Calling Variadic Functions from a Strongly Typed Language

Matthias Blume *Toyota Technological Institute at Chicago*
Mike Rainey *University of Chicago*
John Reppy *University of Chicago*

Variadic functions in C

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int printf (const char *, ...);
```

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int printf (const char *, ...);

printf (“%d”, 10);
```

Variadic functions in C

```
int printf (const char *, ...);

printf (“%d”, 10);

printf (“%g: %d(%f)\n”, 10.0, 3, 0.25);
```

Outline

- Why are we doing this?
- How does calling variadic functions work in C?
- Why doesn't the same approach work in ML?
- Located Arguments via Staged Allocation: Our solution to the (low-level part of the) problem
- Conclusions
- High-level interface via "Danvy-style" typing

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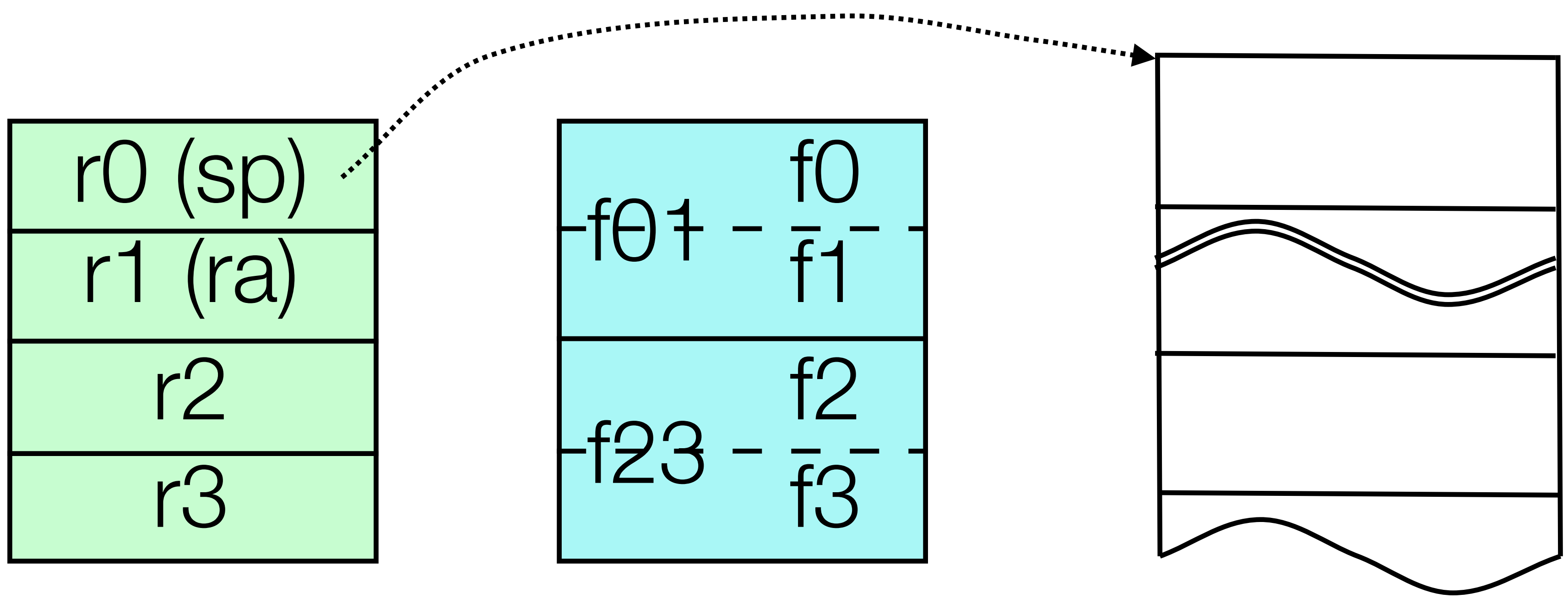
- Being able to call **`printf`**?
    - no
- Utility:
    - Some APIs rely heavily on variadic functions
- Completeness:
    - NLFFI models the *entire* C type system - but (until now) with the single exception of variadic functions

Calling a fixed-arity C function

Call: `j = f (i, x, w, c, p);`

Prototype: `int f (int, double, float, char, void *);`



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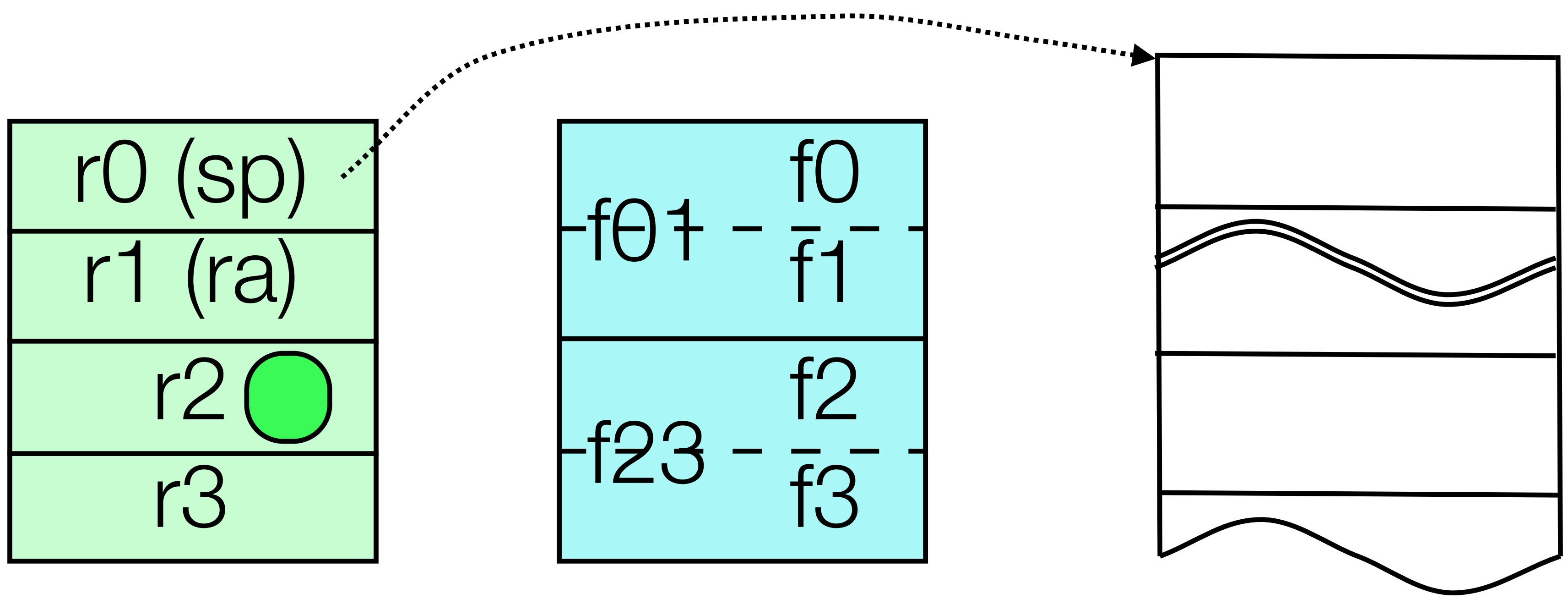

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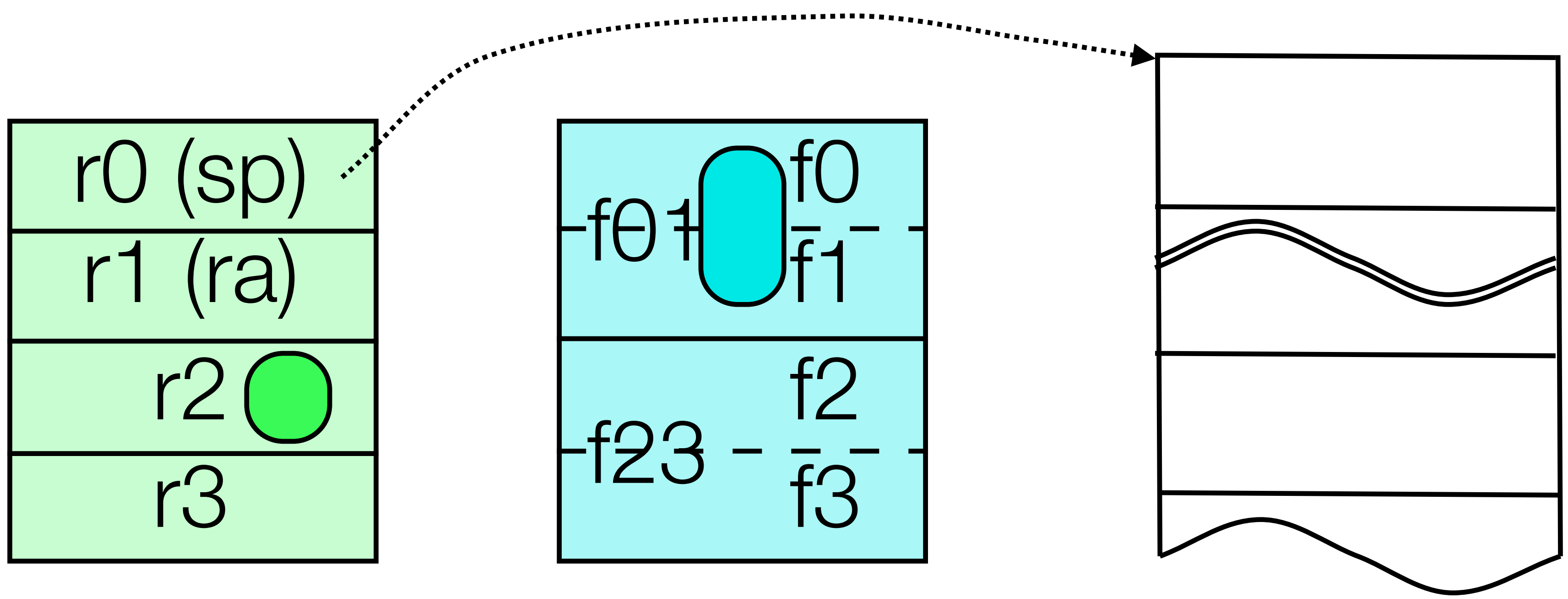

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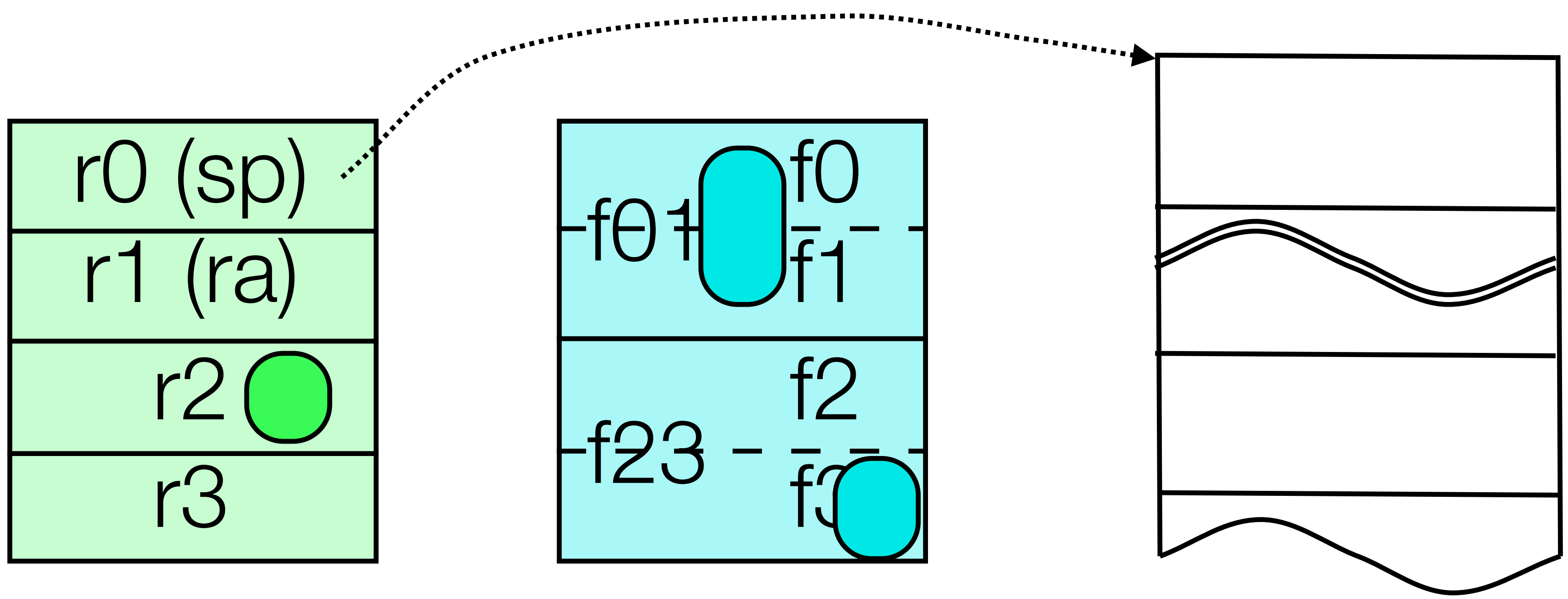

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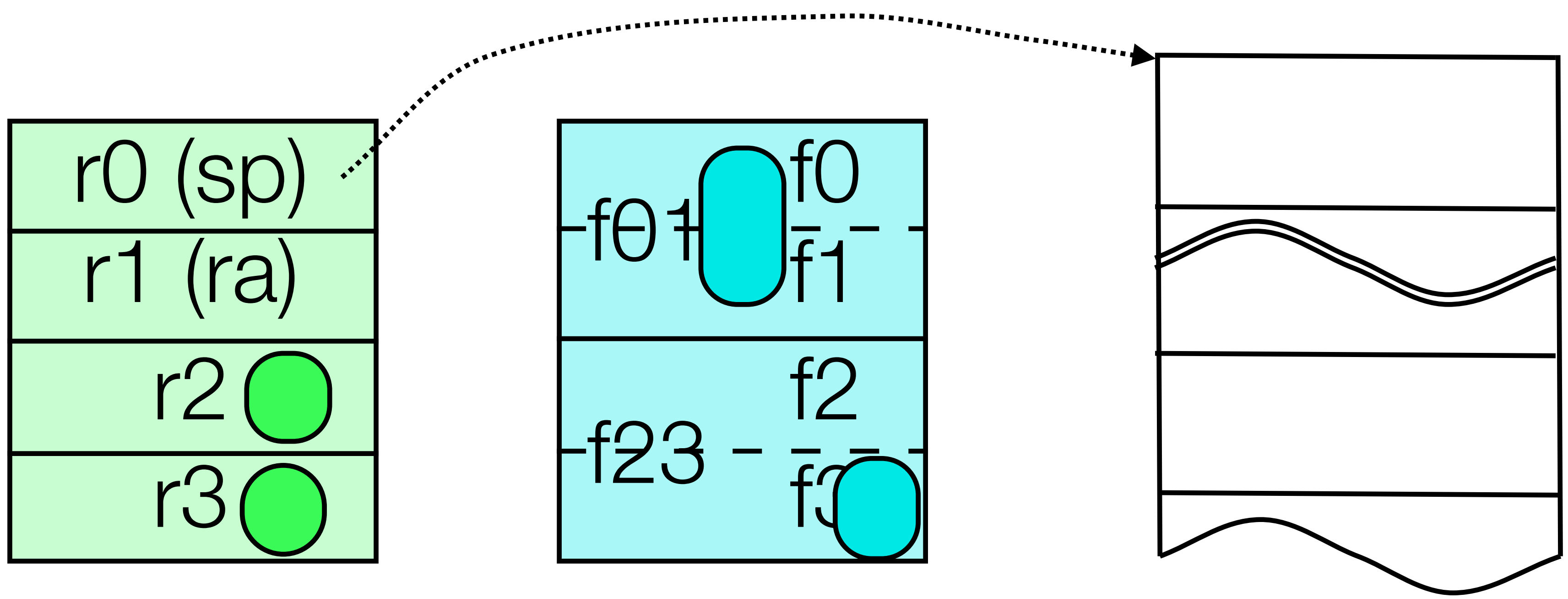

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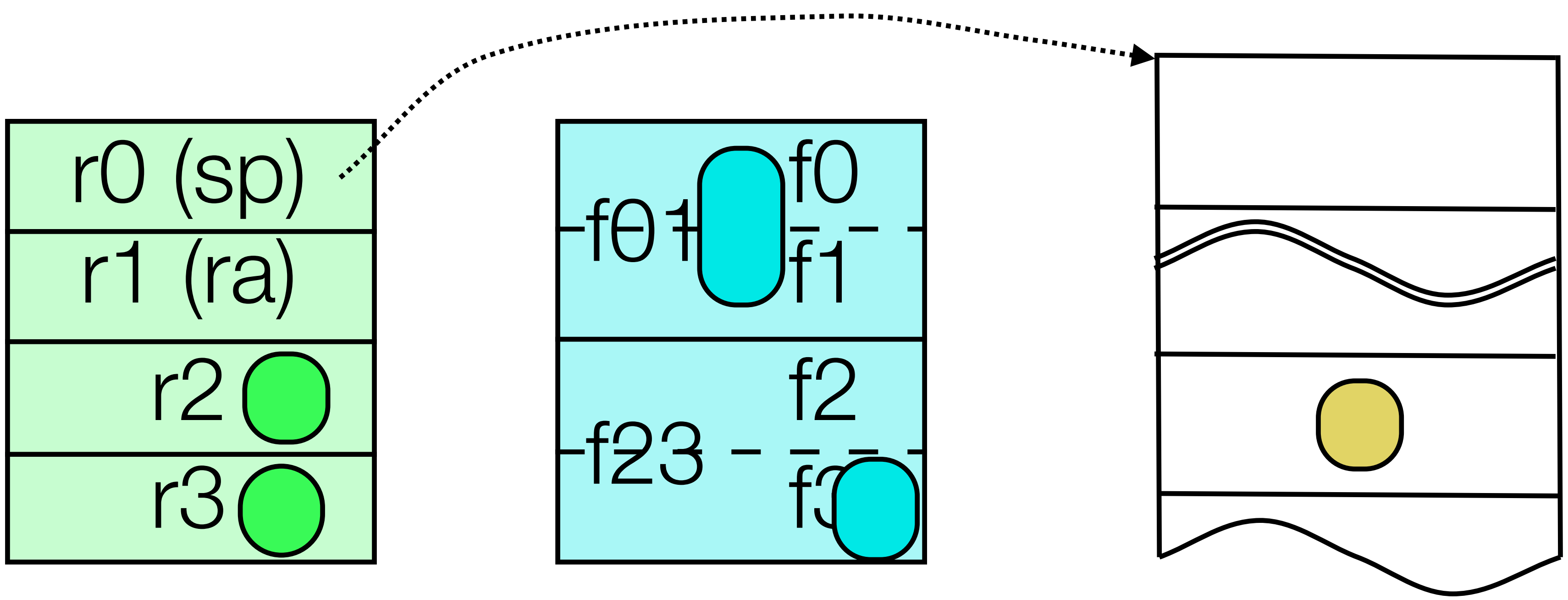

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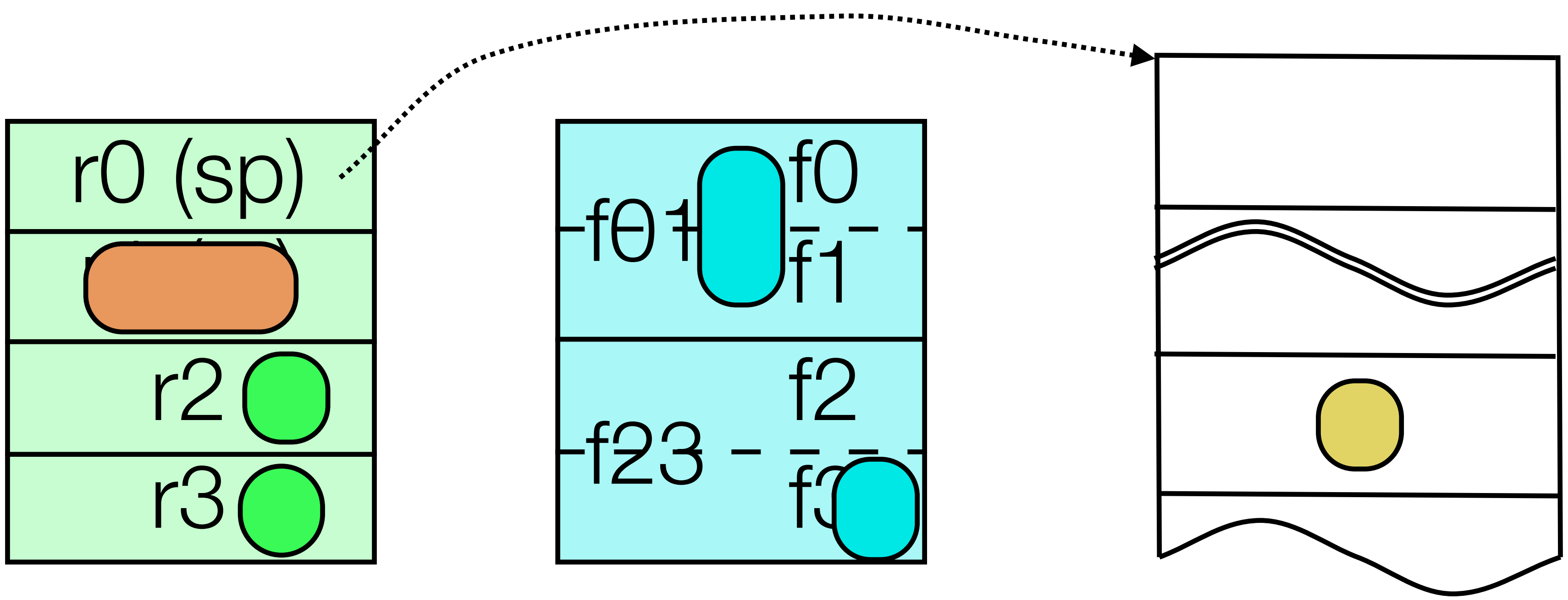

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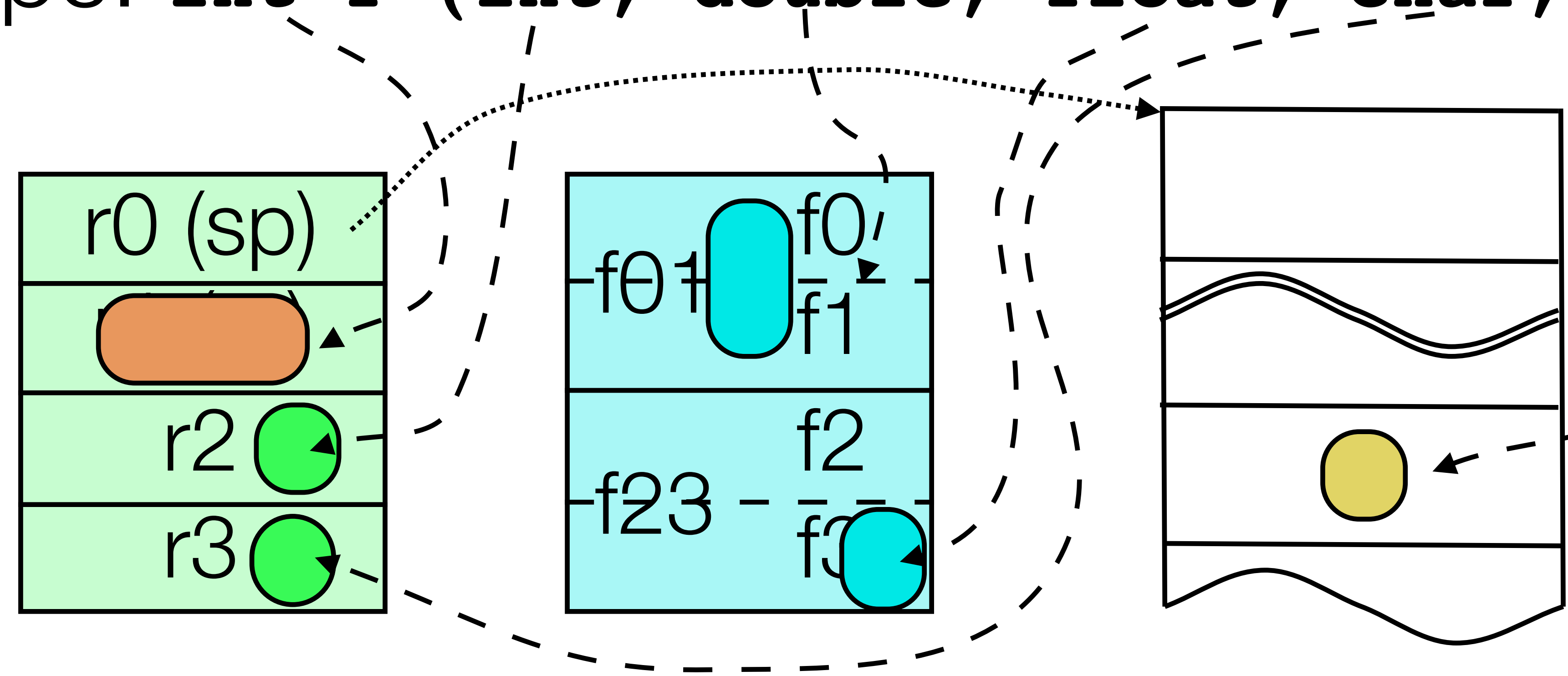

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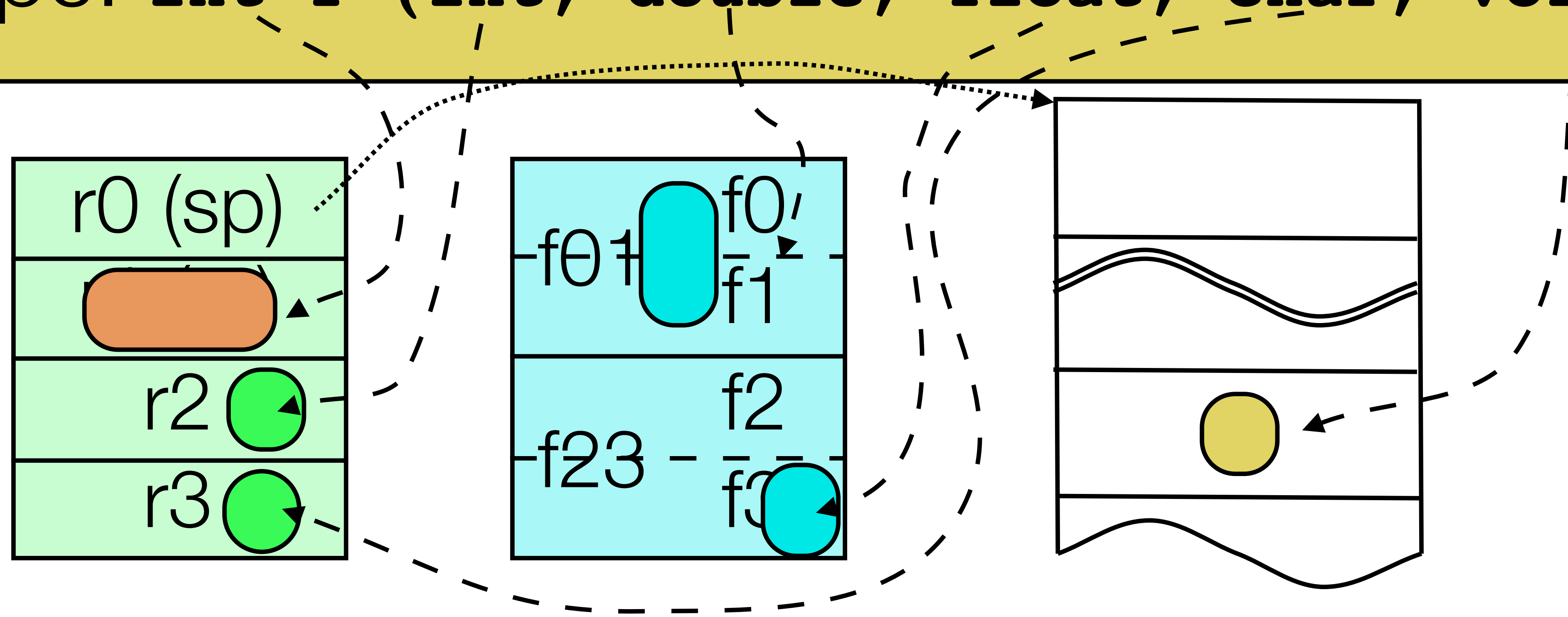

Calling a variadic function *from* C

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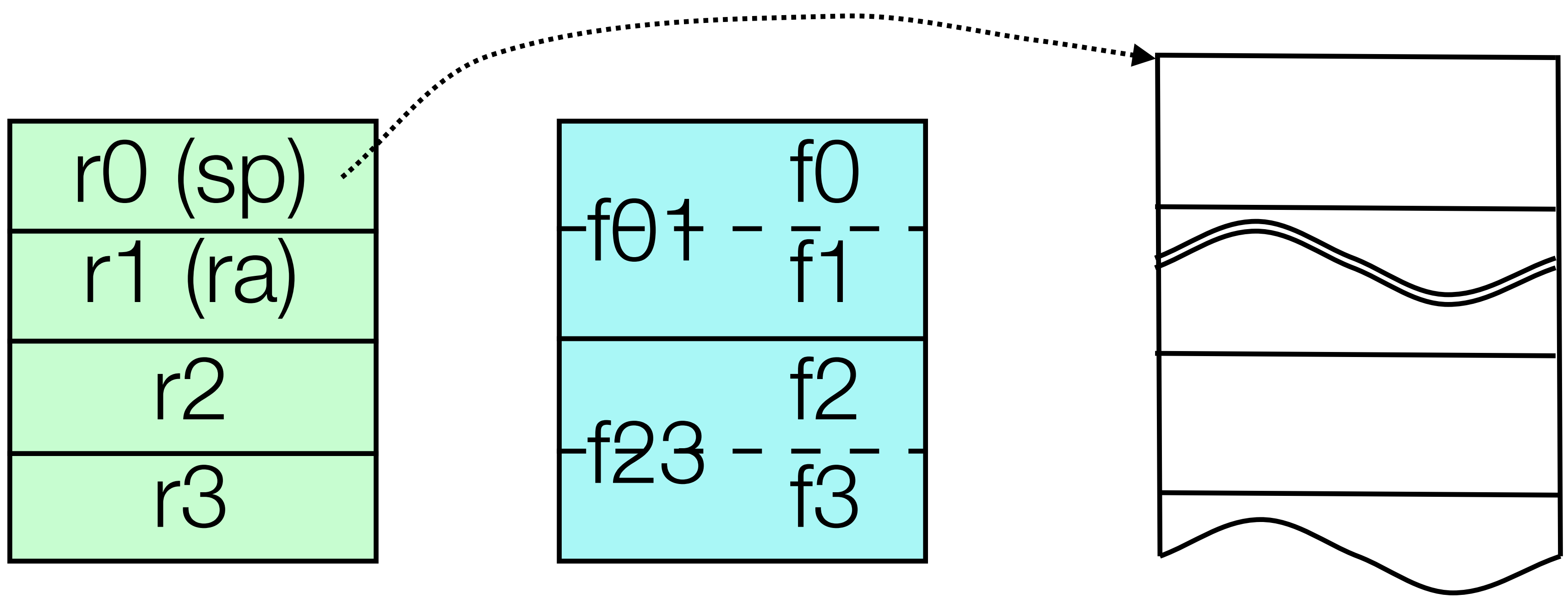

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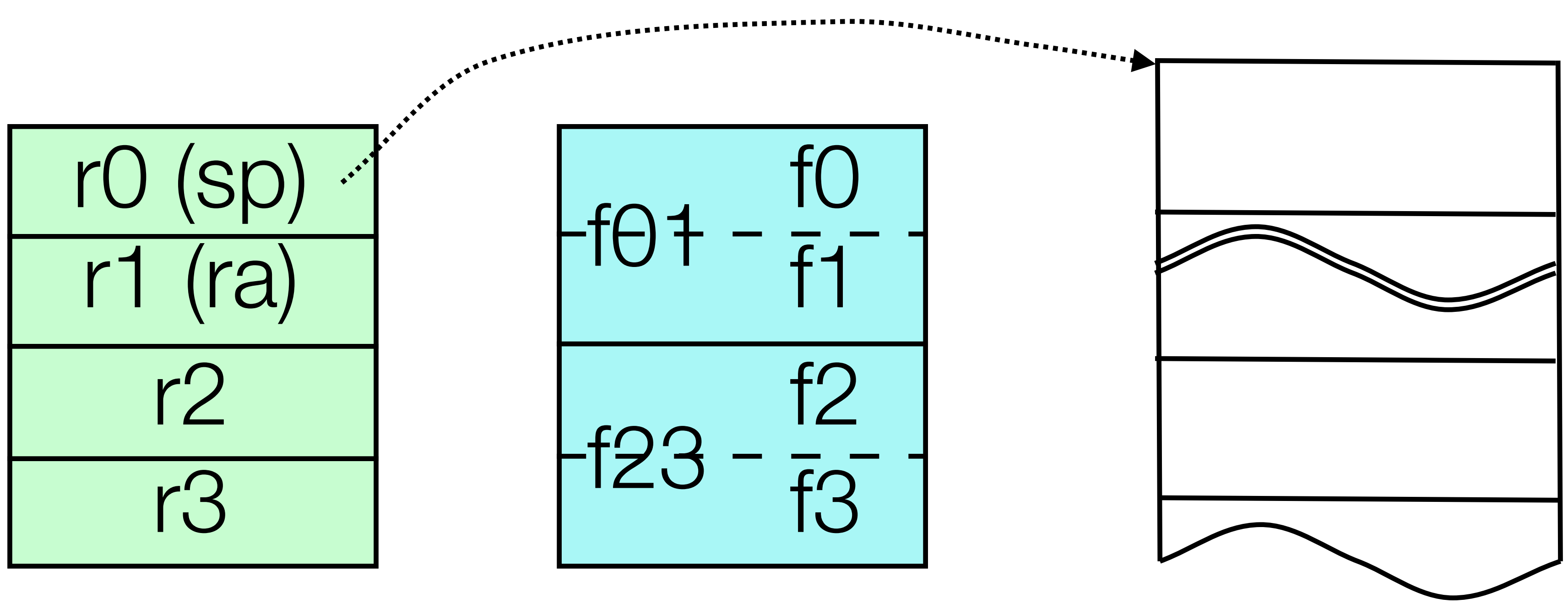

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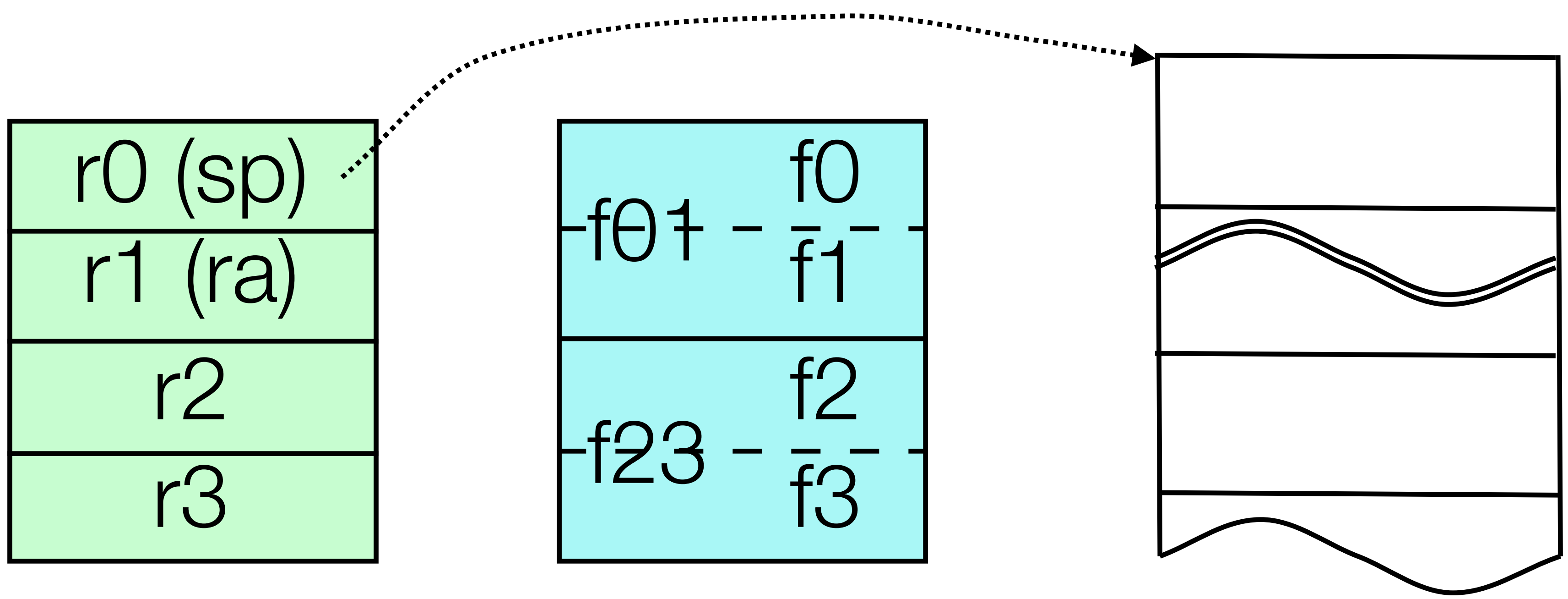

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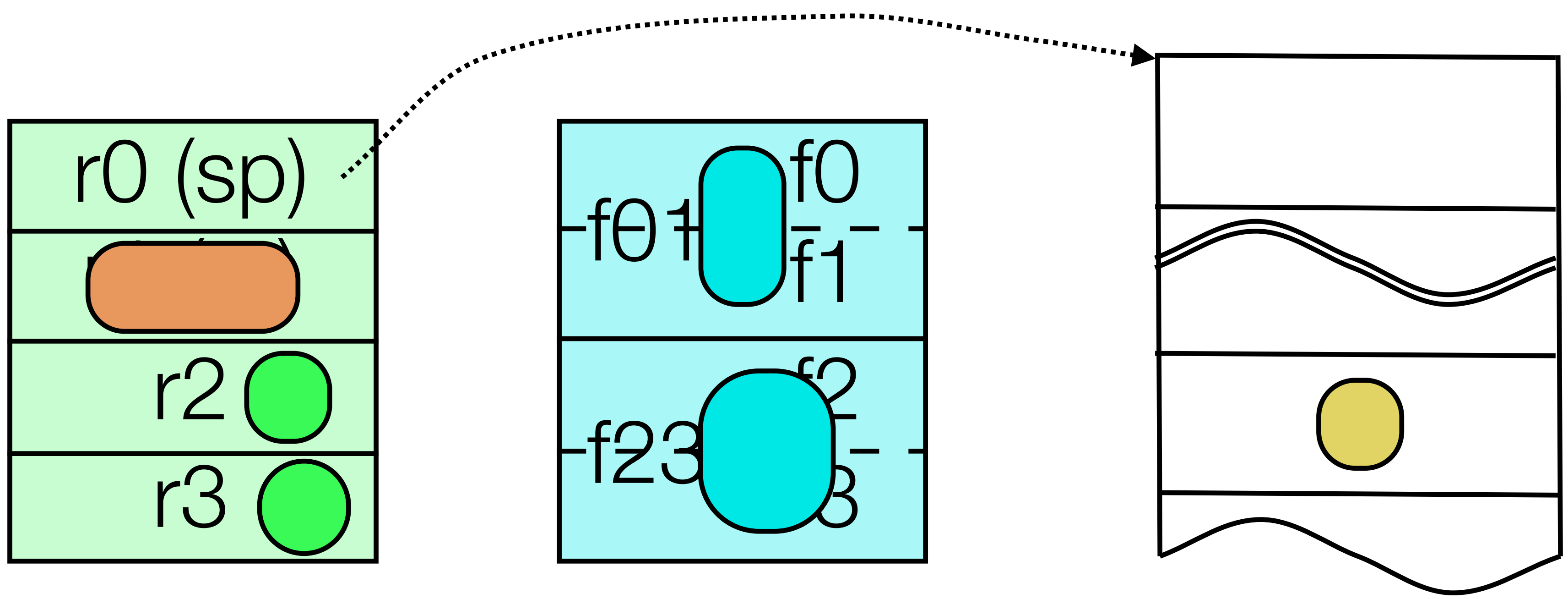

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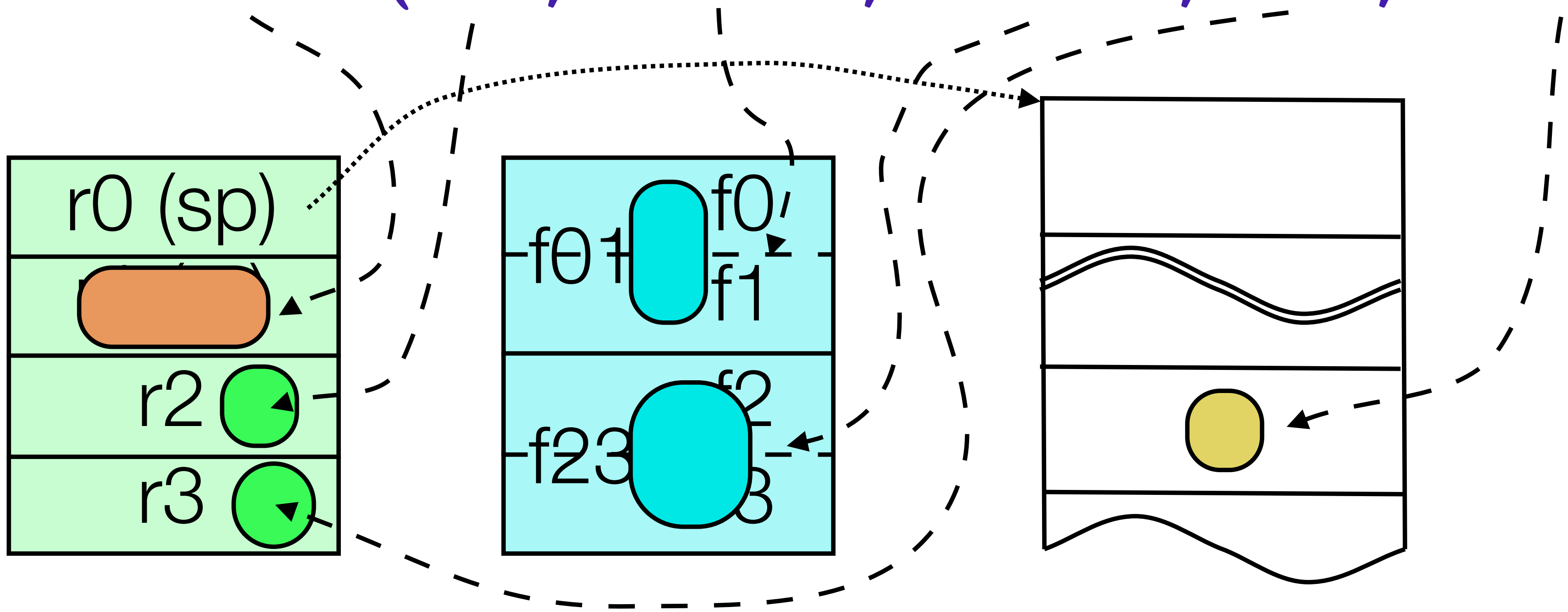

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- The pieces we need:
  - Calling conventions
  - The sequence of types
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Calling a variadic function from ML

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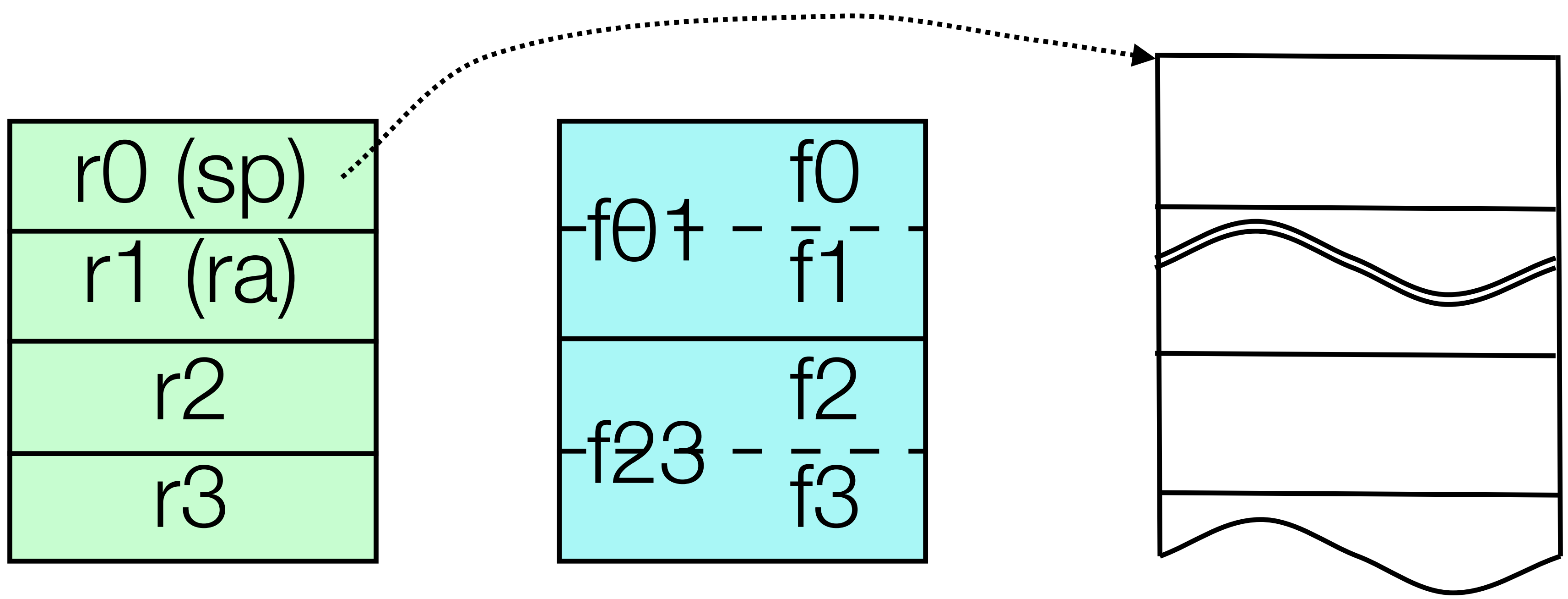

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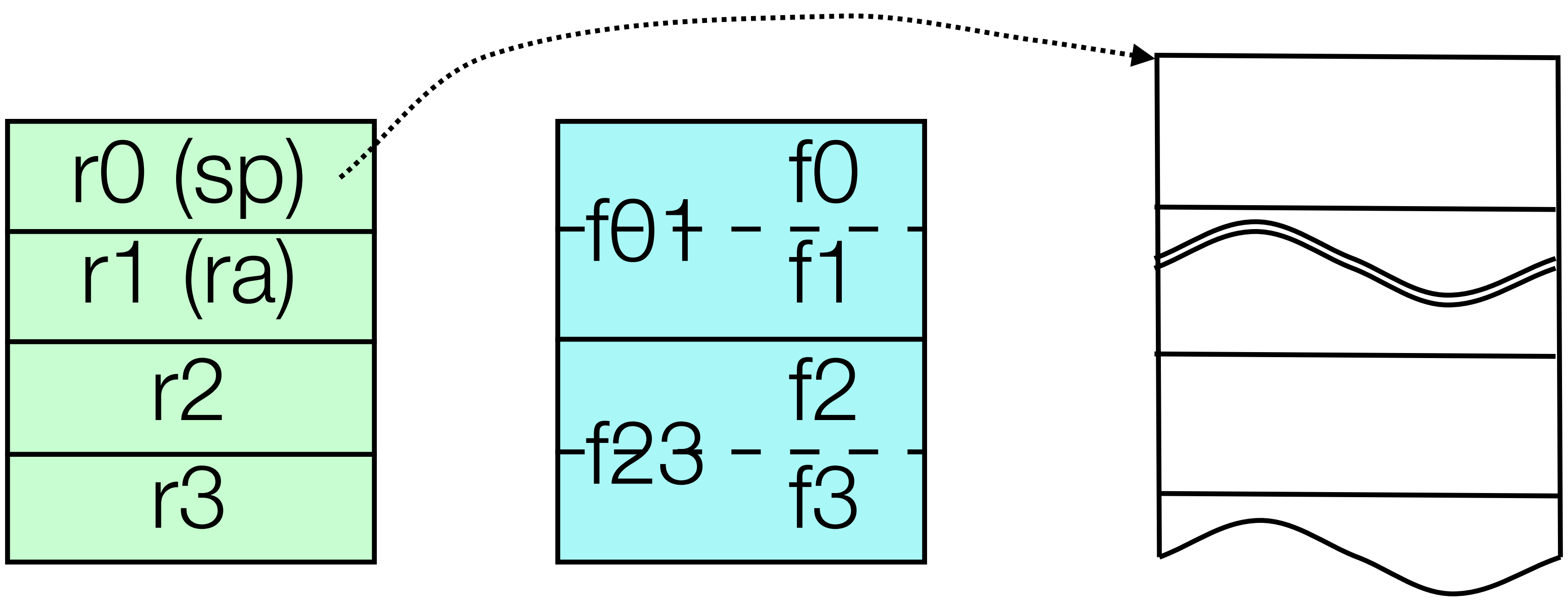
implied (inferred?) Prototype: `? f (?, ?, ?, ?, ?);`



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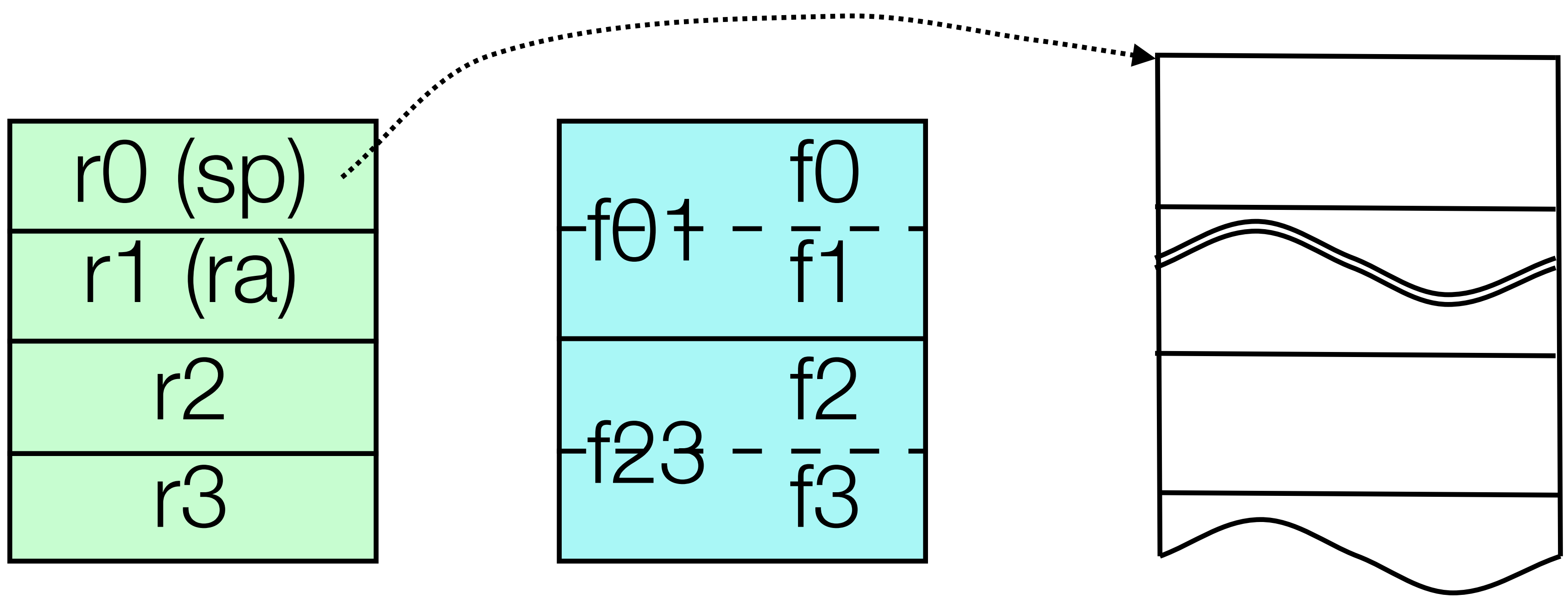

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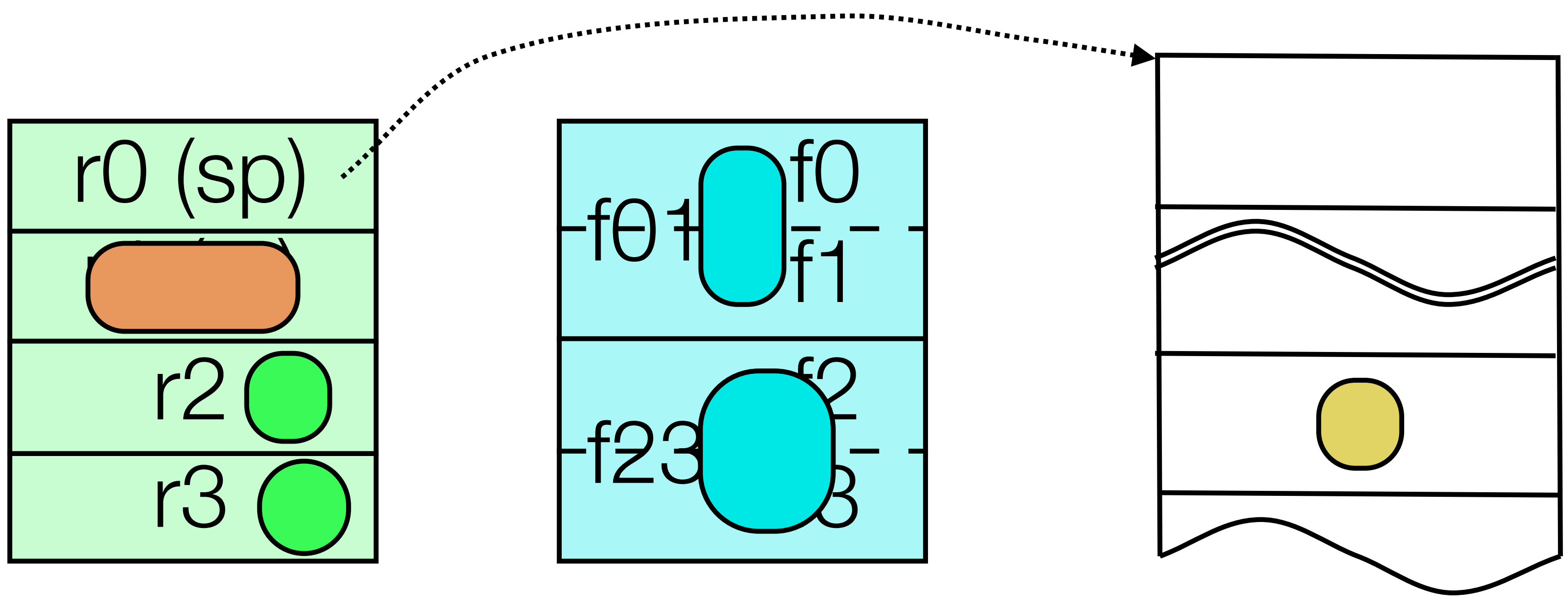

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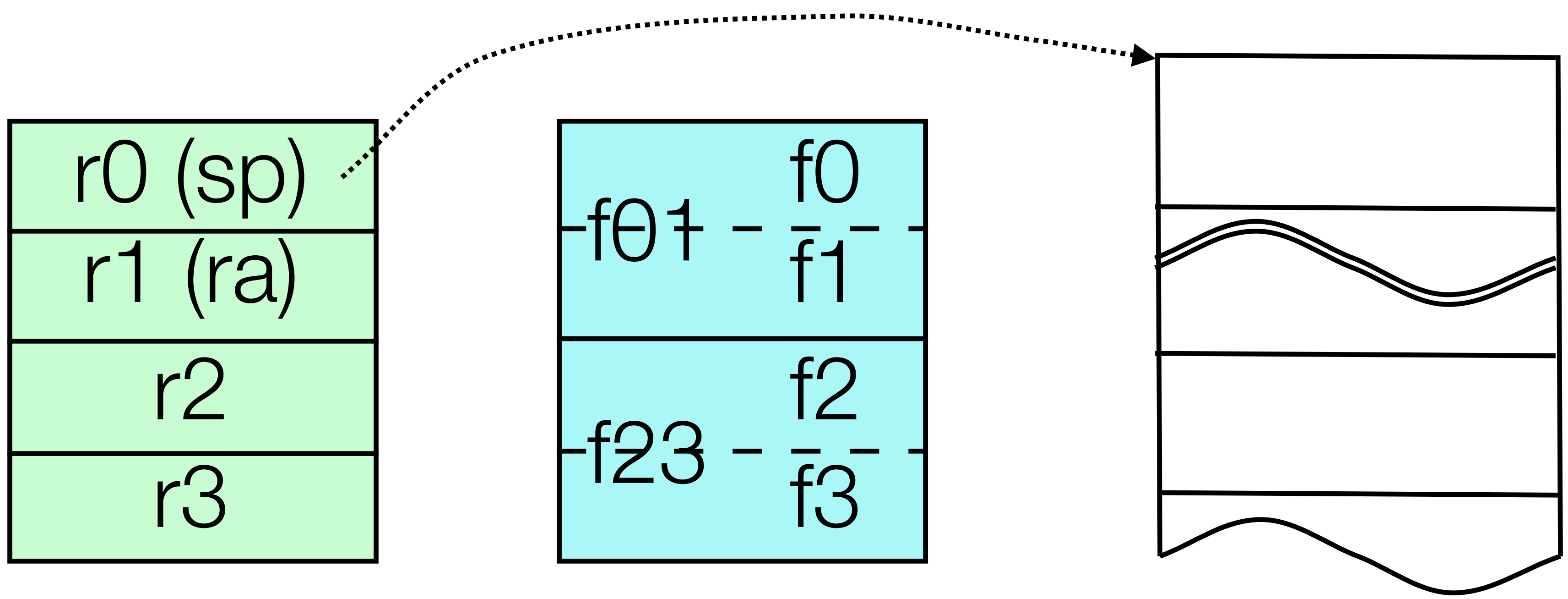

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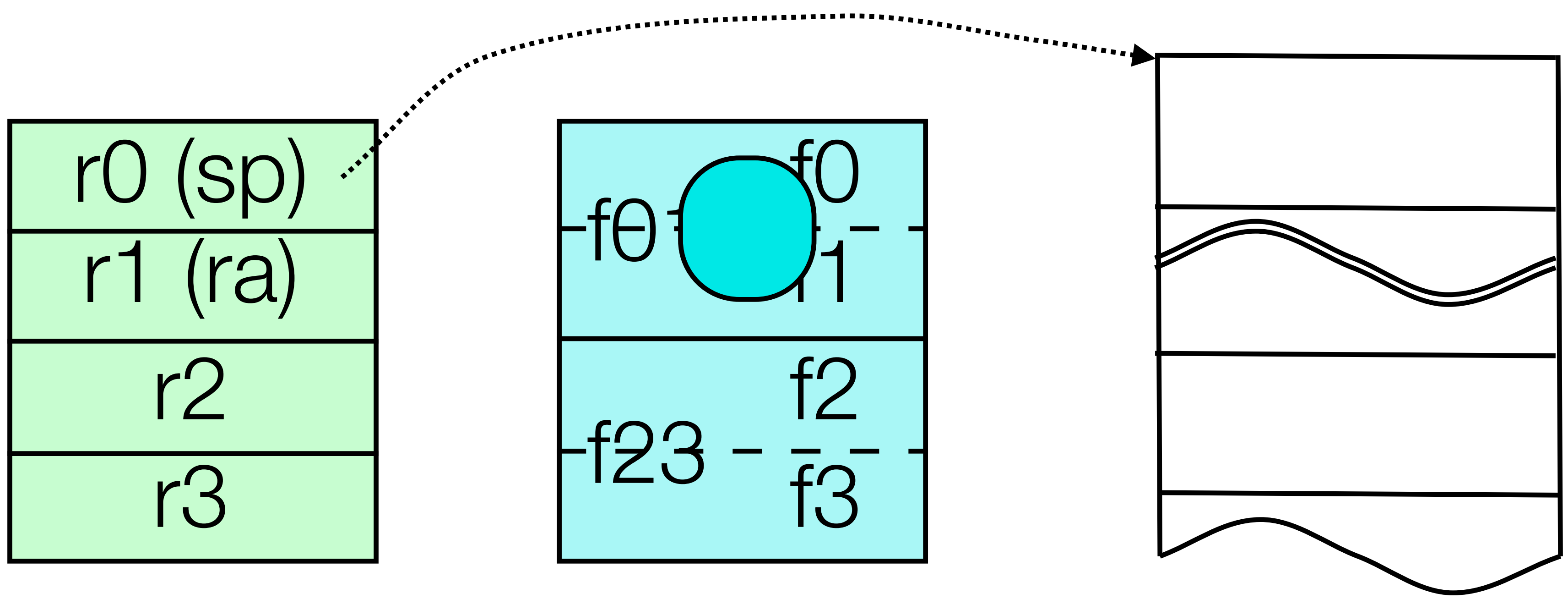

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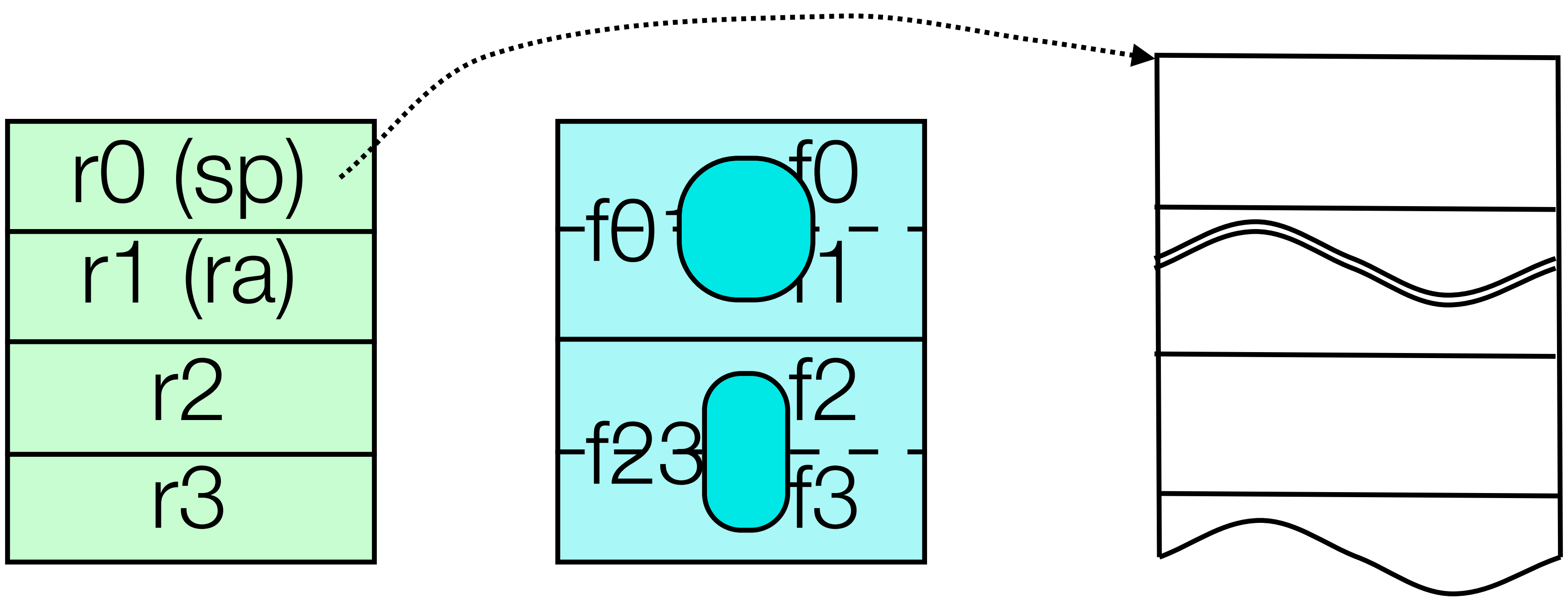

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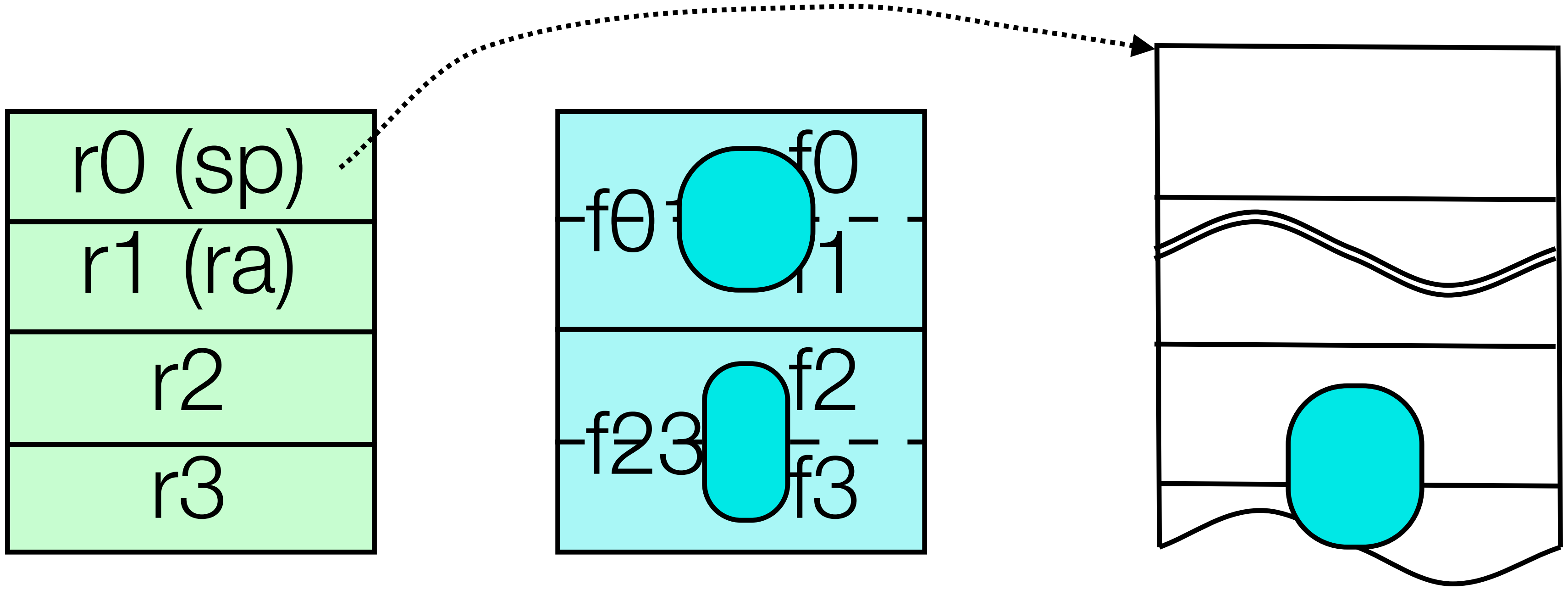

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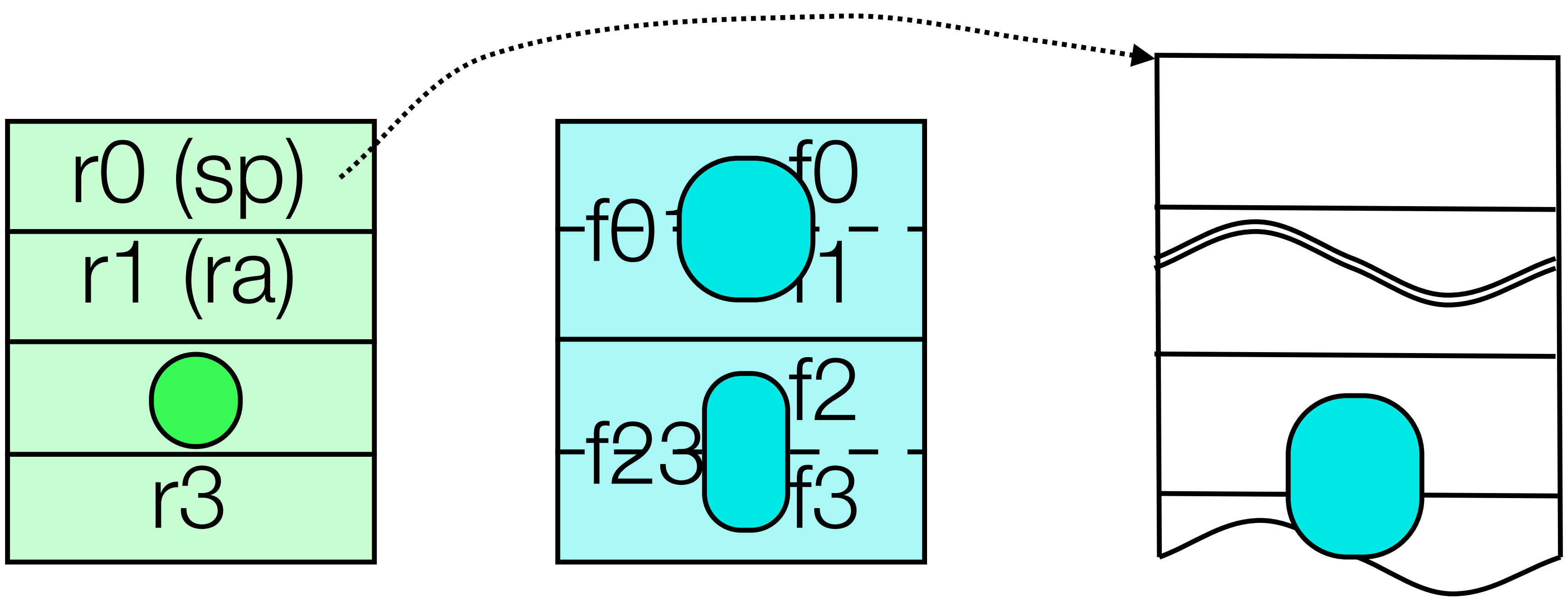

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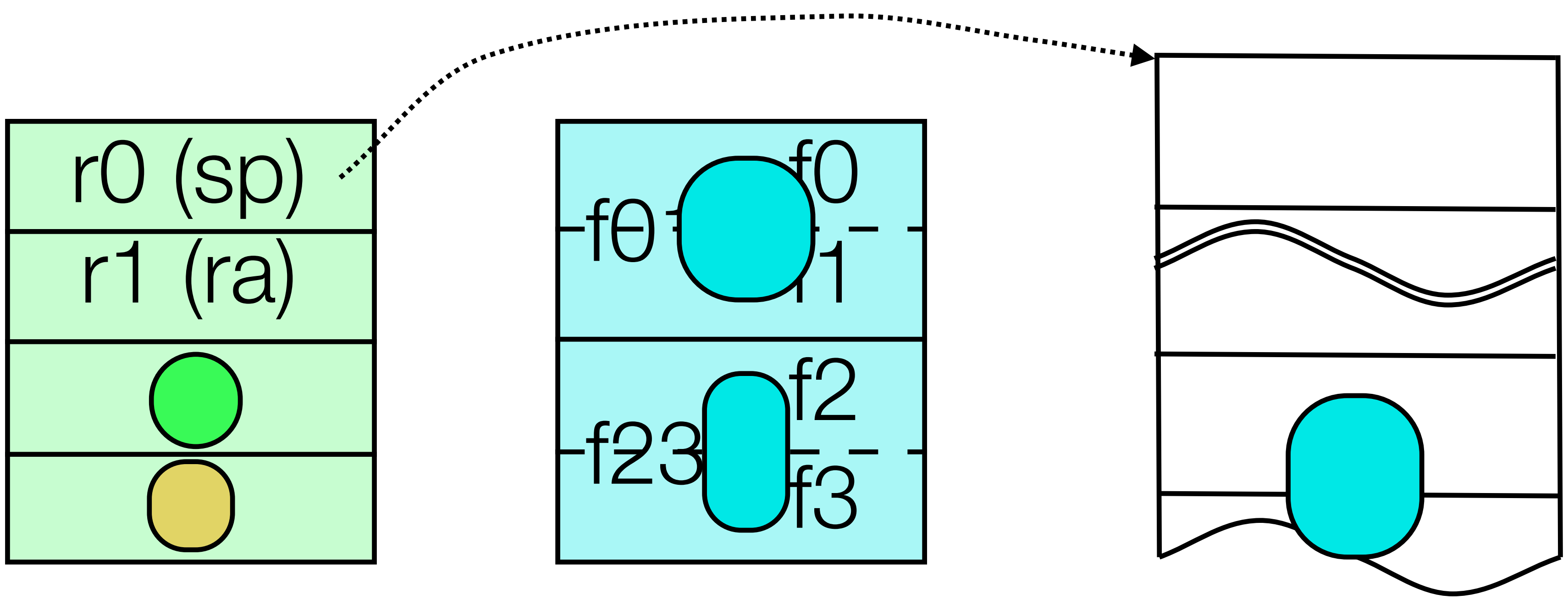

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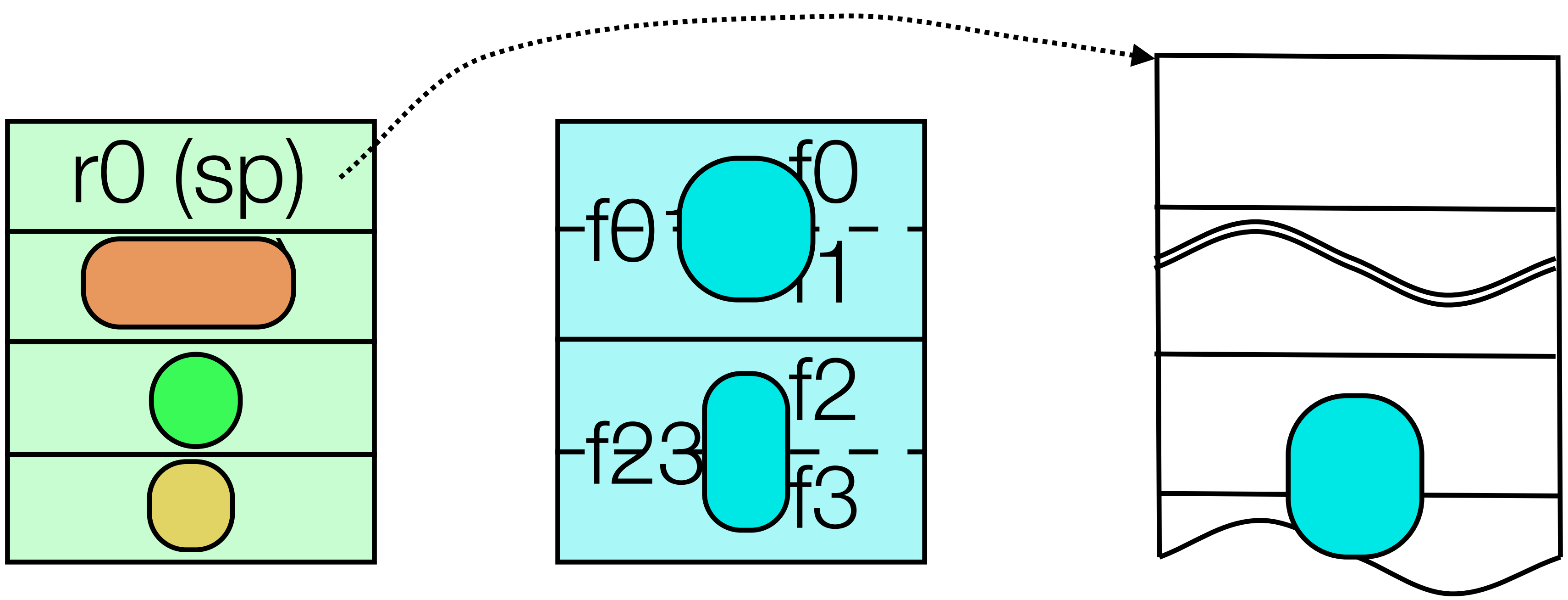
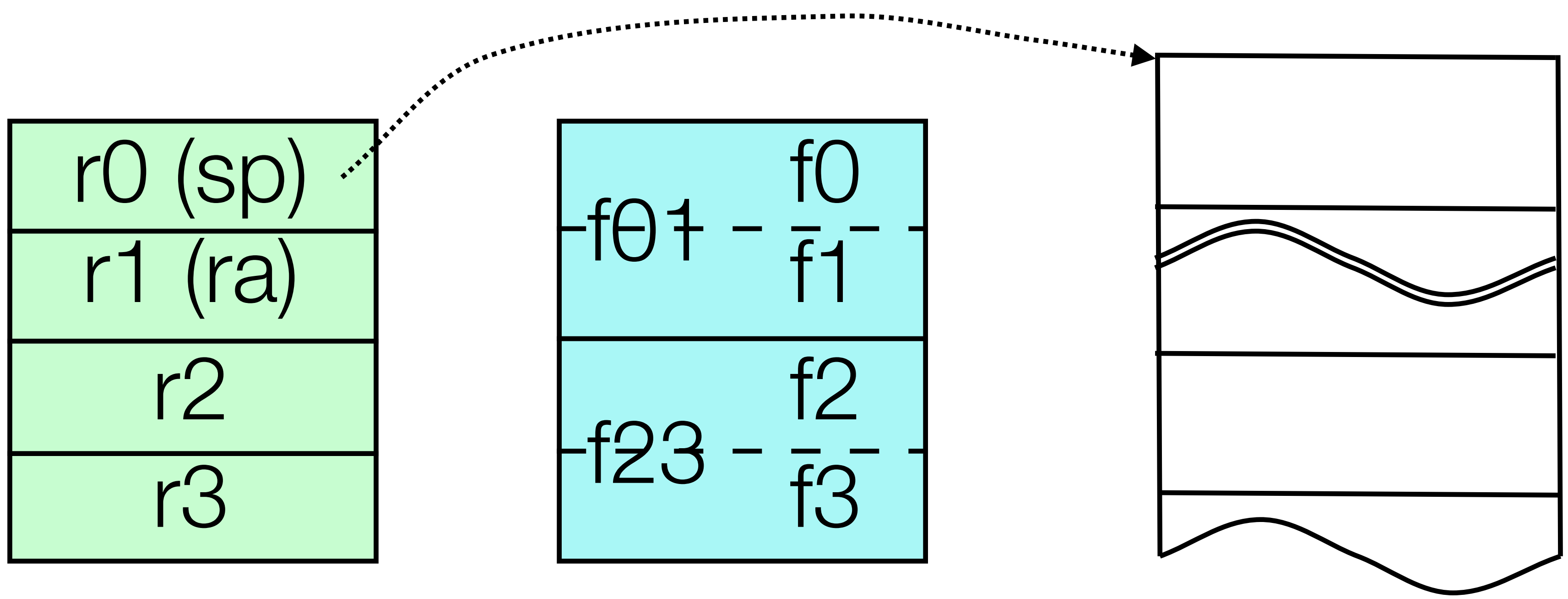


Calling a variadic function from a ***polymorphic*** ML function

```
fun g i =  f (i, x, w, c, p) + 1
```

inferred Prototype: `int f (α, double, double, int, ptr);`



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- **Two routes:**

  1. Monomorphize

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  2. Use intensional type information

     - *... complicated*

     - *... not static,* i.e., *is a runtime technique*

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```
datatype arg = INT of xint
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             | FLOAT of xfloat
             | DOUBLE of xdouble
             | PTR of xaddr

val dispatch : xaddr * arg list -> unit
```

So ultimately...

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dispatch (f, [INT i, DOUBLE x, FLOAT w, CHAR c, PTR p])
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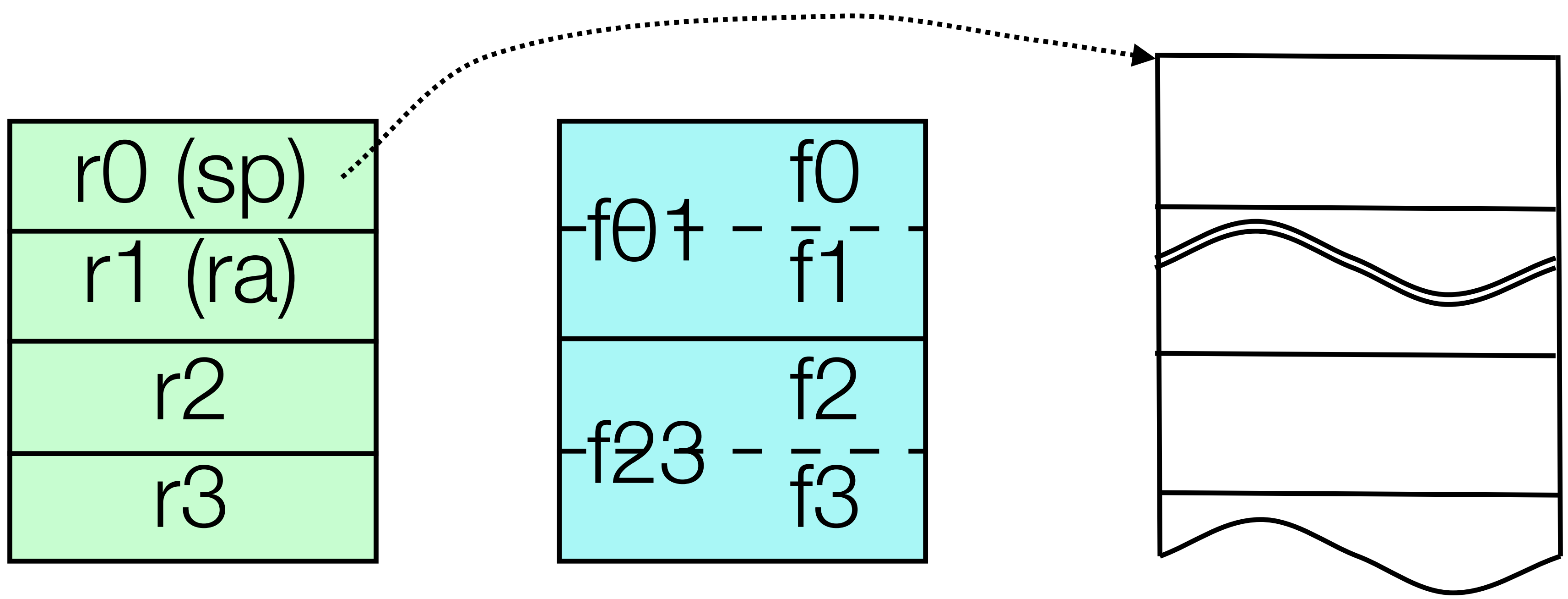
- ... we don't make use of the ML compiler's type information
  - Solution is not ML-specific.
  - It can be adapted even to dynamically typed settings.
  - Use "universal" type of C values in statically typed setting.

Calling a variadic function

`dispatch (f, [INT i, DOUBLE x, FLOAT w, CHAR c, PTR p])`



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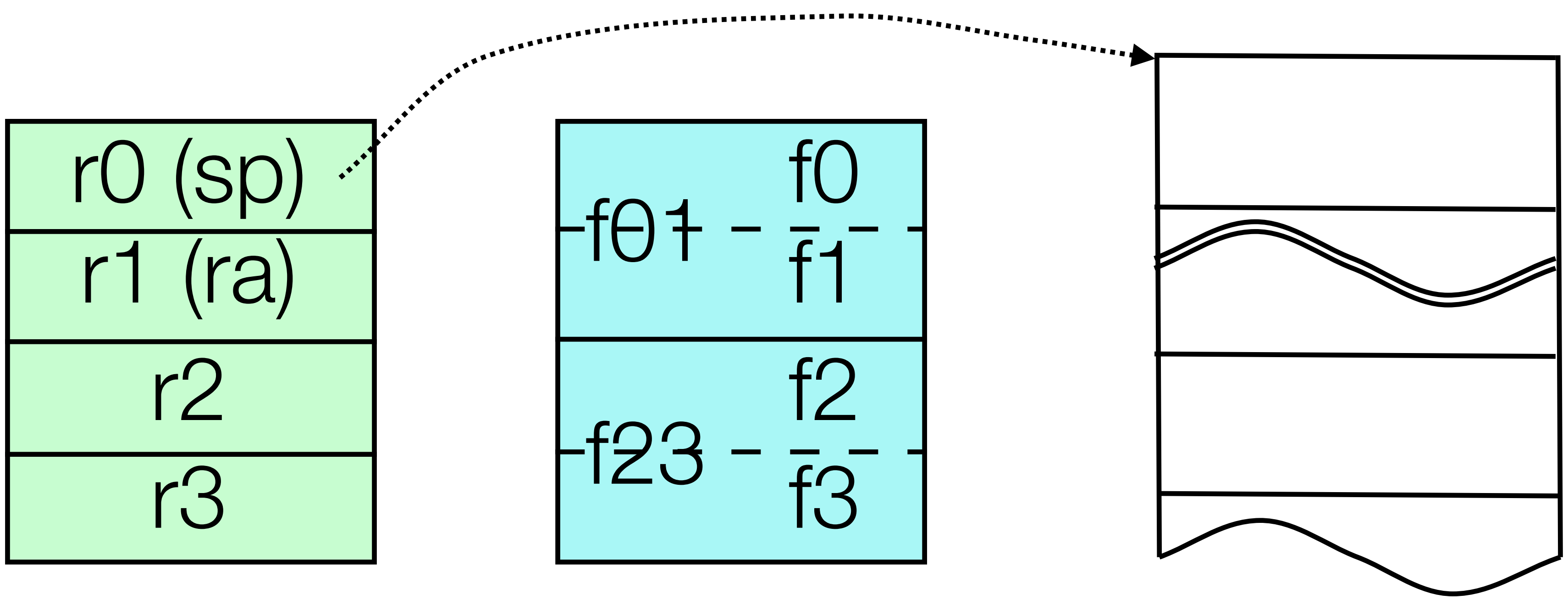

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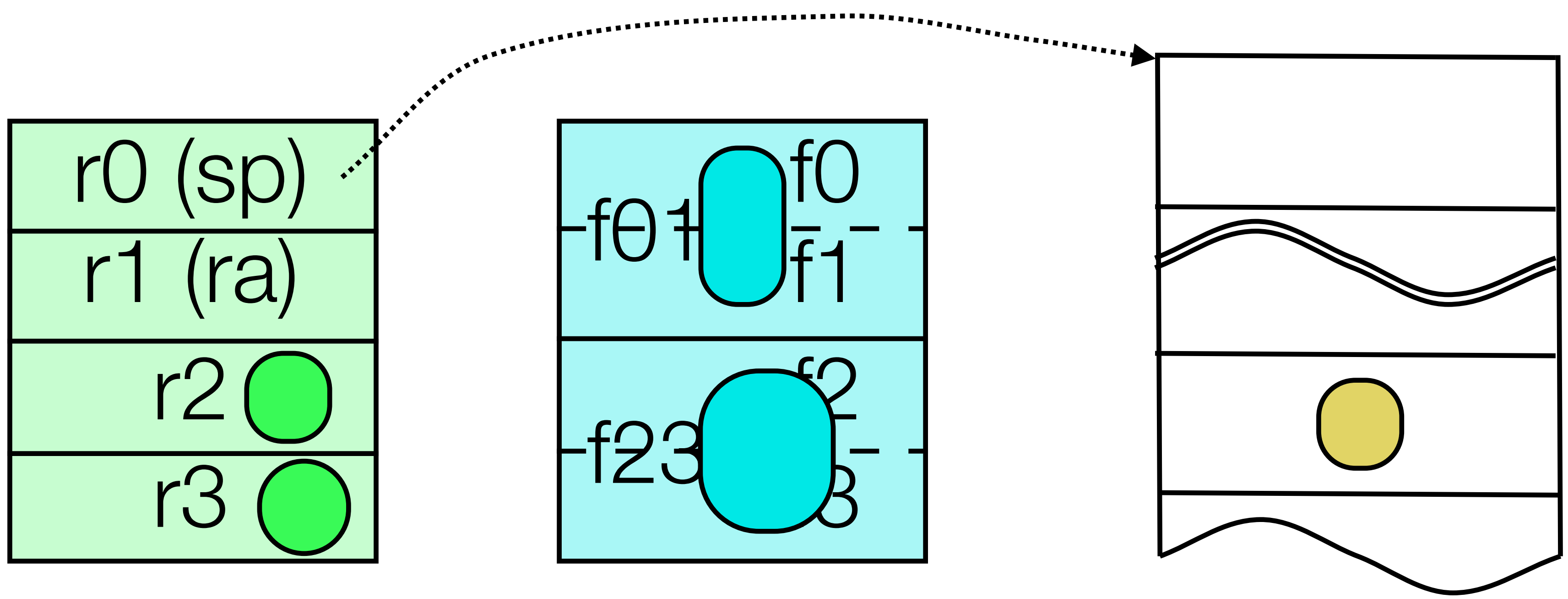

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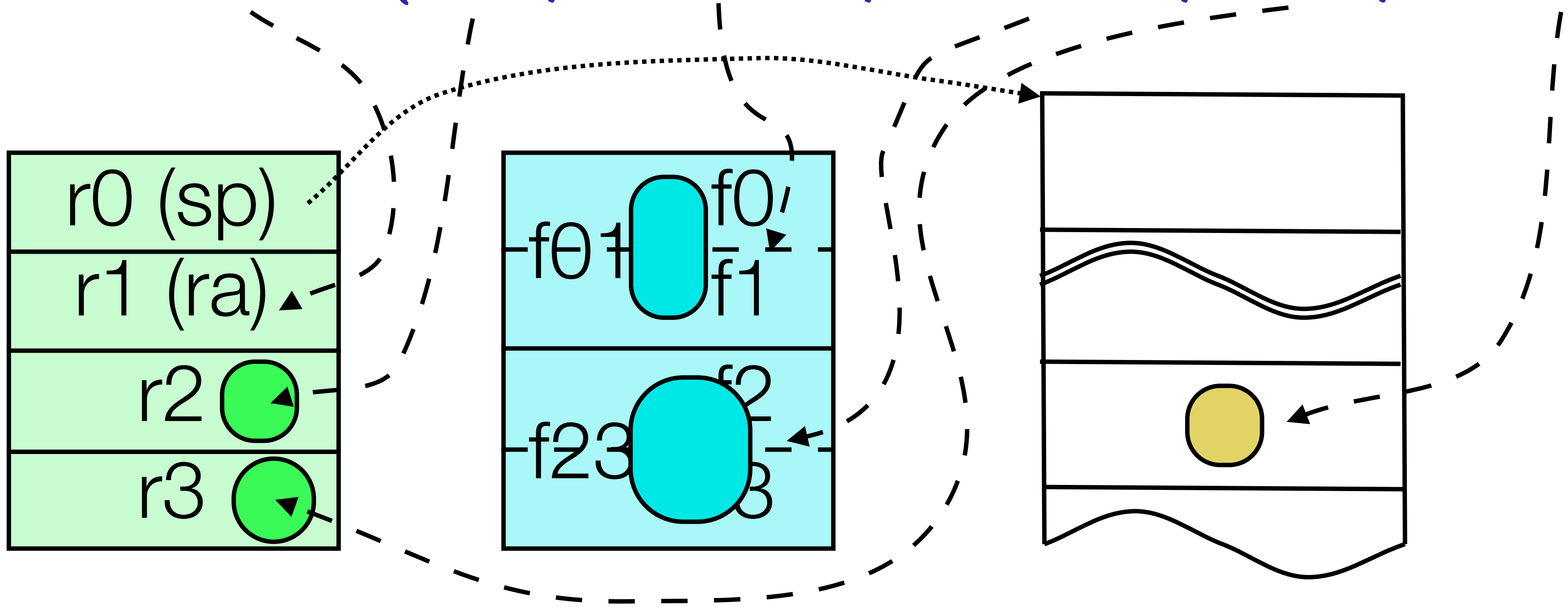
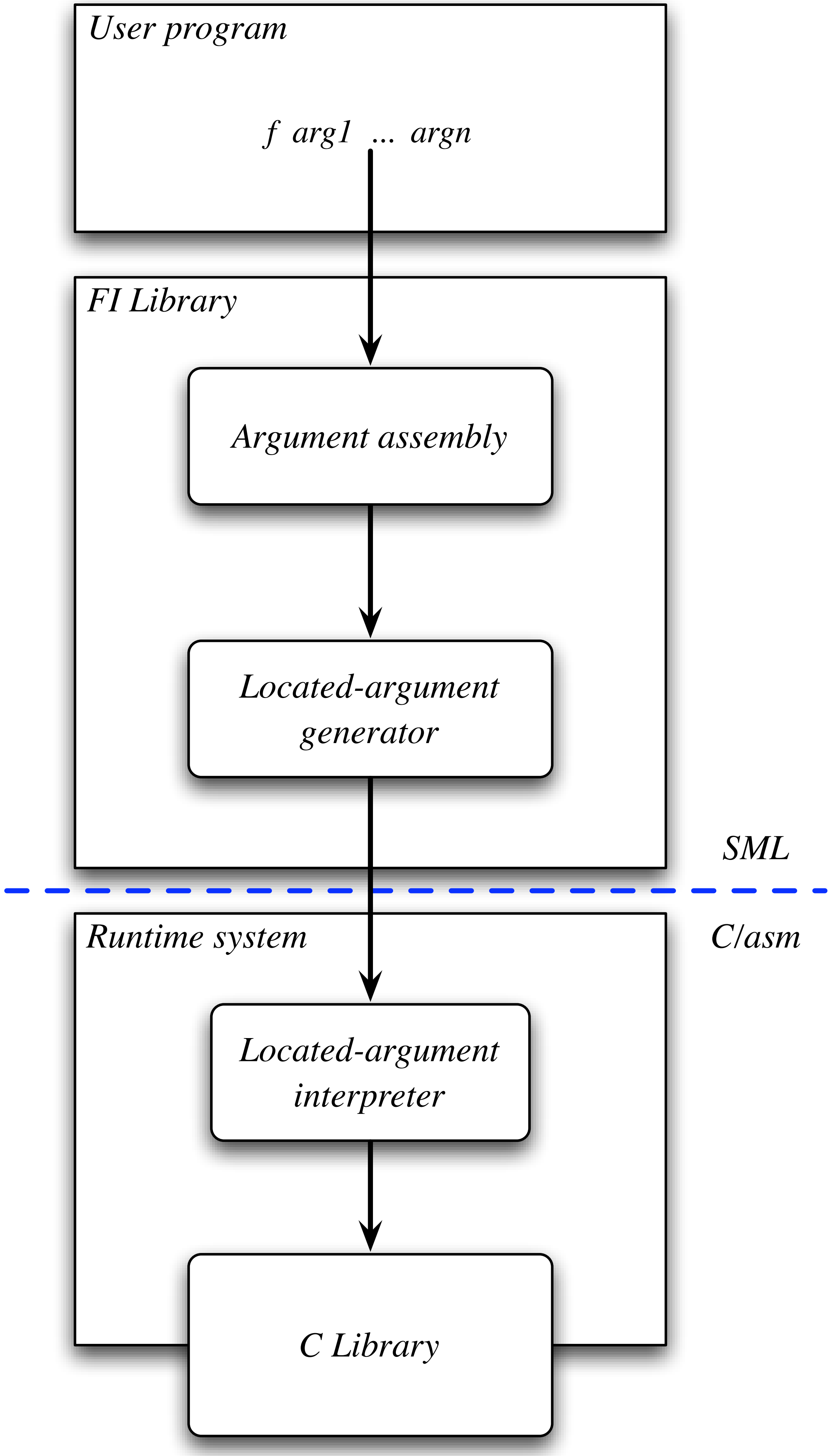
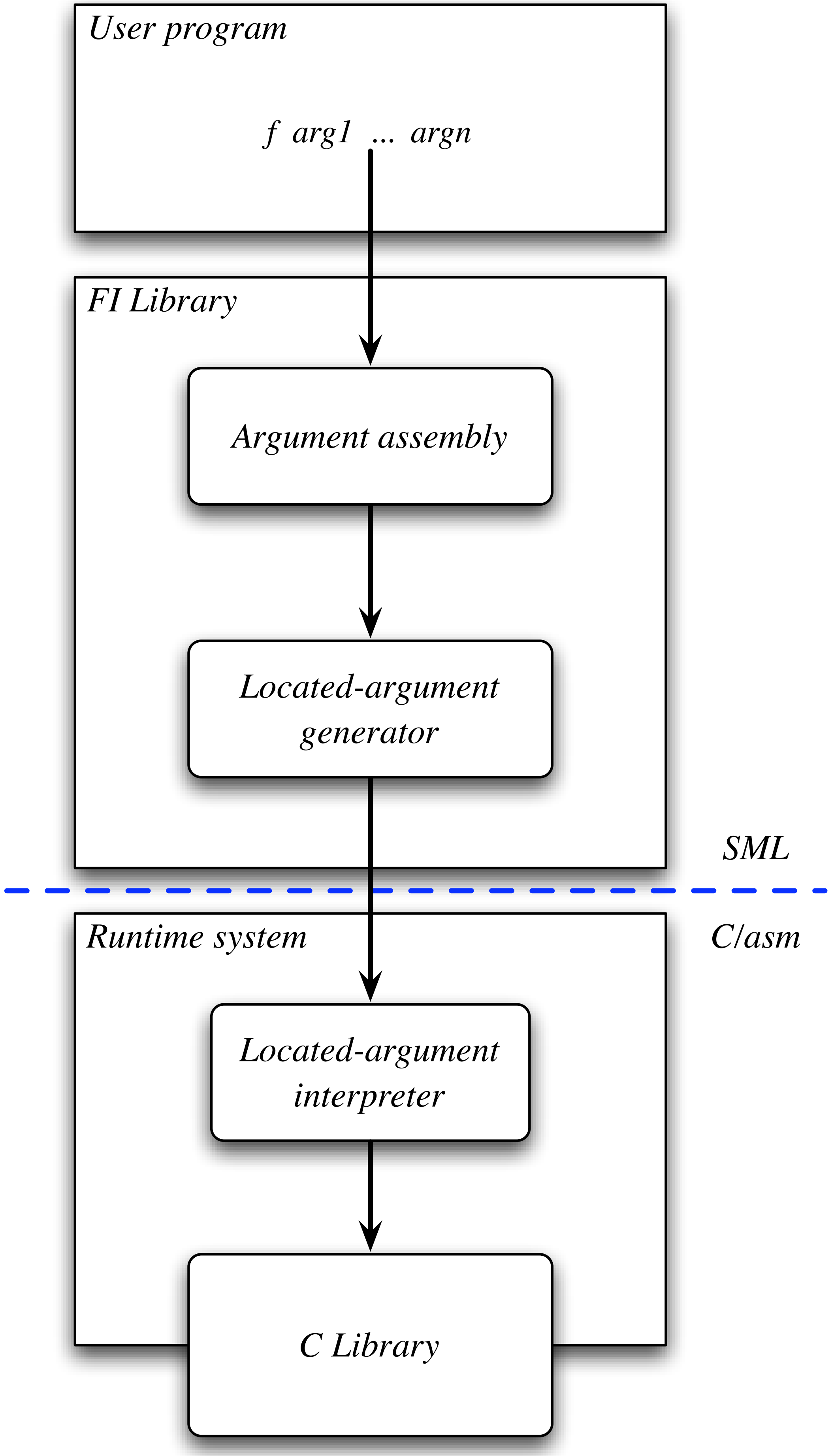
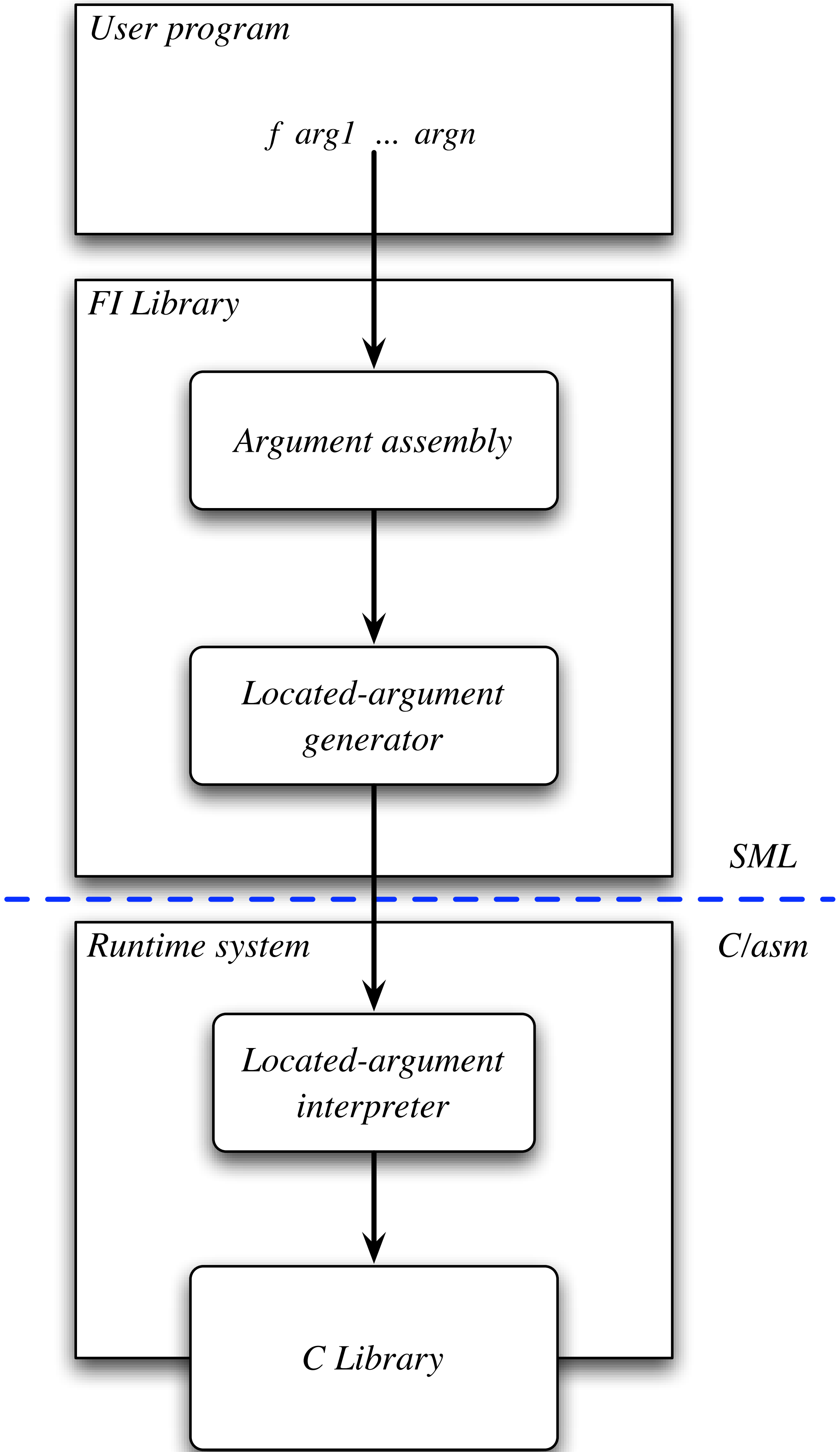



User program
f arg1 ... argn
FI Library
Argument assembly
Located-argument generator
SML
C/asm
Runtime system
Located-argument interpreter
C Library



"Staged Allocation"
(Olinsky, Lindig, Ramsey; POPL'06)

Reuses existing specs;
< 600 lines of (new) ML code



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(Olinsky, Lindig, Ramsey; POPL’06)

Reuses existing specs;
< 600 lines of (new) ML code

Generated for different architectures from a single MLRISC template

< 400 lines of ML code;
result is not implementation- or language-specific

Located arguments

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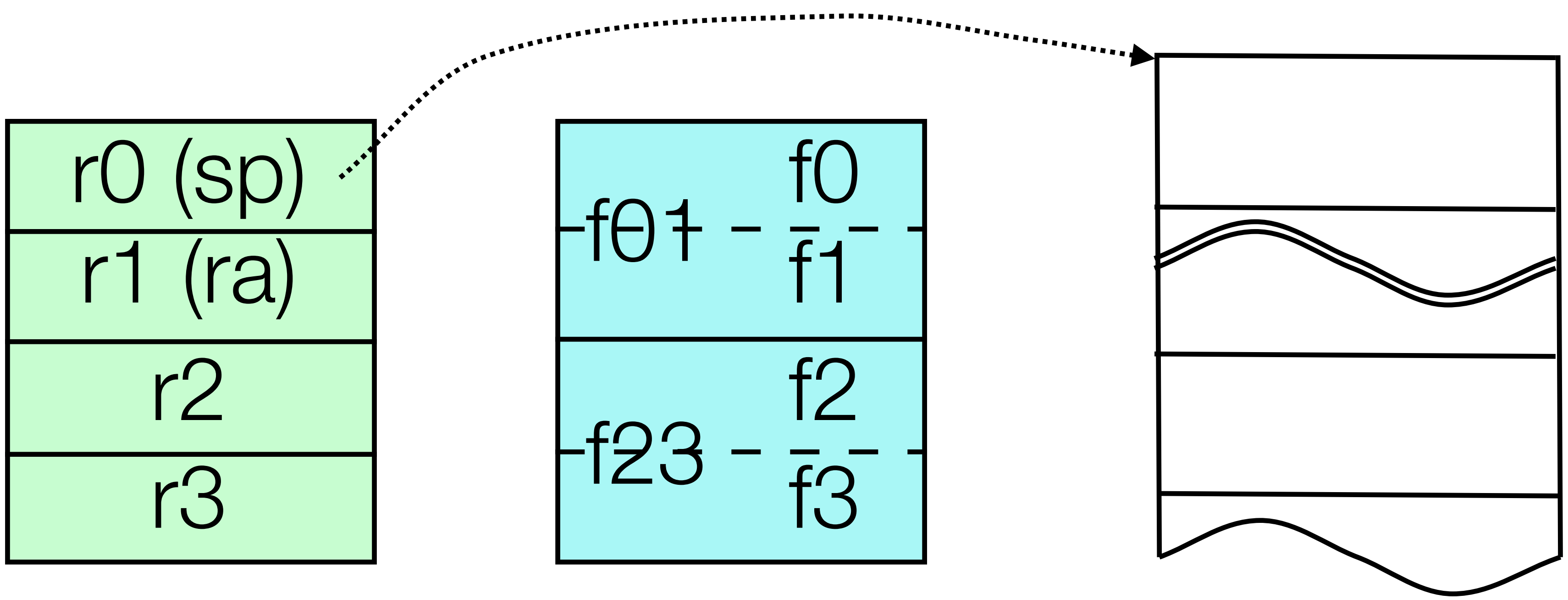
```



Staged Allocation

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`arg` constructor (e.g., **`DOUBLE`**, ...) value

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↓

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value

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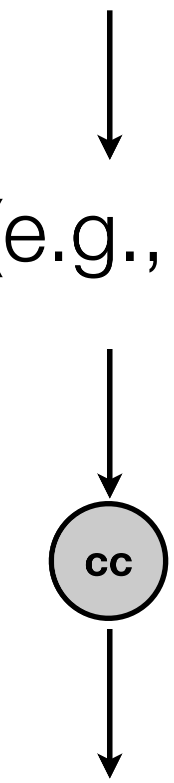
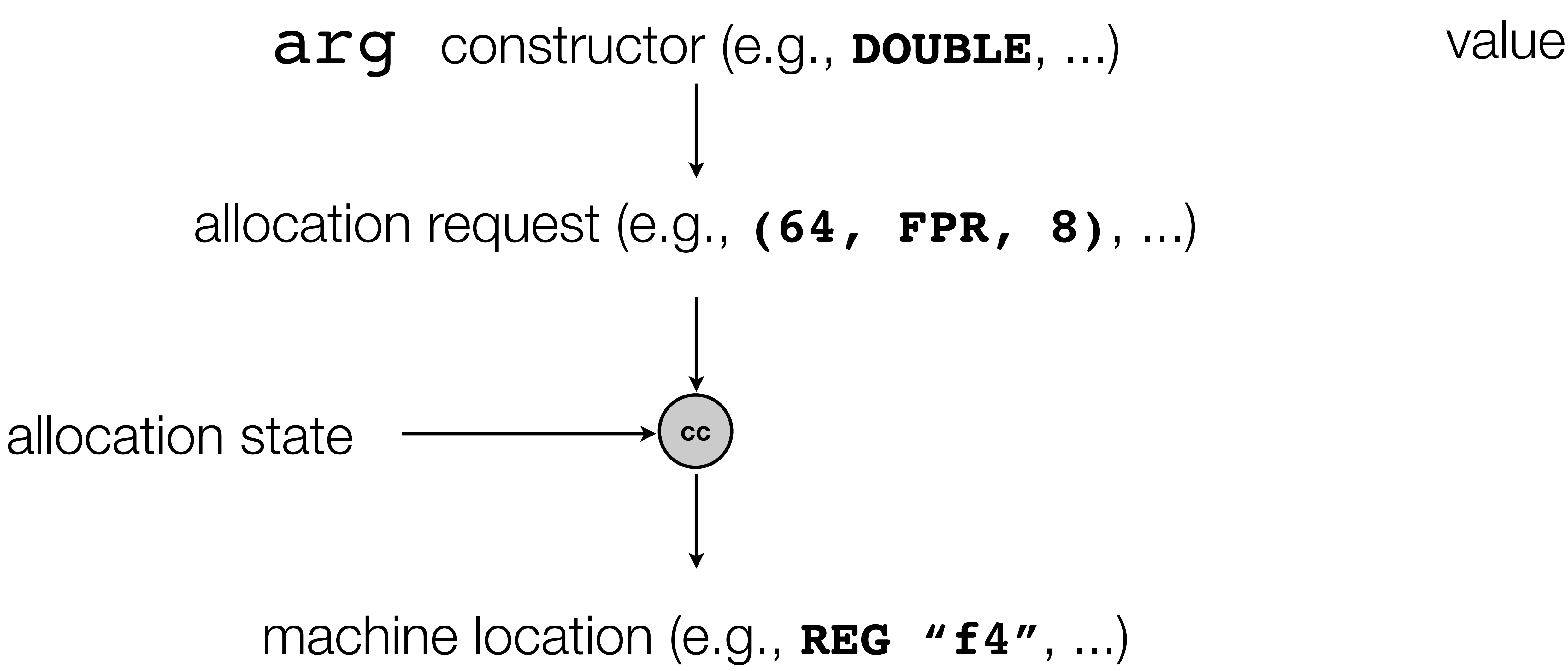


machine location (e.g., **`REG “f4”`**, ...)

Staged Allocation



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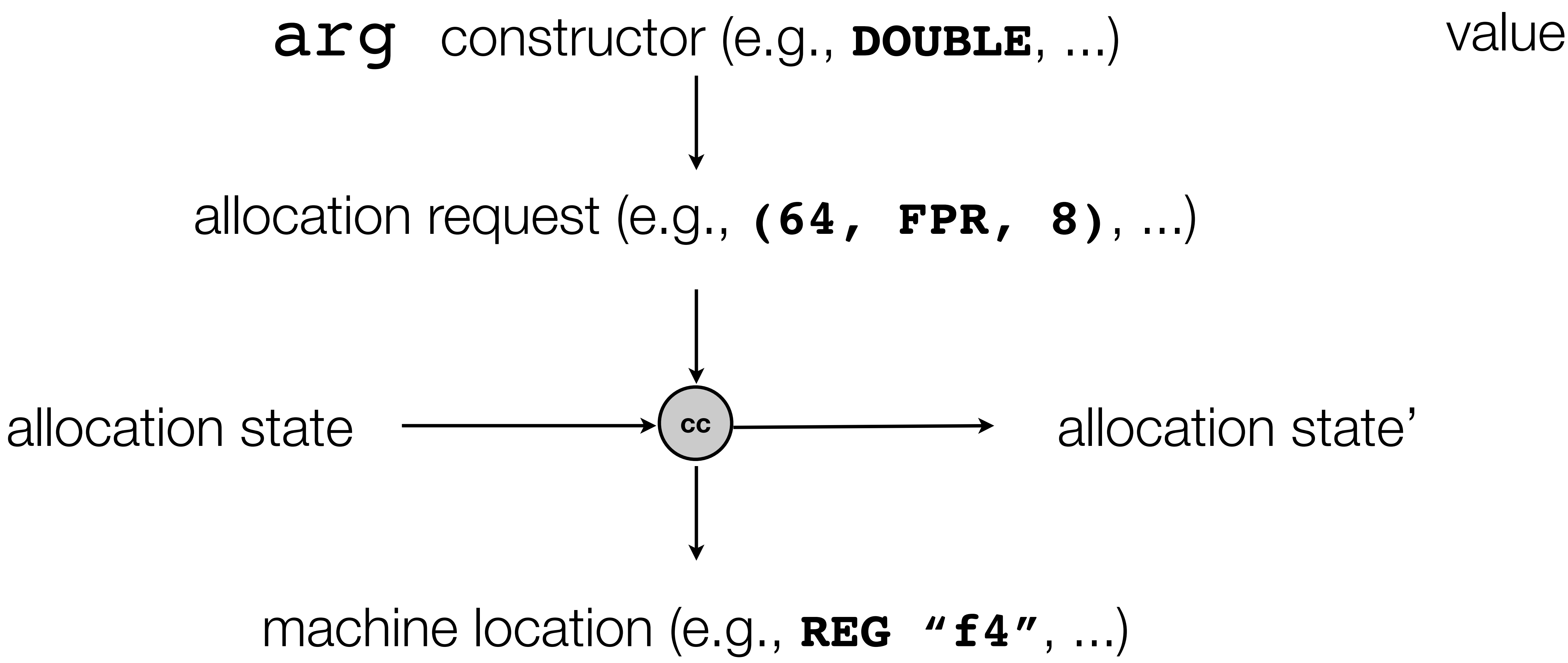

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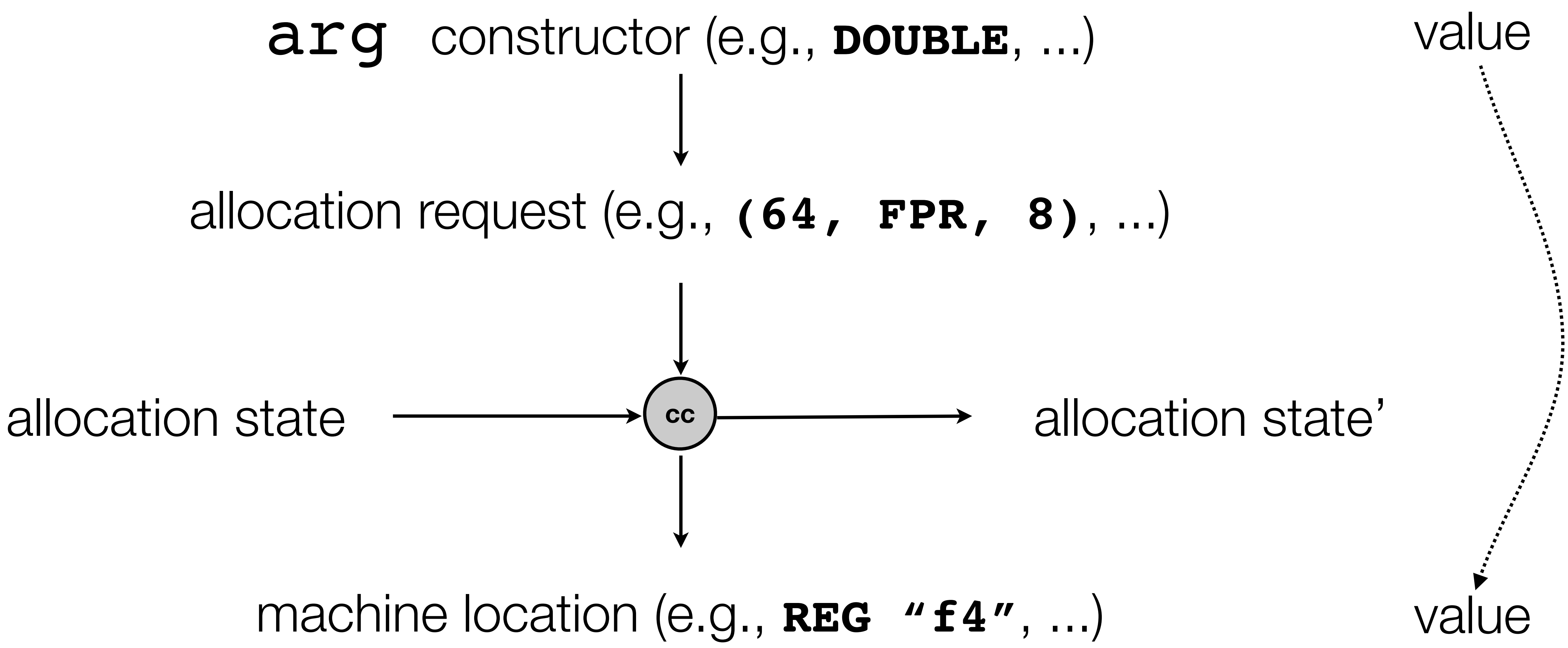

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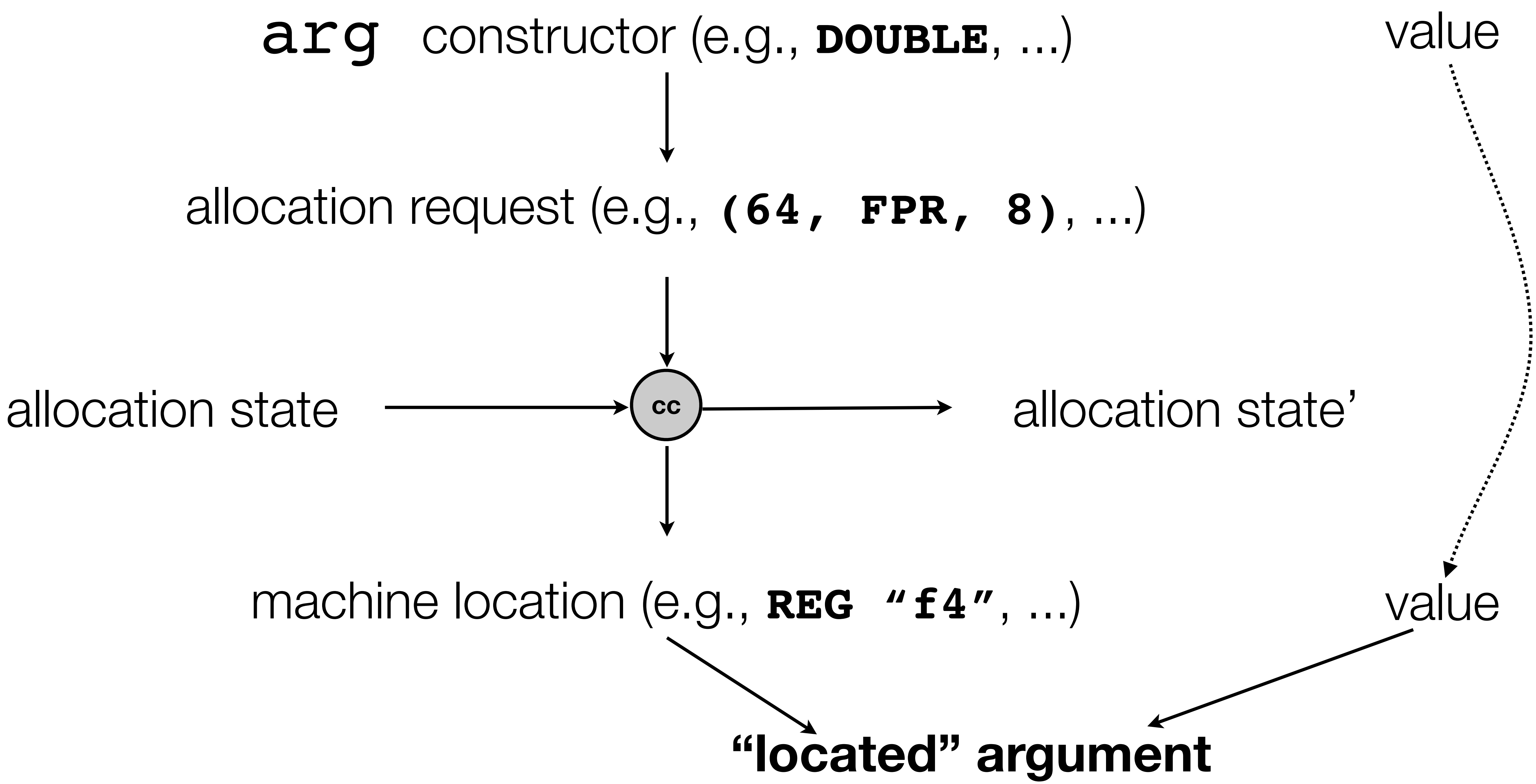

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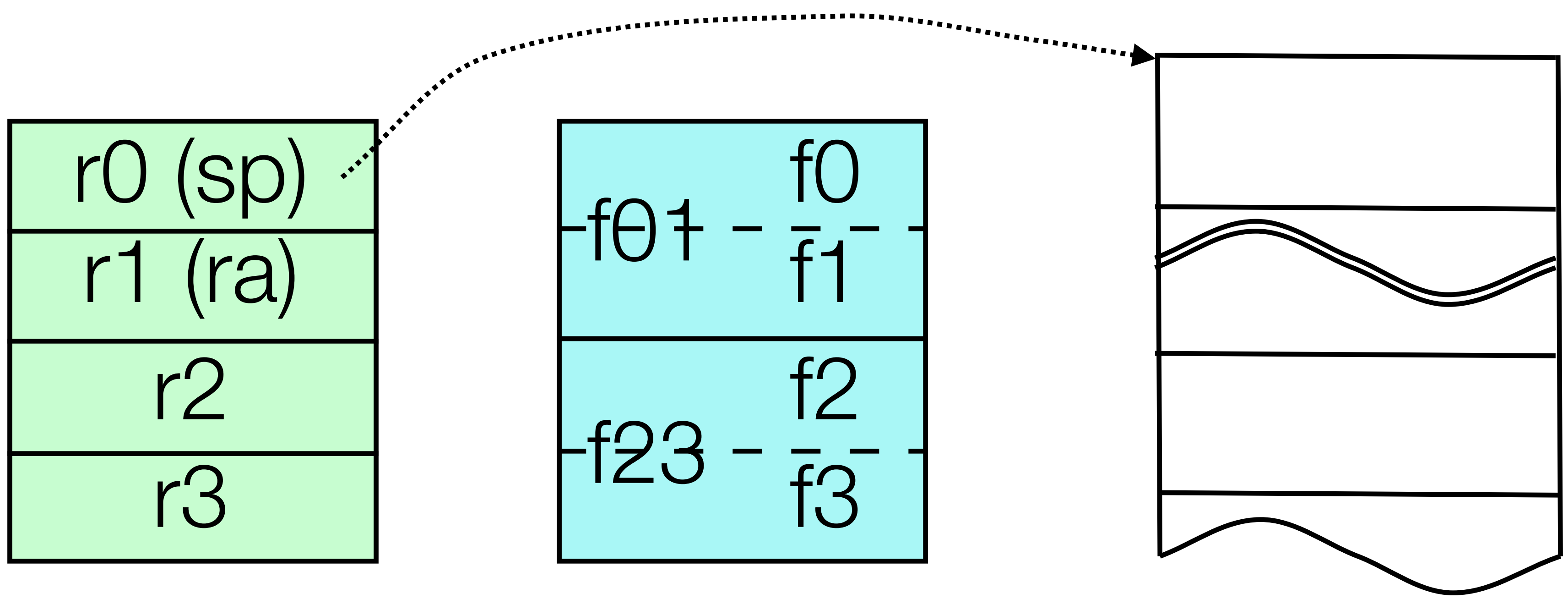
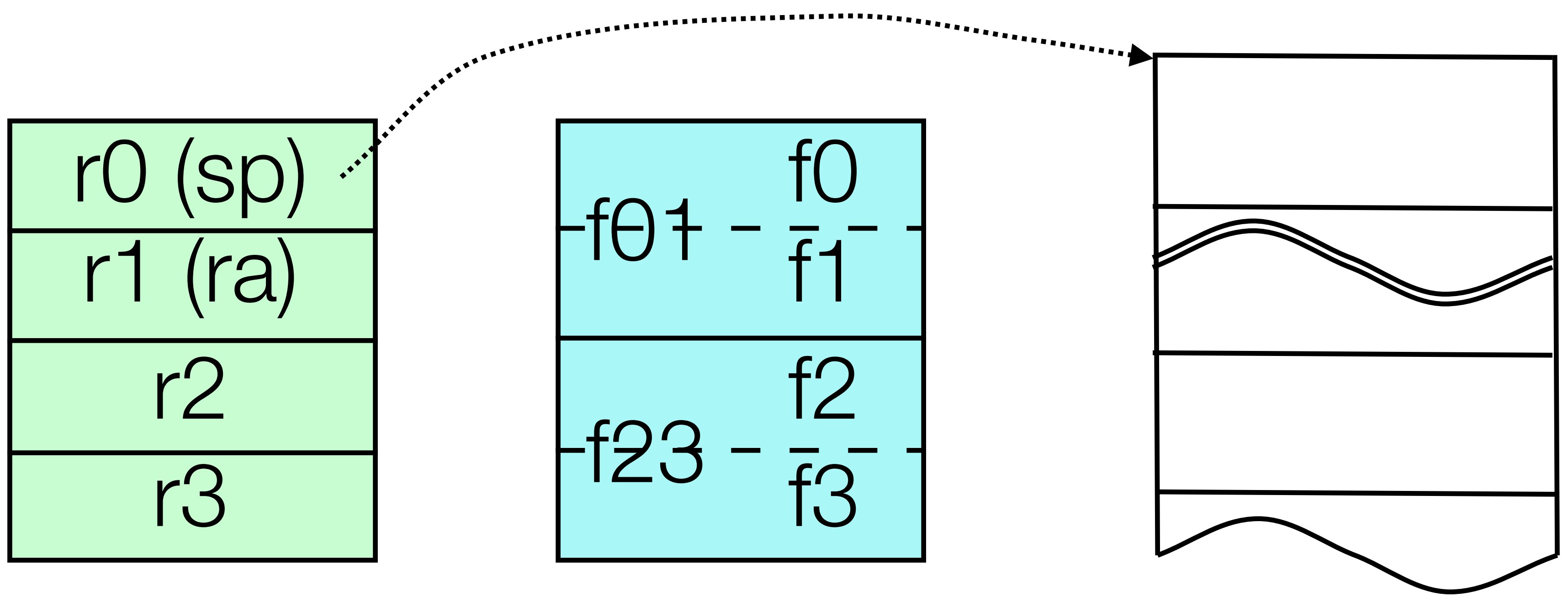


Located arguments

`dispatch (f, [INT i, DOUBLE x, FLOAT w, CHAR c, PTR p])`

“r2”	“f01”	“f23”	“r3”	“(sp+24)”



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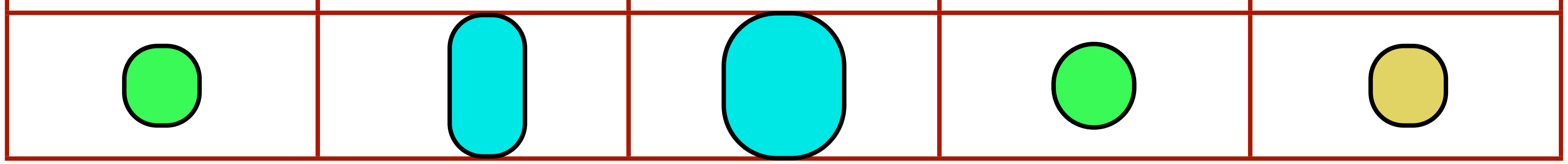
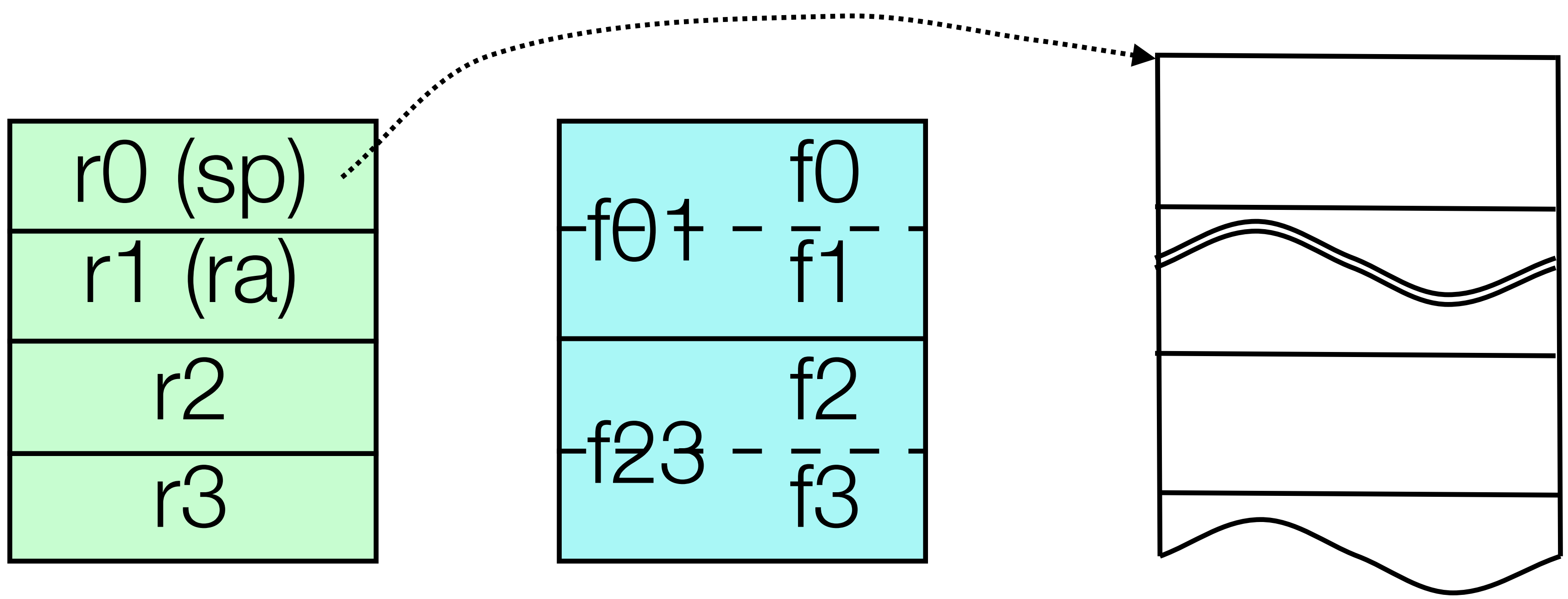
“r2”	“f01”	“f23”	“r3”	“(sp+24)”

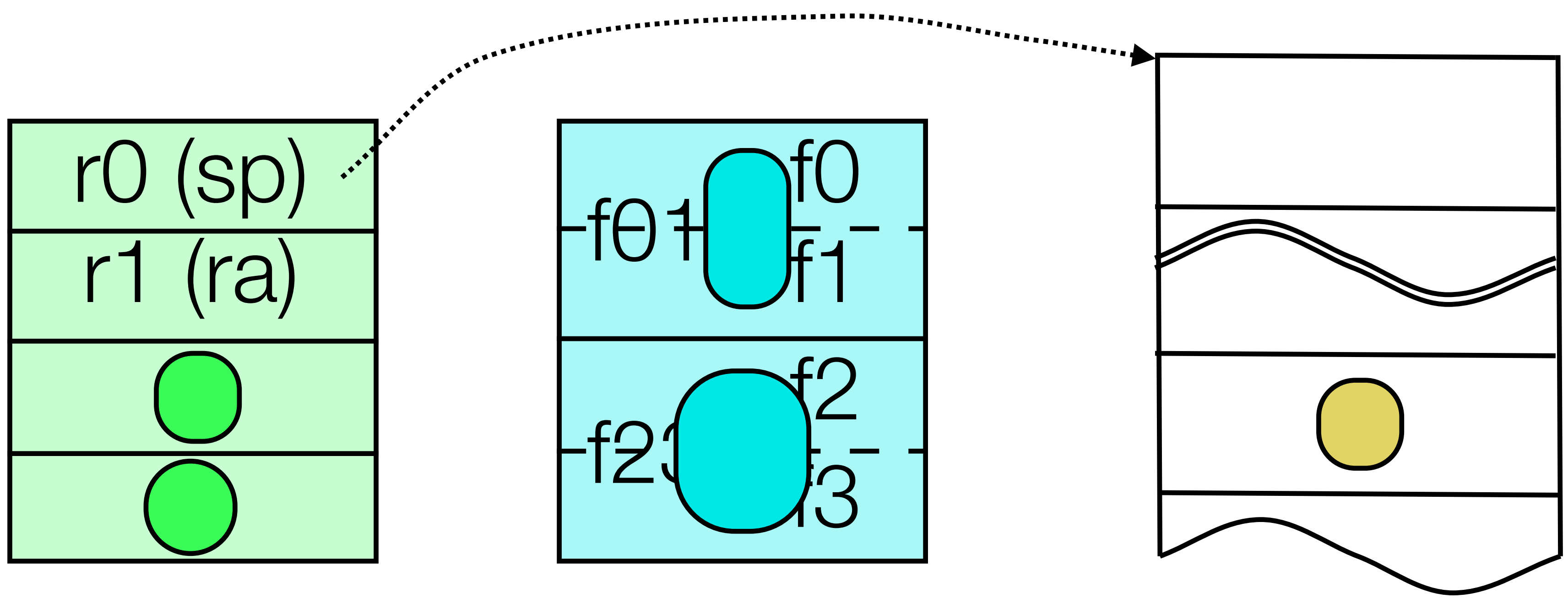




Located arguments

`dispatch (f, [INT i, DOUBLE x, FLOAT w, CHAR c, PTR p])`

“r2”	“f01”	“f23”	“r3”	“(sp+24)”



Conclusions

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  - Use runtime techniques instead.
- Separate the generation of located arguments from their actual placement into machine registers and stack locations.
  - First task can be done in the high-level language;
  - second task must be done at the assembly level
- Reuse existing technology (Staged Allocation, MLRISC).
  - Modular implementation.
  - Overall implementation effort is very manageable.

Thank you!