Towards Multi-Objective Dynamic SPM Allocation

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Overview

1. **Motivation**
2. Dynamic SPM Allocation (DSA)
3. Multi-Objective DSA-based Optimization
4. Evaluation
5. Conclusion

Motivation

- Worst-Case Execution Time (WCET)
- Energy consumption
- Static SPM allocation constrained by small SPM size

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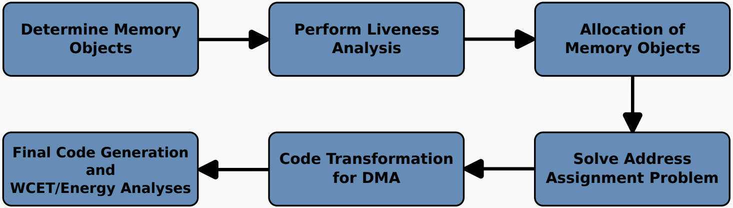
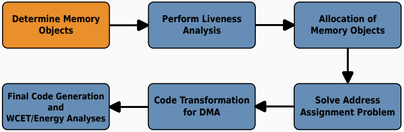
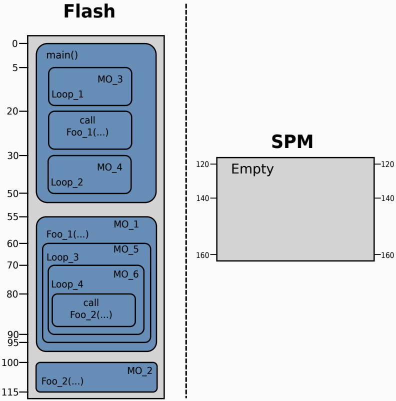
Dynamic SPM Allocation (DSA)



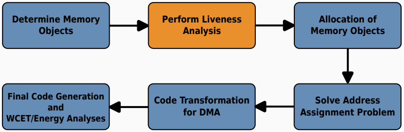
DSA: Memory Objects

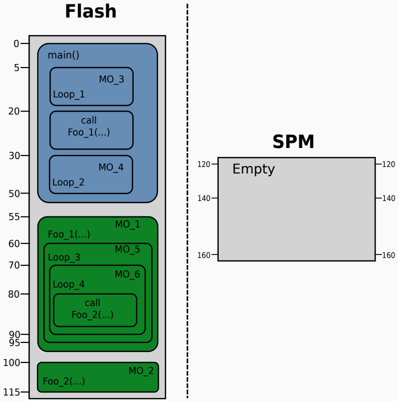




Memory Objects:
- -- *Functions*: Foo_1() and Foo_2()
- -- *Loops*: Loop_1, Loop_2, Loop_3, and Loop_4

DSA: Liveness Analysis





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Liveness conflicts:
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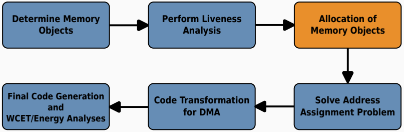

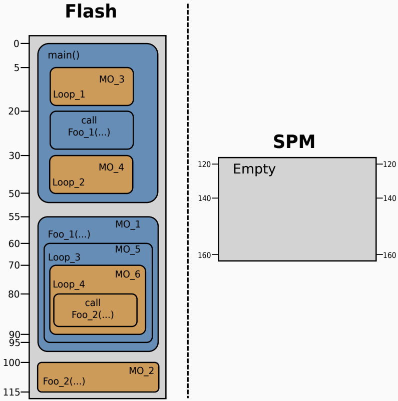

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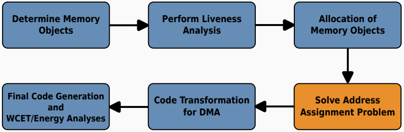
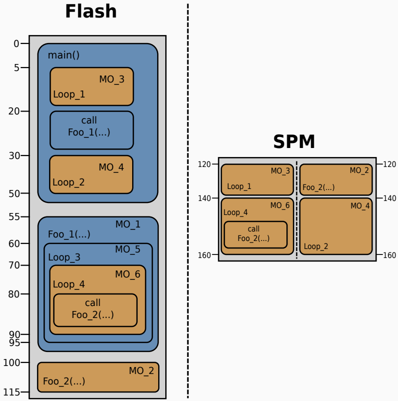
Memory Object Allocation:
- -- *Flash*: Foo_1() and Loop_3()
- -- *SPM*: Foo 2(), Loop_1, Loop_2, and Loop_4

DSA: Address Assignment





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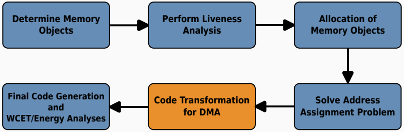
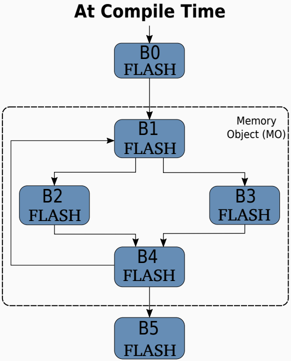
Address Assignment:
-- First-Fit Heuristic
-- Best-Fit Heuristic

DSA: Code Transformation





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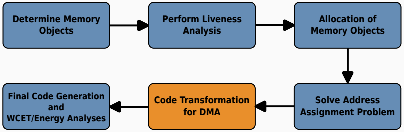
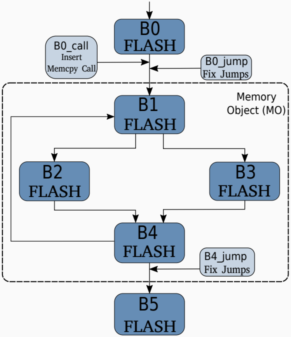


At Compile Time



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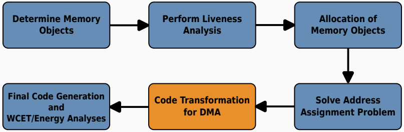

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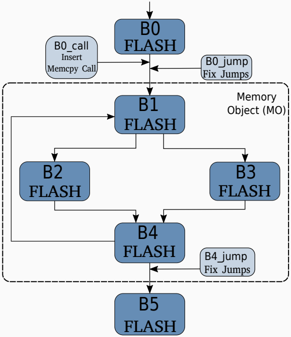
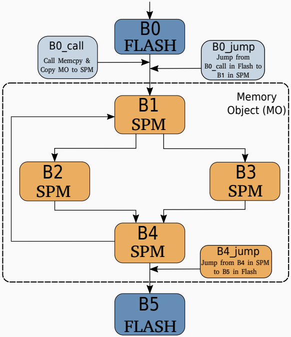
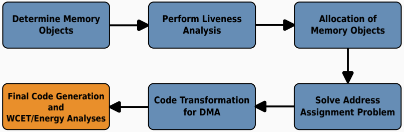
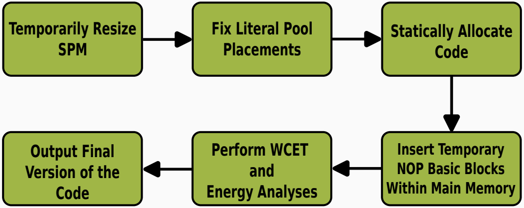


During Runtime



DSA: Code Generation and Analyses





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    Where,

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- **Address Assignment Algorithm Constraint:**
  - $(\mathcal{T} - \eta) = 0$

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Metaheuristic Algorithms

To solve multi-objective DSA-based optimization problem, we use:

- Flower Pollination Algorithm (FPA)
- Strength Pareto Evolutionary Algorithm (SPEA)

Algorithm Multi-Objective DSA-based optimization

```
Collect memObj, perform Liveness Analysis, and randomly initialize initial population of size N
for n = 1 : N do
    Generate DSA code
while Stopping criteria is not reached do
    Update Individual using respective update operators
    for Each updated Individual do
        Generate DSA code
    Update to next generation using selection operator
return Pareto-optimal solution set
```

Comparison between...

- Proposed multi-objective DSA-based optimization (MO_D)
  −>Solved using:
  - FPA
  - SPEA
- Multi-objective static SPM allocation-based optimization (MO_S)
  −>Solved using:
  - FPA
  - SPEA
- ILP-based single objective dynamic SPM allocation (SO_D)

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Pareto fronts

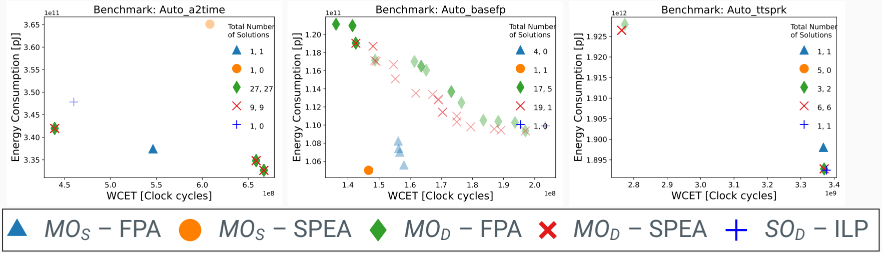

Figure 1: Solutions Obtained from MO_S, MO_D, and SO_D optimization runs

Pareto fronts

The following percent of solutions were on the final Pareto front

- MO_S–FPA: 3.62%
- MO_S–SPEA: 5.26%
- SO_D–ILP: 0.66%
- MO_D–FPA: 70.4%
- MO_D–SPEA: 20.1%

–> MO_D–FPA found most number of solution on the final Pareto front

Quality Indicators

- Coverage: $\mathcal{C} = 1 - \frac{|\{a \in A : \exists p \in \mathcal{P}, a \preceq p\}|}{|A|}$
- Non-Dominance Ratio: $NDR = \frac{|\mathcal{P} \cap A|}{|\mathcal{P}|}$
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From overall Evaluations, in terms of Quality Indicators:

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Overheads due to dynamic copying in MO_D optimization run:

- WCET overheads on average: 24.39%
- Energy overheads on average: 22.65%

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Conclusion

- Proposed compiler-level DSA-based multi-objective optimization
- WCC performs WCET and energy analysis of DSA code
- MO_D is solved using FPA and SPEA
- MO_D outperforms SO_D
- MO_D performs slightly better than MO_S

Future Work

- Reducing the WCET and energy overheads by using DMA
- Reducing the compilation time needed by multi-objective DSA-based optimization

Thank You