

# Making Dynamic Memory Allocation Static To Support WCET Analyses

Jörg Herter    Jan Reineke

Department of Computer Science  
Saarland University

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What we have ...

- 1 Precise WCET analysis
- 2 Dynamic Memory Allocation
  - ▶ often clearer program structure
  - ▶ easy memory reuse (e.g. in-situ transformations)

... but can we have both together?

What are the challenges?

```
...  
x = malloc(8);  
y = malloc(4);  
...  
x->data = y->data + 2;  
...
```

**Is the access to y  
a cache hit?**

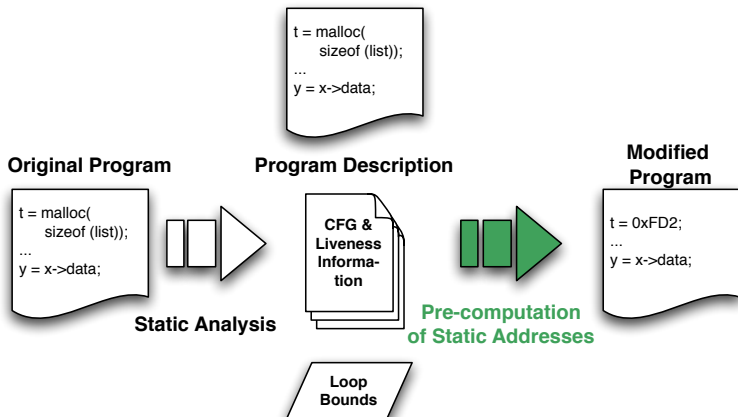
(a) allocation  
to cache sets  
unknown!

(b) effects of  
calls to malloc  
on cache?

**How long will  
malloc take?**

What can be done?

- Predictable Allocator
  - ▶ J. Herter, J. Reineke, R. Wilhelm, 2008
- Predictable Hardware
  - ▶ M. Schöberl, 2009
- **Replace Dynamic Allocation by Static Allocation**



# What are *Good* Addresses?

What do we consider good addresses for heap allocated objects?

- Good addresses enable a subsequent WCET analysis to calculate minimal WCET bounds ...
- ... by minimal memory consumption.

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- 4 Modify addresses s.t. WCET contribution of selected block is minimized**
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- 5 **Continue at 2**

- ILPs to compute memory and block optimal addresses can be replaced by simulated annealing algorithms to cope with
  - ▶ more complex hardware (more cache sets)
  - ▶ more complex software (more heap allocated blocks)

- Algorithm to compute static memory addresses for heap allocated objects.
- Preliminary experiments suggest feasible computational costs for addresses.
  
- Future Work:
  - ▶ Static (pre-) analysis to collect needed information.
  - ▶ *Fully Automatic Transformation.*