CerCo Work Package 2 : The Untrusted Compiler Prototype

(part 2)

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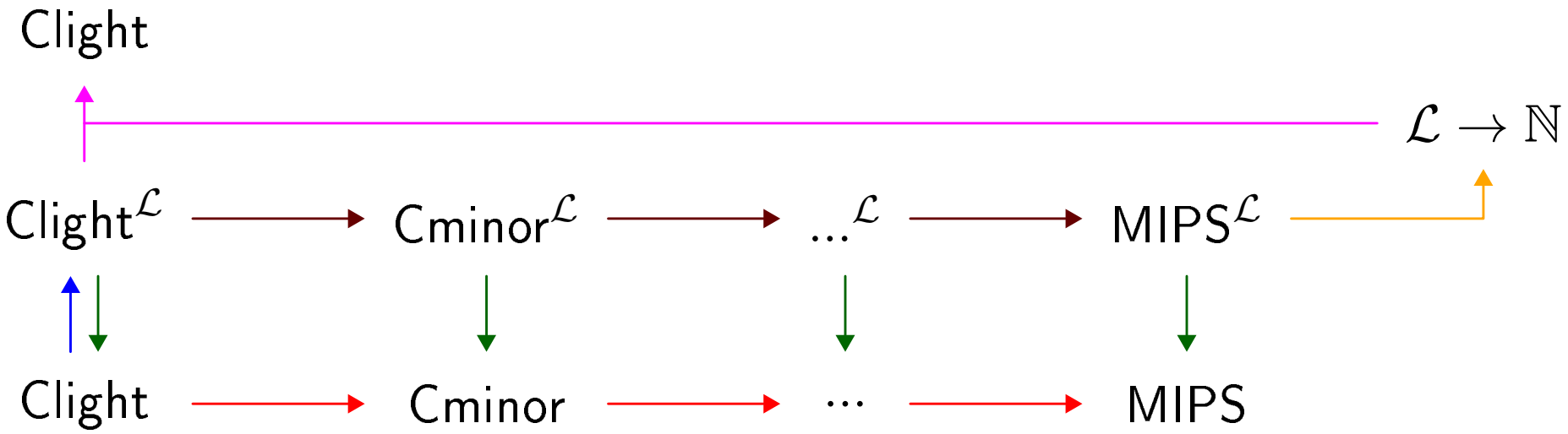
SEVENTH FRAMEWORK PROGRAMME

Architecture of the Compiler



Labelling

Erasure

Compilation

Labelled compilation

Cost deduction

Instrumentation

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Benchmarks on the MIPS compiler

	gcc -O0	acc	gcc -O1
badsort	55.93	34.51	12.96
fib	76.24	34.28	45.68
mat_det	163.42	156.20	54.76
min	12.21	16.25	3.95
quicksort	27.46	17.95	9.41
search	463.19	623.79	155.38

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Porting from MIPS to the 8051 microprocessor

Targetting the 8051 microprocessor raised the following issues:

- How to represent 32 bits values in an 8 bits architecture?
- How to deal with heterogeneous representation of pointers and integers? (Words are 8 bits long whereas memory addresses are stored using 16 bits.)
- How to select instructions for this microprocessor?
- What calling convention to use?

Where was the difficulty in the prototype implementation?

The main issue in scaling our approach from the toy compiler to the C compiler was **function calls** because they add an extra complexity in the labelling process.

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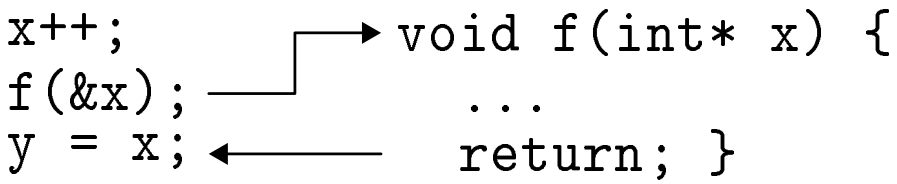
How to cover the control flow with cost labels?



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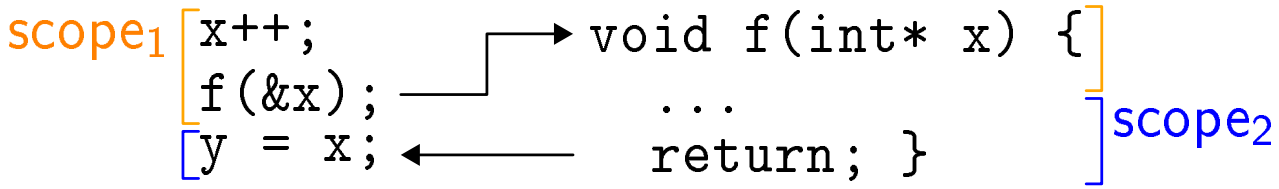
How to cover the control flow with cost labels?



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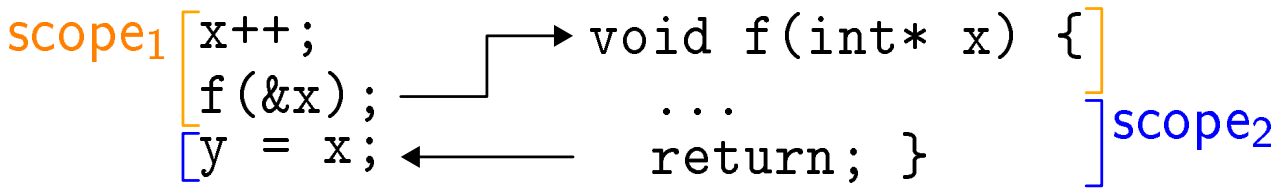
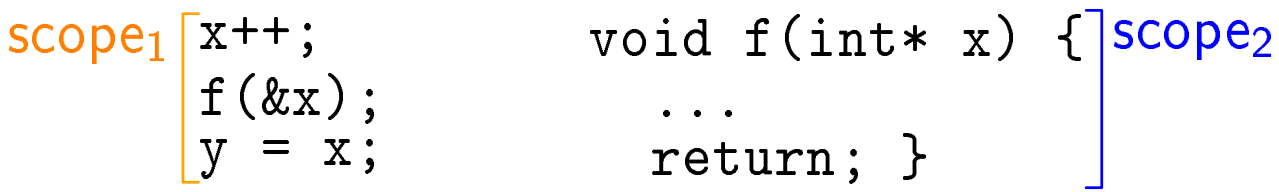
How to cover the control flow with cost labels?



Function pointer: statically unresolvable destination

Each function should handle its cost. [a]

[a] Notice that the proof of the compiler will provide the invariant that function pointers always only contain valid addresses to code generated using the same compiler.



A glimpse on the compiler passes

```
char search (char tab[], char size, char to_find) {
  char low = 0, high = size-1, i;

  while (high ≥ low) {
    i = (high+low) / 2;
    if (tab[i] == to_find) return i;
    if (tab[i] > to_find) high = i-1;
    if (tab[i] < to_find) low = i+1;
  }

  return (-1);
}
```

A glimpse on the compiler passes : Labelling in Clight

```
unsigned char search(unsigned char *tab, unsigned char size,
                    unsigned char to_find)
{
  unsigned char low, high, i;
  _cost8:
  low = (unsigned char)0;
  high = (unsigned char)((int)size - 1);
  while ((int)high ≥ (int)low) {
    _cost6:
    i = (unsigned char)(((int)high + (int)low) / 2);
    if ((int)tab[i] == (int)to_find) {
      _cost4: return i;
    } else { _cost5: }
    if ((int)tab[i] > (int)to_find) {
      _cost2: high = (unsigned char)((int)i - 1);
    } else { _cost3: }
    if ((int)tab[i] < (int)to_find) {
      _cost0: low = (unsigned char)((int)i + 1);
    } else { _cost1: }
  }
  _cost7:
  return (unsigned char)(-1);
}
```

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A glimpse on the compiler passes : RTL_{abs}

```
"search"([%9 ; %8], [%2], [%3])
:  ptr → int → int → int
     locals:  ...
     result:  [%10]
     stacksize:  0
     entry:  search40
     exit:  search0

     search9:  lt [%13], [%3] --→ search8, search5
     search8:  emit  _cost0 --→ search7
     search7:  imm [%12], imm_int 1 --→ search6
     search6:  add [%5], [%7], [%12] --→ search4
     search5:  emit  _cost1 --→ search4
     search40:  emit  _cost8 --→ search39
     search4:  --→ search36
     // ...
```

A glimpse on the compiler passes : 8051

```
// ...
317:  nop                  ;; 1  _cost4
318:  mov 002h, #000h      ;; 3
321:  mov A, 002h          ;; 1
323:  mov 005h, A          ;; 1
325:  mov A, 009h          ;; 1
327:  mov 004h, A          ;; 1
329:  mov A, 000h          ;; 1
331:  push 0E0h            ;; 2
333:  mov A, 001h          ;; 1
335:  push 0E0h            ;; 2
337:  mov 0E0h, #004h      ;; 3
340:  add A, 006h          ;; 1
342:  mov 006h, A          ;; 1
344:  mov 0E0h, #000h      ;; 3
347:  addc A, 007h         ;; 1
349:  mov 007h, A          ;; 1
351:  mov A, 005h          ;; 1
353:  mov 083h, A          ;; 1
355:  mov A, 004h          ;; 1
357:  mov 082h, A          ;; 1
359:  ret                  ;; 2
```

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A glimpse on the compiler passes : Annotating in Clight

```
unsigned char search(unsigned char *tab, unsigned char size,
                    unsigned char to_find)
{
  unsigned char low, high, i;
  _cost8: cost += 117;
  low = (unsigned char)0;
  high = (unsigned char)((int)size - 1);
  while ((int)high ≥ (int)low) {
    _cost6: cost += 77;
    i = (unsigned char)(((int)high + (int)low) / 2);
    if ((int)tab[i] == (int)to_find) {
      _cost4: cost += 30; return i;
    } else { _cost5: cost += 103; }
    if ((int)tab[i] > (int)to_find) {
      _cost2: cost += 98; high = (unsigned char)((int)i - 1);
    } else { _cost3: cost += 85; }
    if ((int)tab[i] < (int)to_find) {
      _cost0: cost += 98; low = (unsigned char)((int)i + 1);
    } else { _cost1: cost += 88; }
  }
  _cost7: cost += 43;
  return (unsigned char)(-1);
}
```

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Future work

- Prototype maintenance, validation and testing.
- Integration of the 8051 specification (recently provided as deliverable 4.1).
- Integration of the non-standard extensions of the C language consisting of directives that specifies storage location (given that their semantics have been addressed in deliverable 3.1).
- Integration of a preprocessor to encode 16 bits and 32 bits integers into records of 8 bits integers.
- Improvement of instruction selection (but we will not sacrifice conceptual simplicity to keep mechanized proofs manageable).
- Development of a `Frama-C` plugin that will embed the compiler as well as an algorithm to produce synthetic information on the execution of C functions from the current cost annotations (which only give information about constant time portions of code).