COMP90048: Workshop 7

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Logic Programming, but better

Intro

- In Prolog, it can be easy to accidentally write very inefficient code.

- There are two tricks: **tail recursion** and **asymptotic complexity**.

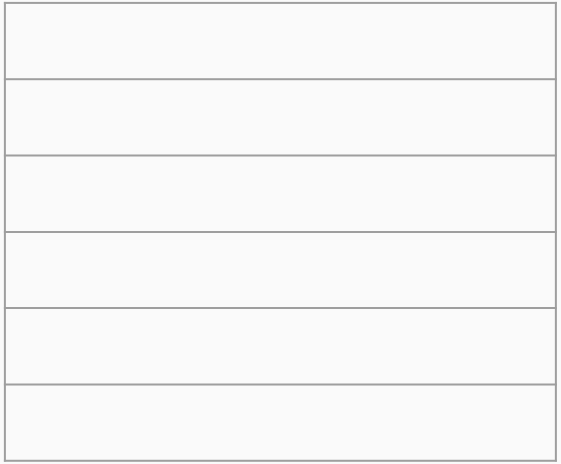
Tail recursion and the stack

- What happens when you call a function in C?

```
int n = 2;
int x;
x = factorial(n);
// x = 2

int factorial(int n) {
    return n <= 1
        ? 1
        : (n * factorial(n - 1);
}
```

The stack



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```

The stack*

n (4 bytes)

* it grows downwards by convention

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x (4 bytes)
return address (8 bytes)
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The stack

n (4 bytes)
x (4 bytes)
return address (8 bytes)
n (4 bytes)
~~return address (8 bytes)~~
~~n 1 (4 bytes)~~

popped

Tail recursion and the stack

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The stack

n (4 bytes)
x (4 bytes)

Tail recursion and the stack

- We've got two stack entries per call...

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```

The stack

n (4 bytes)
x (4 bytes)
return address (8 bytes)
n (4 bytes)
return address (8 bytes)
n - 1 (4 bytes)

Tail recursion and the stack

- Now with tail recursion!

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Tail recursion and the stack

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The stack

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Tail recursion and the stack

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Tail recursion and the stack

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The stack

n (4 bytes)
x (4 bytes)
~~return address (8 bytes)~~
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Tail recursion and the stack

- By reducing stack use, we save both memory and time.

```
int n = 2;
int x;
x = factorial(n);
// x = 2

int factorial(int n) {
    return n <= 1
        ? 1
        : (n * factorial(n - 1);
}
```

The stack

`n (4 bytes)`
`x (4 bytes)`

Tail recursion and the stack

- By reducing stack use, we save both memory and time.

The stack (no tail recursion)

`n (4 bytes)`
`x (4 bytes)`
`return address (8 bytes)`
`n (4 bytes)`
`return address (8 bytes)`
`n - 1 (4 bytes)`

The stack (tail recursion)

`n (4 bytes)`
`x (4 bytes)`
`return address (8 bytes)`
`n * (n - 1) (4 bytes)`
`n - 1 (4 bytes)`

Tail recursion and the stack

- We can do this because **recursion is the last step.**

```
int factorial(int n) {
    return n <= 1
        ? 1
        : (n * factorial(n - 1);
}
```

Tail recursion in Prolog

- Prolog works in much the same way! Consider:

```
prodlist([], 1).

prodlist([N|Ns], Prod):-
    prodlist(Ns, Prod0),
    Prod is N * Prod0.
```

- This is **not** tail recursive.

Tail recursion in Prolog

- We introduce an **accumulator** (and a helper predicate).

```
prodlist(List,Prod):-
    prodlist_acc(List, 1, Prod).

prodlist_acc([], Prod, Prod).
% to be continued
```

- The idea: `prodlist_acc` holds when its accumulator is the sum.

Tail recursion in Prolog

- We introduce an **accumulator** (and a helper predicate).

```
prodlist(List, Prod):-
    prodlist_acc(List, 10, Prod).

prodlist_acc([], Prod, Prod).
prodlist_acc([N|Ns], Acc, Prod):-
    Prod0 is Acc * N,
    prodlist_acc(Ns, Prod0, Prod).
```

Avoiding append

- Similarly to Haskell, `append/3` is O(n). We try to avoid it where we can. Consider:

Prolog

```
reverse([], []).

reverse([A|BC], CBA):-
    reverse(BC, CB),
    append(CB, [A}, CBA).
```

Avoiding append

- We can use the accumulator approach here too!

DCBAcc is the reversed list, with Acc on the end

```
reverse([], A, A).

reverse([B|CD], Acc, DCBAcc):-
    reverse(CD, [B|Acc], DCBAcc).
```

Avoiding append

- We can use the accumulator approach here too!

DCBAcc is the reversed list, with Acc on the end

```
reverse([], A, A).

reverse([B|CD], Acc, DCBAcc):-
    reverse(CD, [B|Acc], DCBAcc).
```

peel B from the **front** of the original list BCD and stick it at the **back** of the new list DCBAcc

Avoiding append

- We can use the accumulator approach here too!

```
reverse([], A, A).

reverse([B|CD], Acc, DCBAcc):-
    reverse(CD, [B|Acc], DCBAcc).
```


- This is a general method for working with lists.

Continue with Grok Workshop 7 (Week 8).