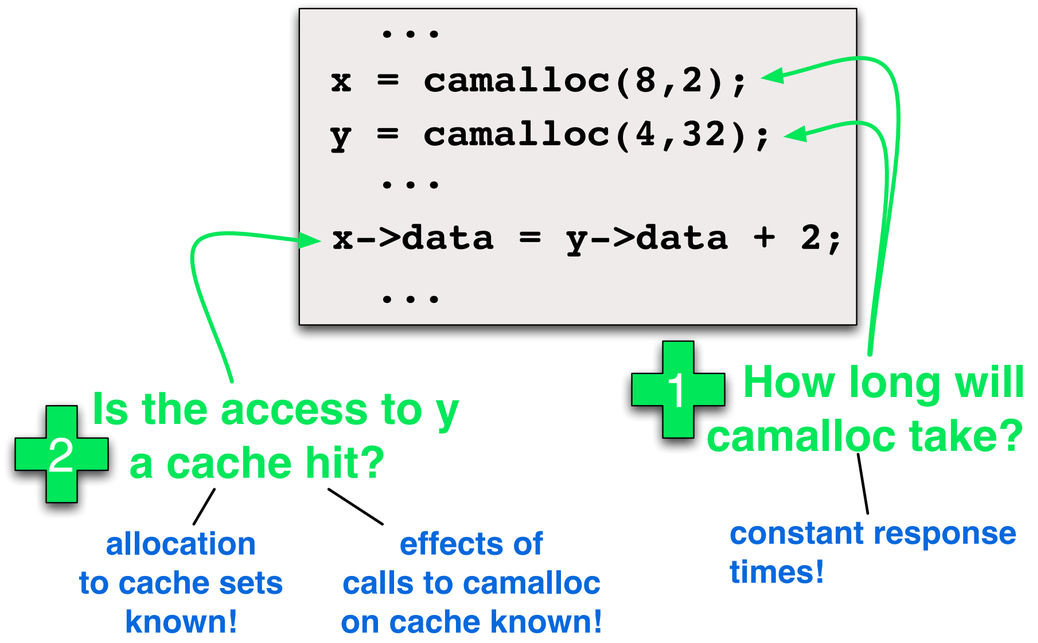
- Preliminary benchmarks suggests feasible computation times.
- No allocator overhead.

Contact information:
http://rw4.cs.uni-sb.de/~jherter
jherter@cs.uni-sb.de

Approach 2: "Making Allocation Cache-Aware"

Idea: Replace all memory allocation requests by cache-aware requests!

- Use a cache-aware memory allocator which can be guided w.r.t. which cache set the allocated memory block is mapped to.
- The problem of finding a suitable cache set for each allocated block can be formulated as an ILP.
- Simulated annealing/hill climbing algorithms can improve the computing time needed to find a suitable cache-set mapping.



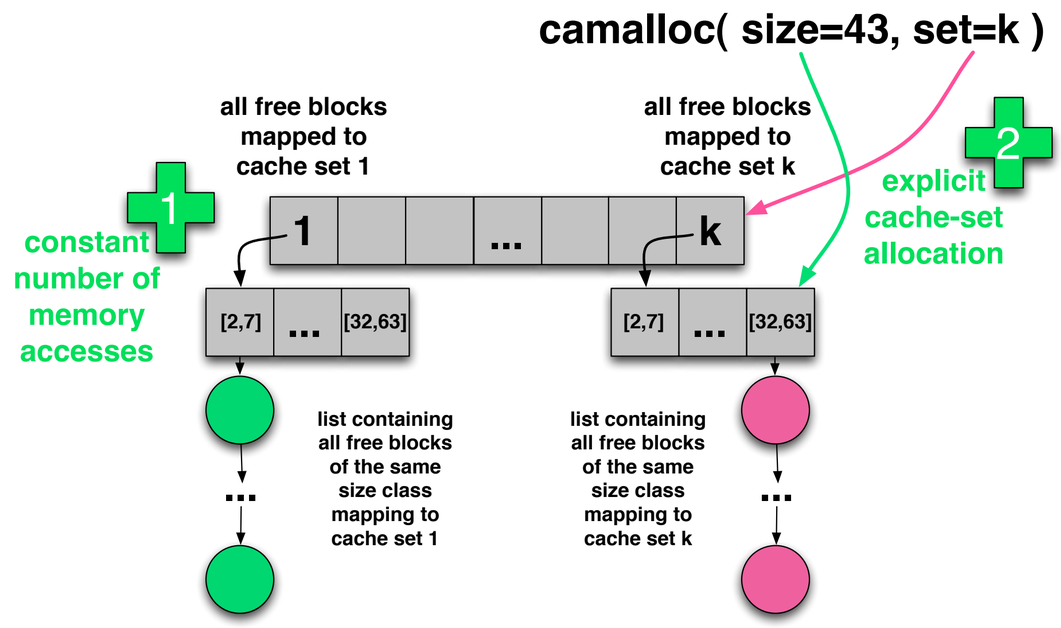
Discussion

- Computationally cheaper than the first approach.
- Prone to memory fragmentation.

Cache-Aware Memory Allocation

How to allocate in a cache-aware manner?

1. Allocate from segregated lists $\Rightarrow$ constant number of memory accesses, $\approx$ constant execution time
2. Add new parameter to **malloc**: the cache set to allocate to



Publications

Jörg Herter, Jan Reineke, and Reinhard Wilhelm:

CAMA: Cache-Aware Memory Allocation for WCET Analysis.

In WIP-Proceedings of the Euromicro Conference on Real-Time Systems 2008.