Lisp Machines and the Analysis of Their High-Level Language Computer Architecture

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April 2016

Overview

1. History of Lisp machines
2. How Lisp works
3. Problems in Execution
4. Example processor
5. Legacy of Lisp machines

Early history of Lisp

- Lambda Calculus introduced in 1930s by Alonzo Church
- Fortran in 1957
- No programming languages optimized for artificial intelligence
- Lisp designed in 1958 by John McCarthy
- Lisp code implemented on IBM 170 months after

Lisp machines

- Lisp machines released in mid-1970s, became popular in 1980s
- Manufactured by Symbolics, Lisp Machines, Inc., Xerox, TI
- Offered GUIs, advanced programmability, flexibility
- Noncompetitive hardware
- Eventually became outperformed by general-purpose computers
- Vendors went bankrupt in 1990s

Functions in Lisp

Consider a simple function `g`, which takes one argument `x`.

Example (Function in mathematics)

```
g(x)
```

In Lisp, this is written in the following manner:

Example (Function in Lisp)

```
(g x)
```

Lists

Consider a simple array of characters in Java:

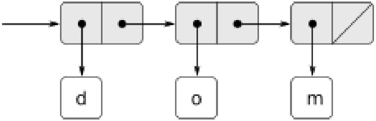
Example (Array in Java)

```
char[] myArray = ['d', 'o', 'm'];
```

In Lisp, we can write the elements as symbols, and our data structure is a `list`.

Example (List in Lisp)

```
'(d o m)
```



List-manipulating functions

car and cdr are primitive operations for lists.

- car extracts the first element from the list
- cdr extracts the rest of the list

Example (car)

```
(car '(d o m)) => 'd
```

Example (cdr)

```
(cdr '(d o m)) => '(o m)
```

Defining a recursive function

Let us define a factorial function in Lisp using recursion:

Example (Factorial function in Lisp)

```
(defun factorial(n)
(if (= n 0)
1
(* n (factorial (- n 1))
)
)
```

Evaluating a recursive function

Consider the following function call:

Example (Factorial function call in Lisp)

```
(factorial 5)
```

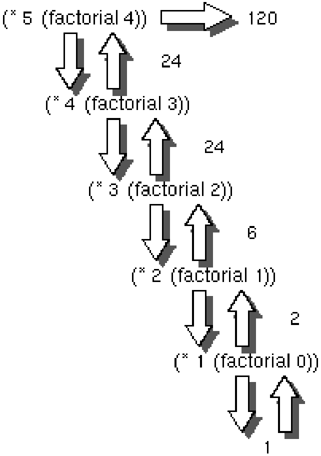
Here is its evaluation path:

Function call	Evaluation 1	Eval 2	Eval 3
`(factorial 5)`	`(* 5 (factorial 4))`	`(* 5 24)`	120
`(factorial 4)`	`(* 4 (factorial 3))`	`(* 4 6)`	24
`(factorial 3)`	`(* 3 (factorial 2))`	`(* 3 2)`	6
`(factorial 2)`	`(* 2 (factorial 1))`	`(* 2 1)`	2
`(factorial 1)`	`(* 1 (factorial 0))`	`(* 1 1)`	1

Table: Complete recursive evaluation

Recursive evaluation example explained

The program checks if the argument `n` is equal to 0 (the base case). If so, the function evaluates to 1 and terminates; otherwise, the function will multiply the argument by the factorial with `n-1` as the argument instead. This creates a chain, and evaluates to the factorial of `n`.



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Multiple Columns

Heading

1. Statement
2. Explanation
3. Example

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Theorem

Theorem (Mass–energy equivalence)

$E = mc^2$

Figure

Uncomment the code on this slide to include your own image from the same directory as the template .TeX file.

Citation

An example of the `\cite` command to cite within the presentation:

This statement requires citation [Smith, 2012].

References

John Smith (2012)
Title of the publication
Journal Name 12(3), 45 – 678.

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