Static Analysis of Dynamically Allocated Data

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under the guidance of

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Static Analysis of Dynamically Allocated Data

- Some questions that my work can help answer:
  - Is there a memory leak in the program?
  - Is there a null dereference?
  - What is the shape (tree, DAG, linked list) of a heap data structure?
    - for program understanding, verification, debugging.

Challenges in Heap Analysis

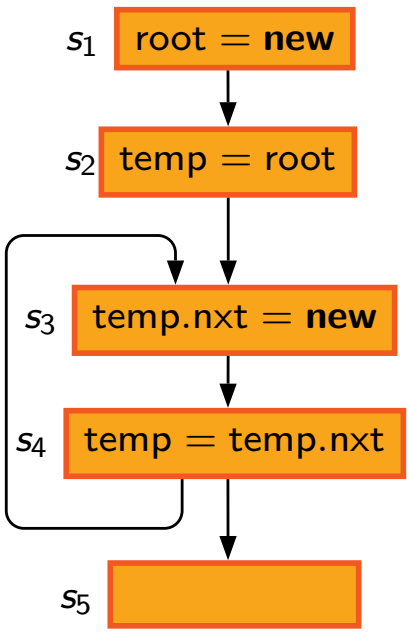
- Challenges in the analysis of pointer variables
  - Undecidable [Chakaravarthy 2003][Ramalingam 1994]
  - Features: dynamic typing, implicit casting, pointer arithmetic, etc.

Challenges in Heap Analysis

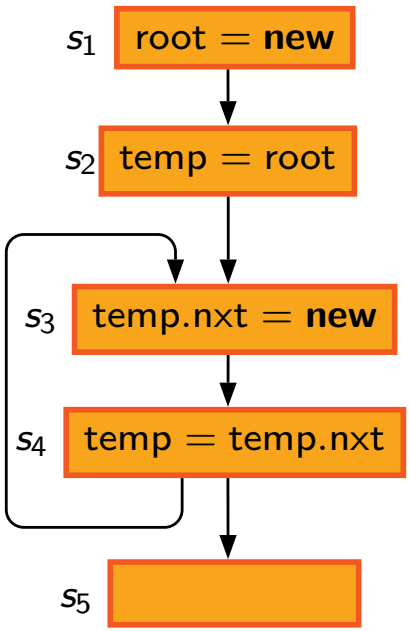
- Challenges in the analysis of pointer variables
  - Undecidable [Chakaravarthy 2003][Ramalingam 1994]
  - Features: dynamic typing, implicit casting, pointer arithmetic, etc.
- Challenges in the analysis of heap pointer variables
  - Unpredictable lifetime
  - Unbounded number of allocations
  - Unnamed locations

Conventional vs. Our Static Heap Analysis

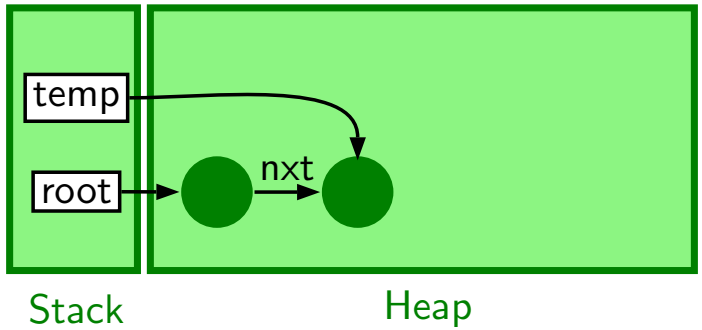
Program creates a linear linked list.



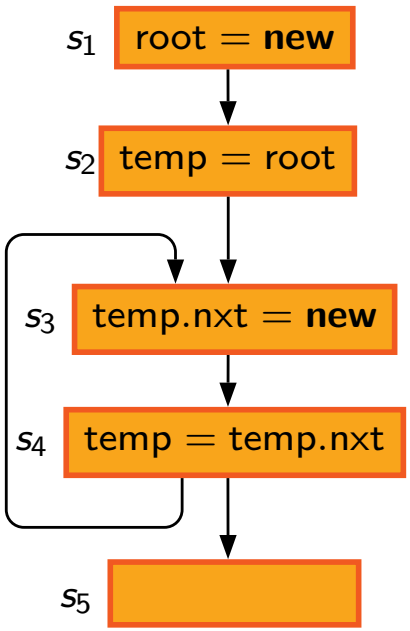
Conventional vs. Our Static Heap Analysis



Possible runtime memory graphs at end of program



Conventional vs. Our Static Heap Analysis



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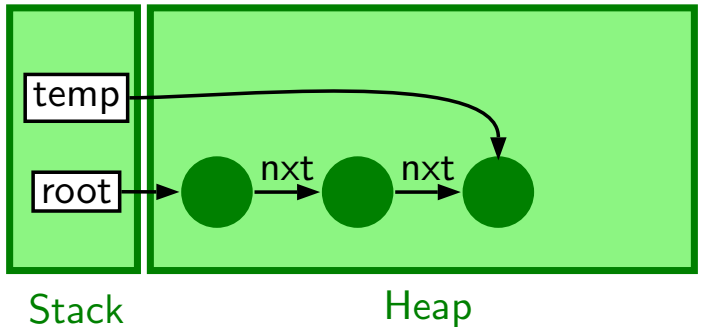

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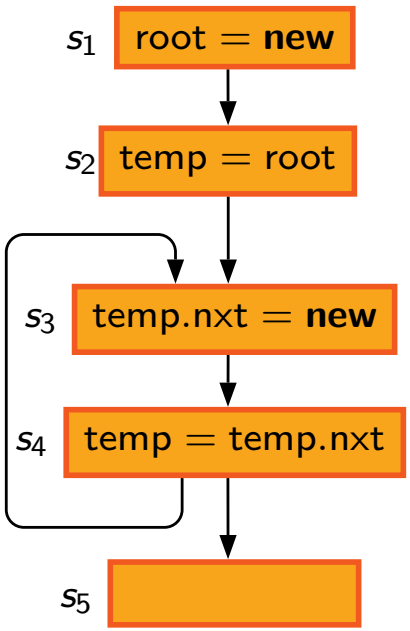

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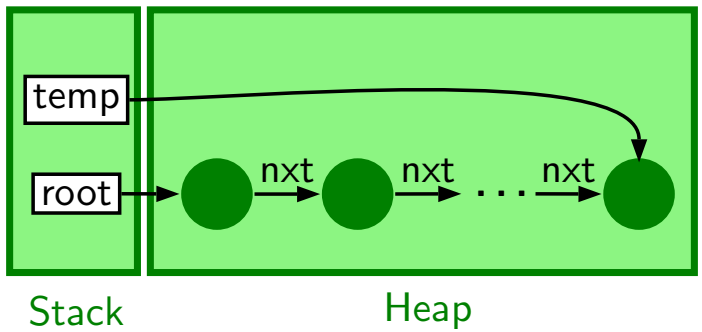
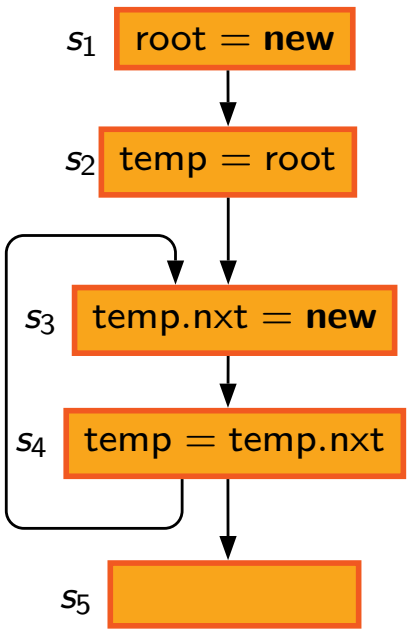


Conventional vs. Our Static Heap Analysis

root points to unbounded number of heap locations.
temp does not; it points to the end of the list.



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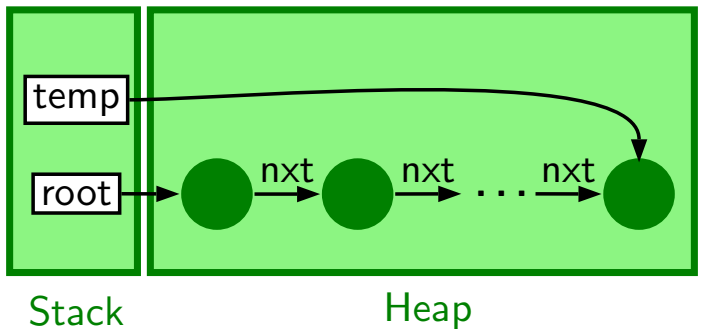
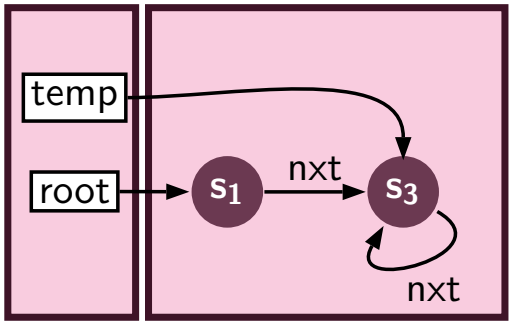
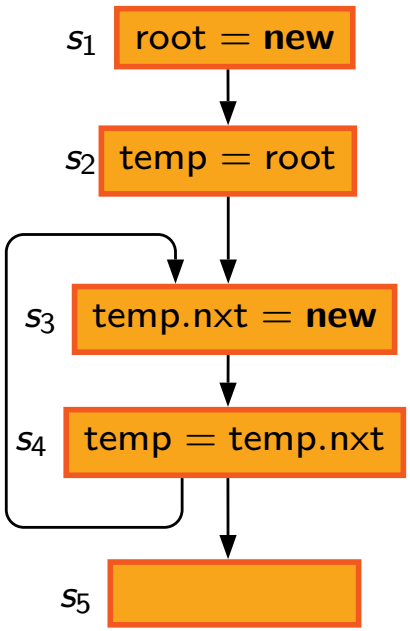


Conventional vs. Our Static Heap Analysis

Conventional static analysis: merges all runtime memory graphs based on the allocation sites.

Static heap analysis
Conventional





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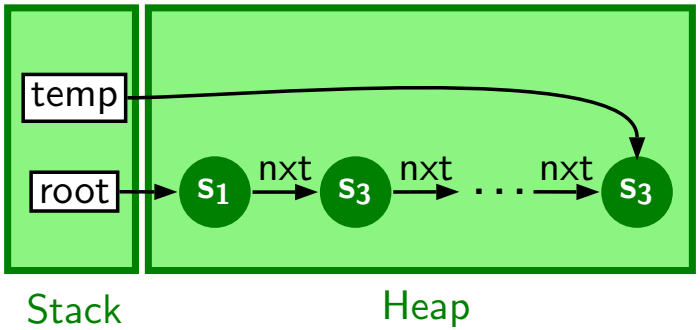
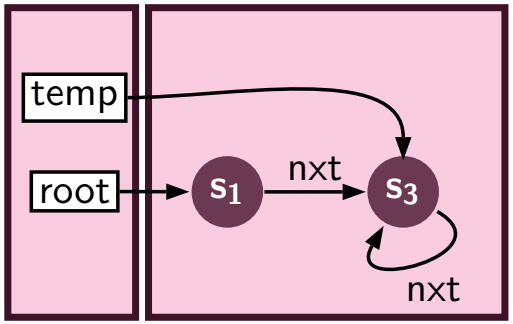
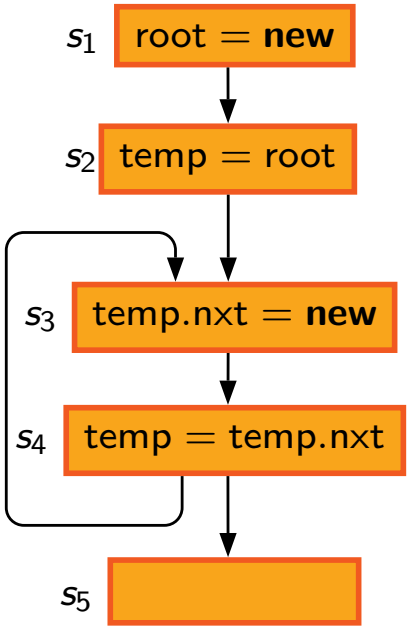


Conventional vs. Our Static Heap Analysis

Cycle denotes unbounded number of heap locations.

Static heap analysis
Conventional





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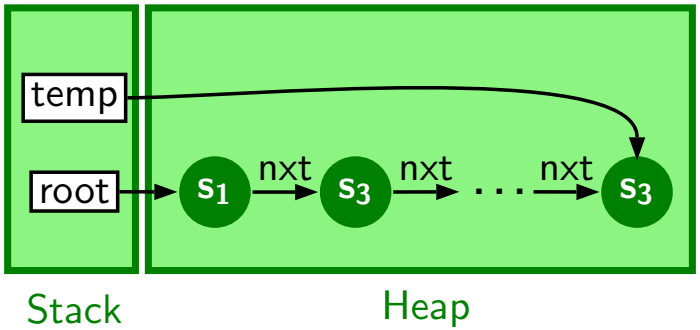
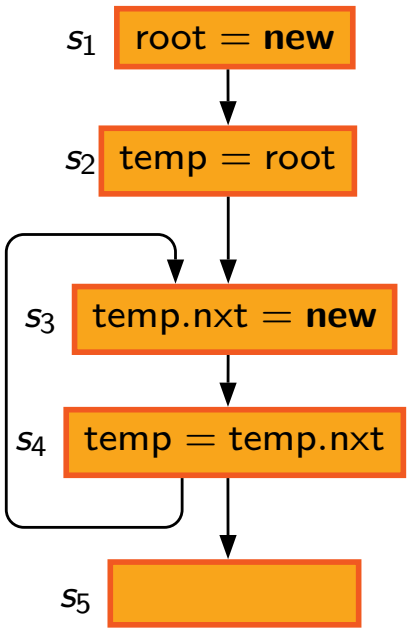


Conventional vs. Our Static Heap Analysis

Conventional static analysis: spuriously computes that **temp** points to an unbounded number of heap locations.



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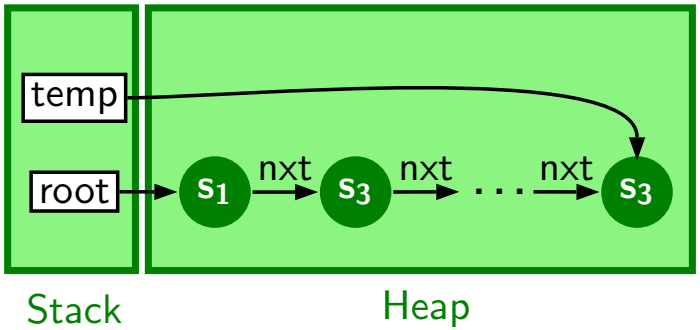

Static heap analysis
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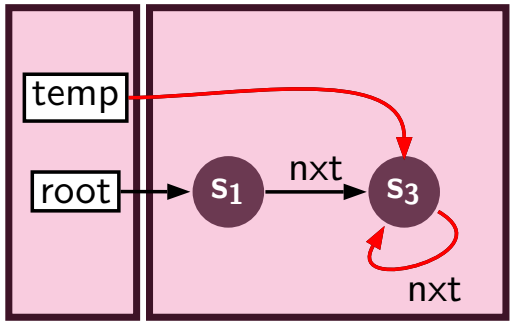
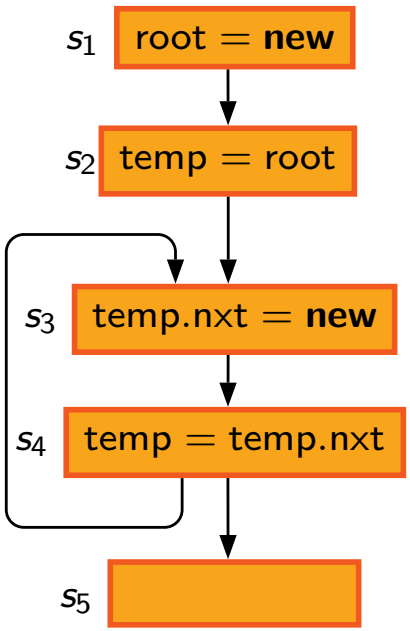


Conventional vs. Our Static Heap Analysis

Our static analysis: we propose to merge all runtime memory graphs based on program accesses.



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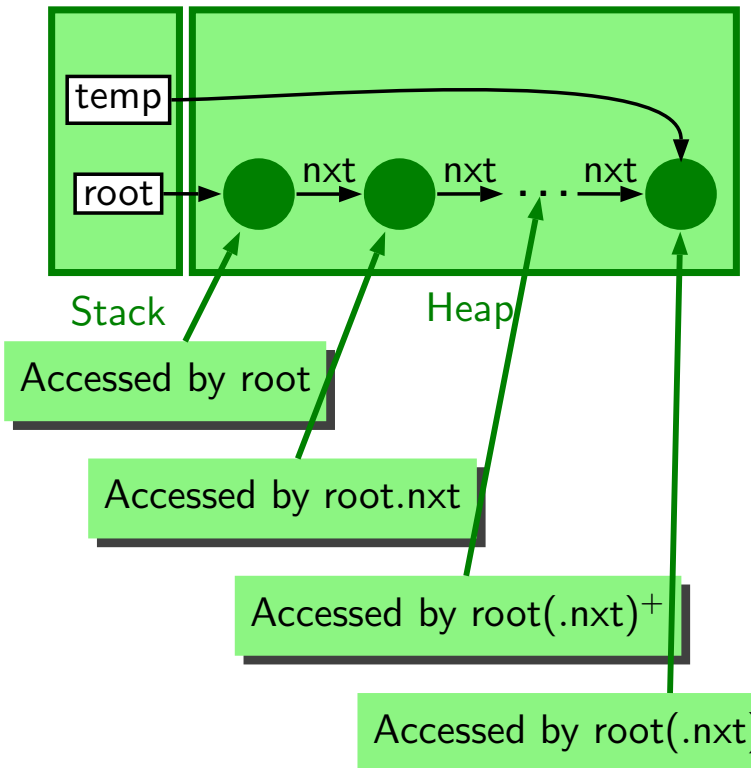

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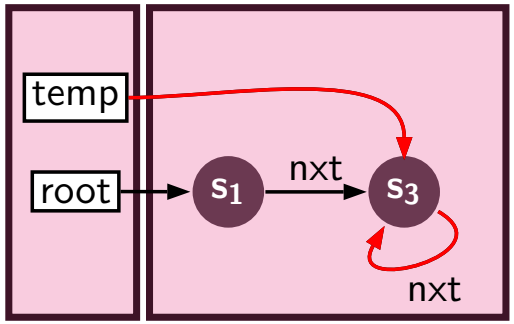
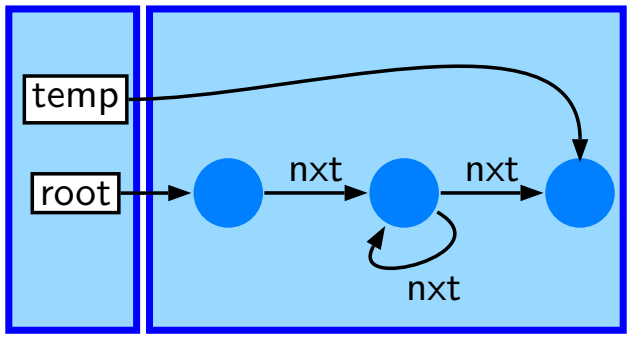
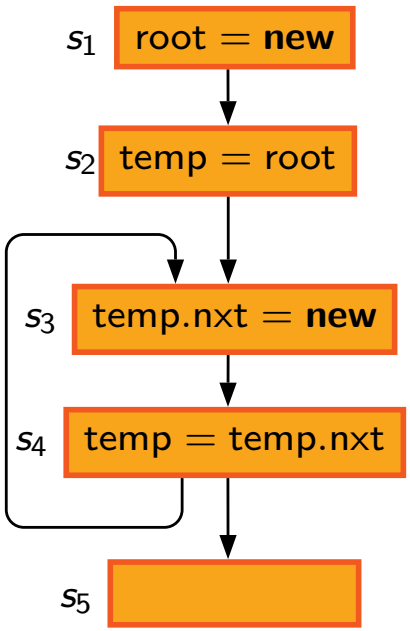


Static heap analysis
Our proposal



Conventional vs. Our Static Heap Analysis

Our static analysis: we precisely compute that **temp** points to a single heap location only.



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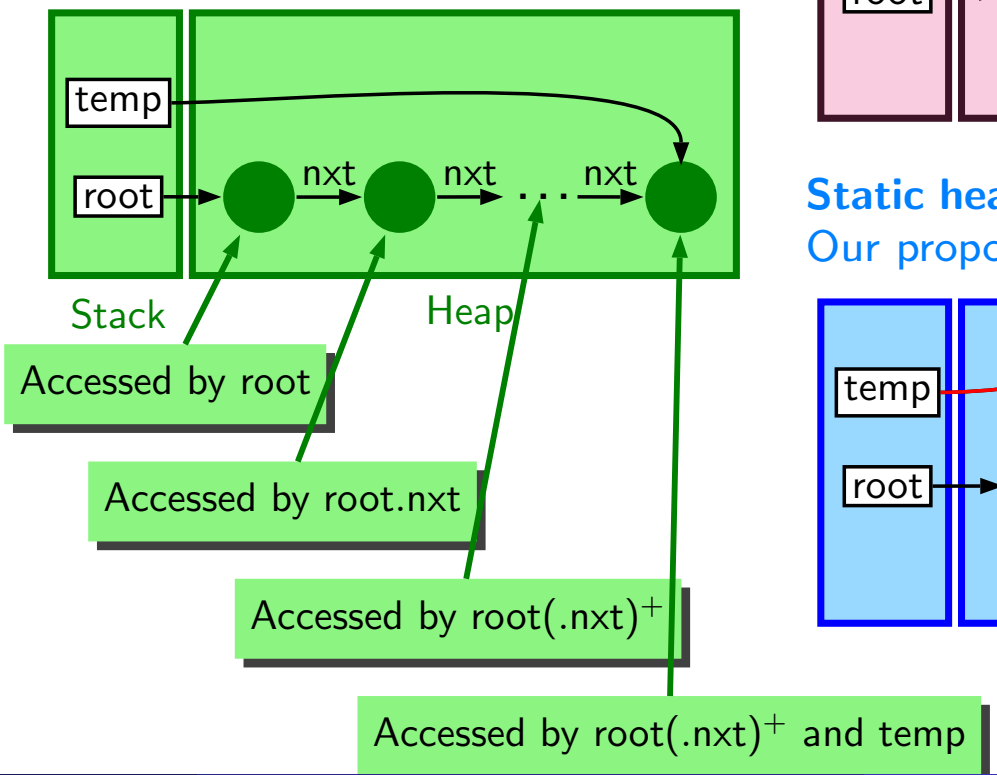

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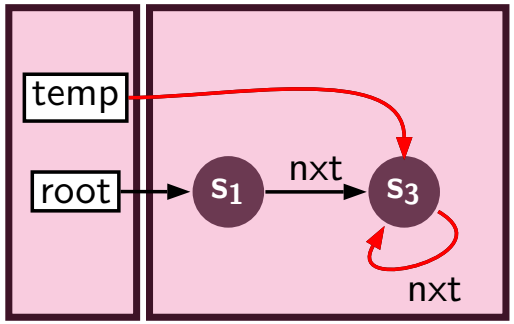

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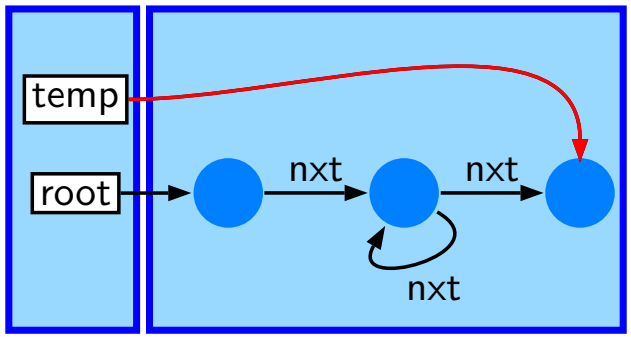
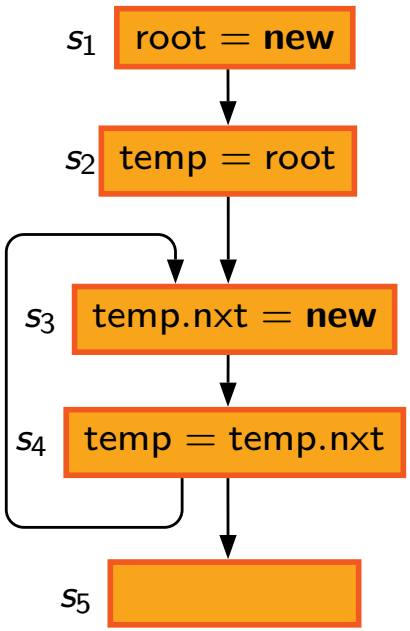


Challenges

- Unbounded number of pointer expressions
  (e.g. root.nxt, root.nxt.nxt, root.nxt.nxt.nxt, etc.)
- Combinatorially large number of pointer expressions



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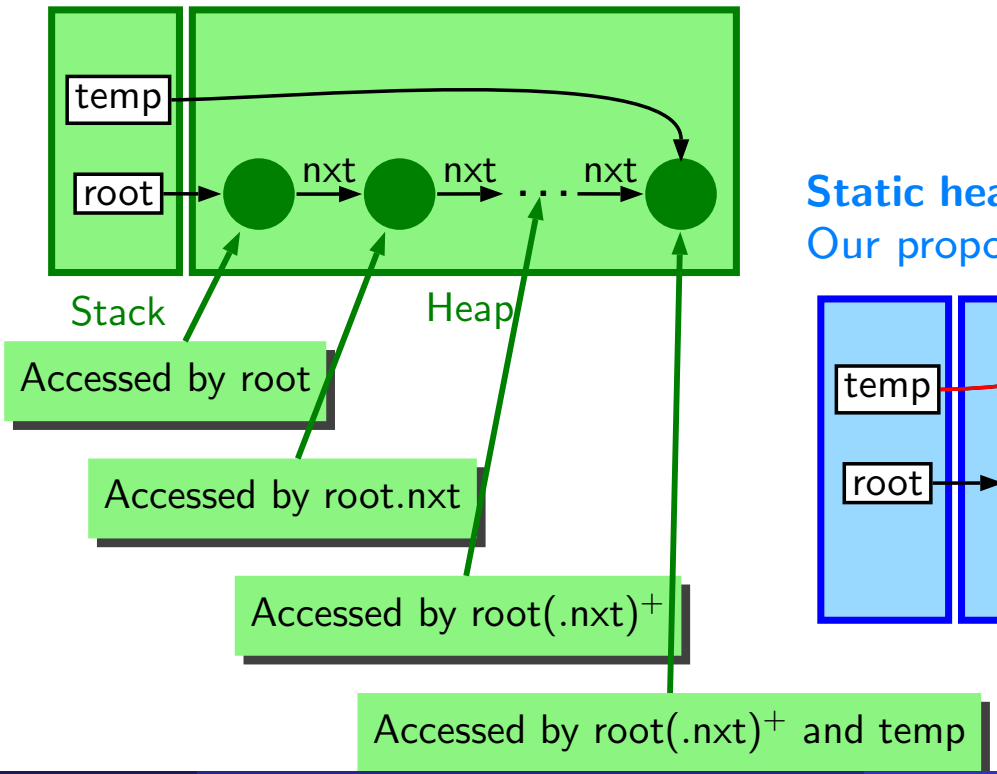

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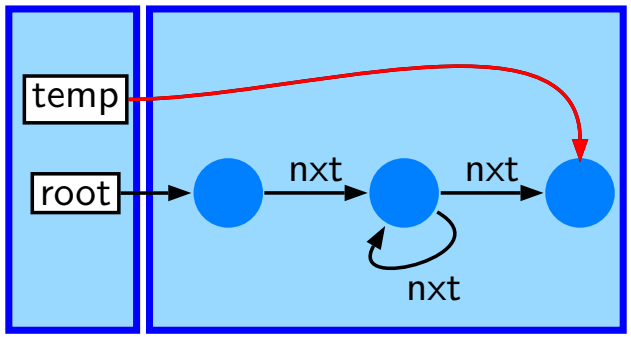
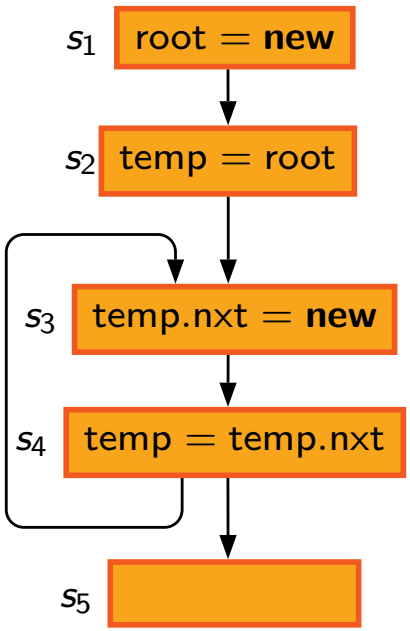


Challenges

- Unbounded number of pointer expressions
  (e.g. root.nxt, root.nxt.nxt, root.nxt.nxt.nxt, etc.)
  - Distinguish betweeen expressions up to a fixed length L
- Combinatorially large number of pointer expressions



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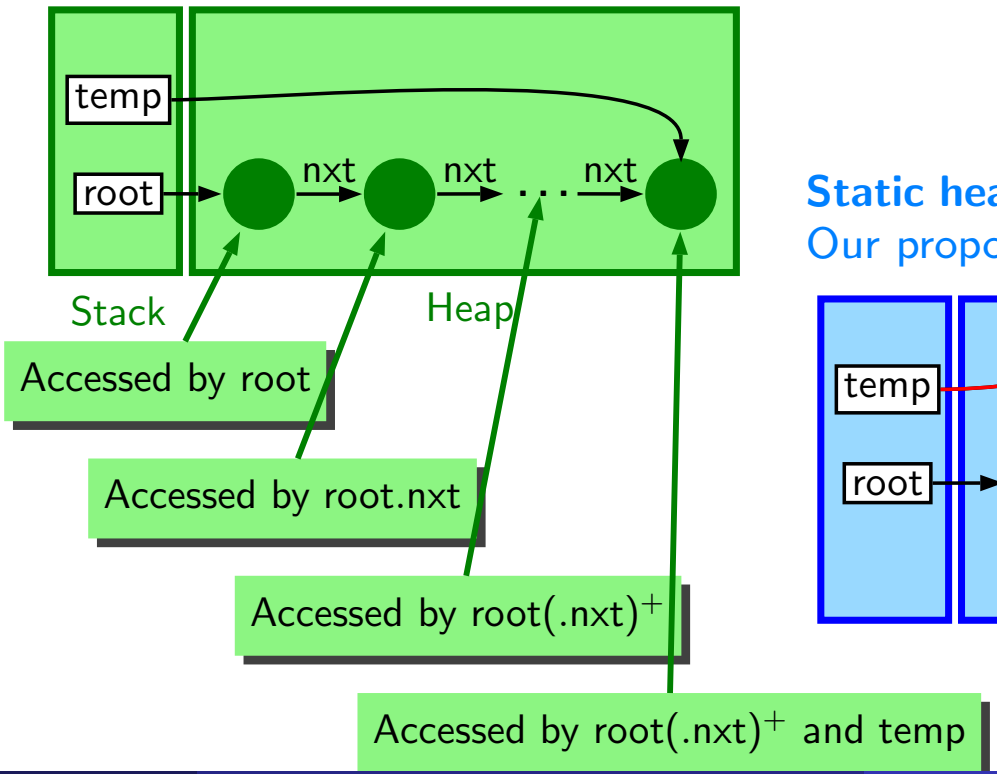

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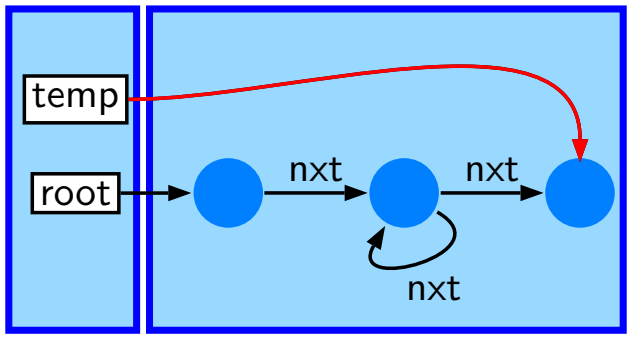
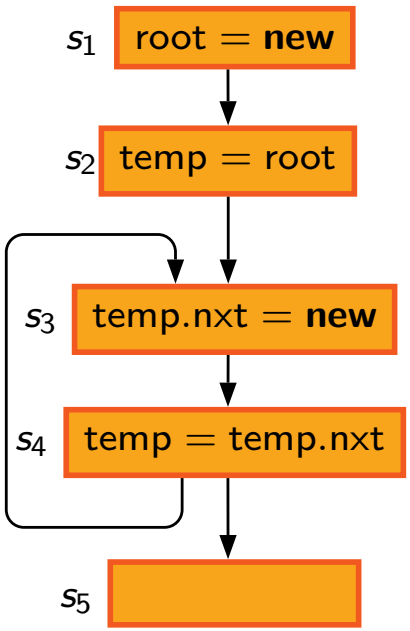


Challenges

- Unbounded number of pointer expressions
  (e.g. root.nxt, root.nxt.nxt, root.nxt.nxt.nxt, etc.)
  - Distinguish betweeen expressions up to a fixed length L
- Combinatorially large number of pointer expressions
  - Memoize expressions used across program points



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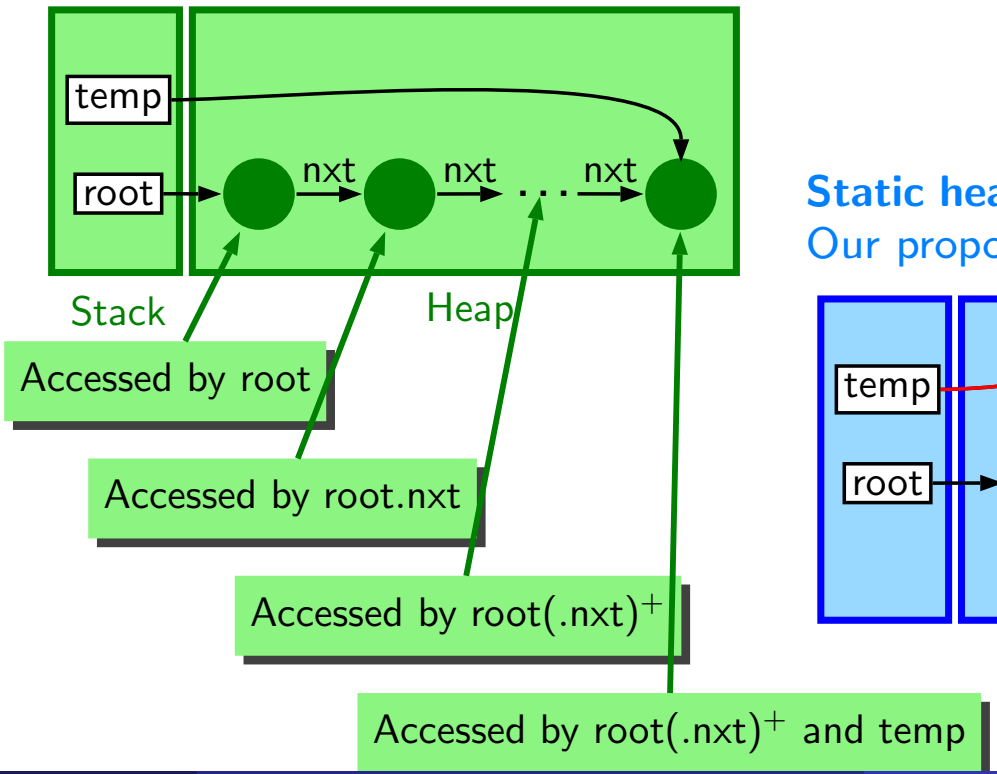

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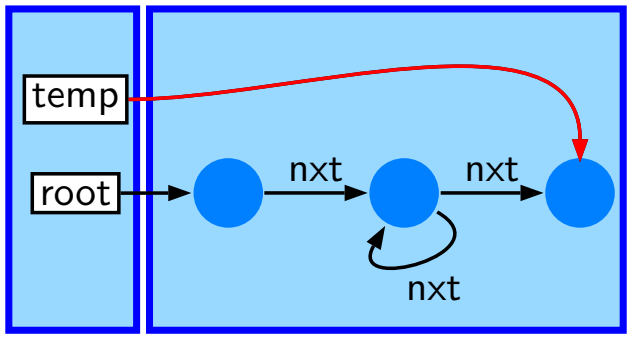

Challenges

- Unbounded number of pointer expressions

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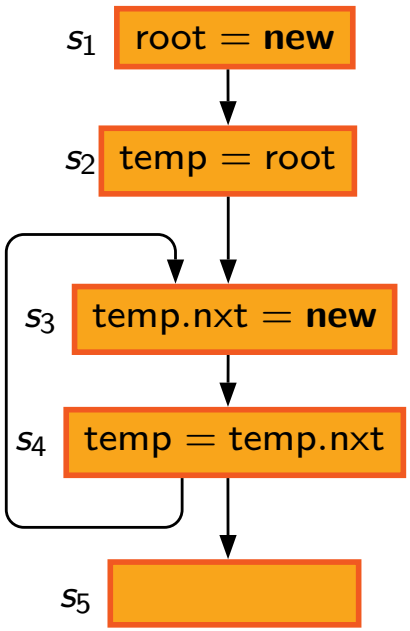
  - Distinguish betweeen expressions up to a fixed length L
- Combinatorially large number of pointer expressions
  - Memoize expressions used across program points
  - Save only live pointer expressions [Khedker et al. 2012]



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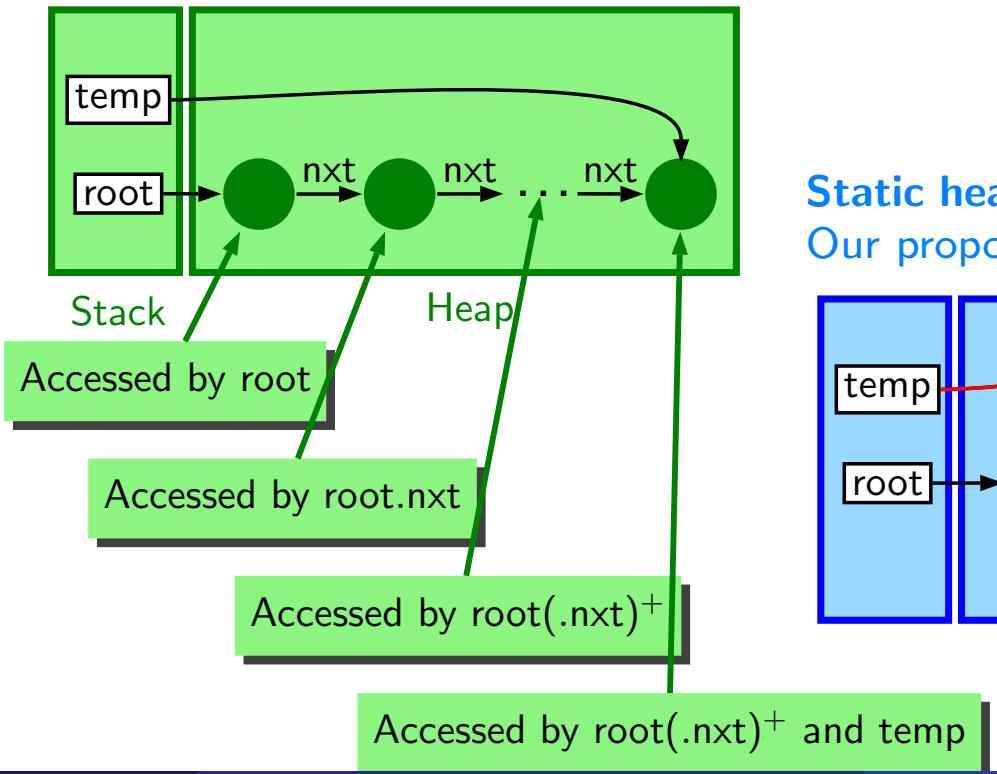

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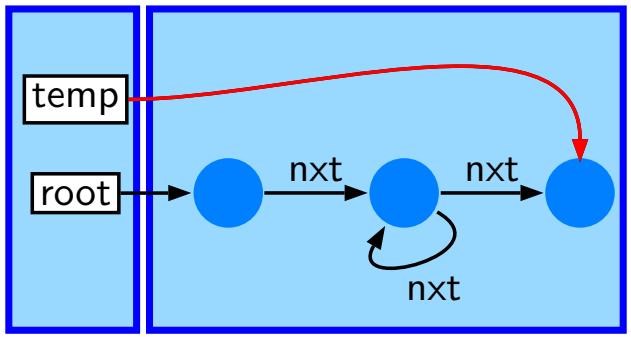

Conclusion

- We aim to improve the precision of static heap analysis (including liveness analysis).
- We are in the process of measuring the effectiveness of our method.