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Overview of Intermediate Representations (IRs)

Compilers course

Masters in Informatics and Computing Engineering (MIEIC), 3rd Year

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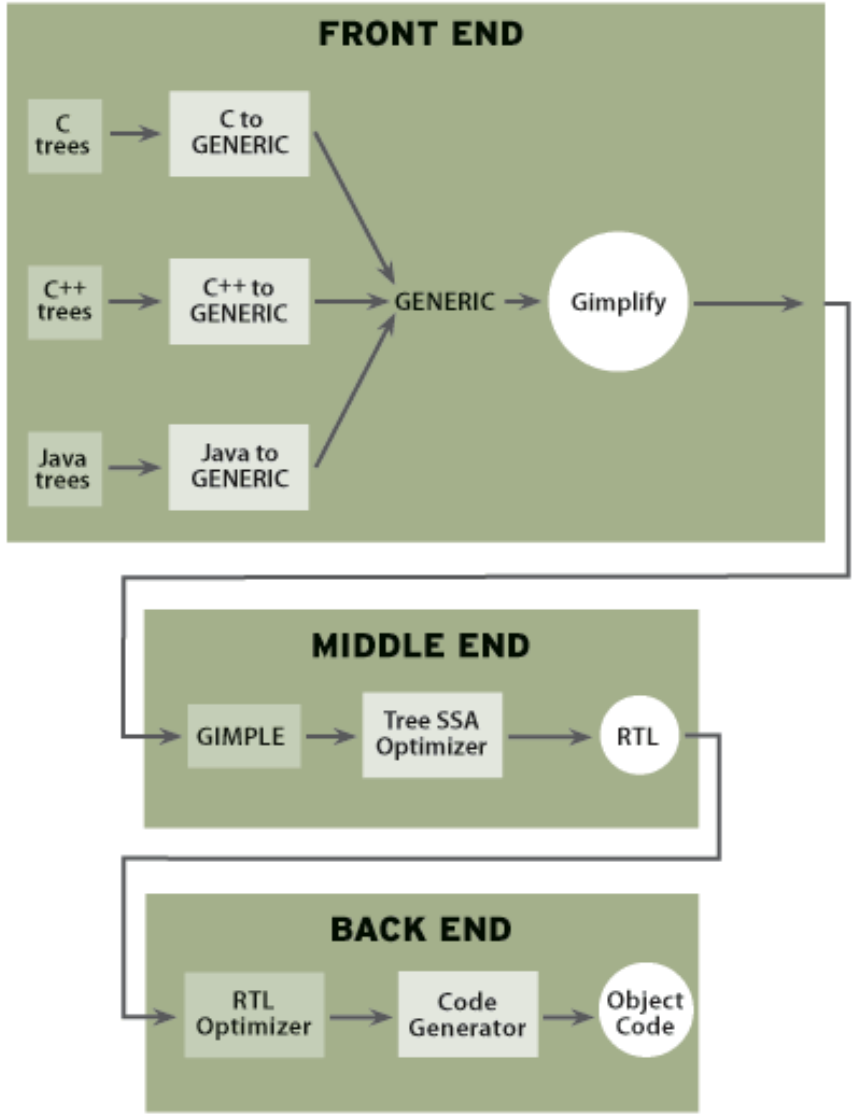
GNU GCC

- **GNU Compiler Collection** (usually shortened to **GCC**)
  - GENERIC (language independent tree structure used by the front-ends)
  - GIMPLE (High-Level, Low-Level and Low-Level in SSA form)
    - http://gcc.gnu.org/wiki/GIMPLE
  - RTL (**register transfer language**), which looks like a Lisp S-expression:
    - (set:SI (reg:SI 140) (plus:SI (reg:SI 138) (reg:SI 139)))
    - Equivalent to: Reg 140 ← Reg 138 + Reg 139;



https://gcc.gnu.org/onlinedocs/gccint/

GNU GCC: Gimple

- Arithmetic Expressions:
  - a = b + c + d
- Becomes:

```
T1 = b + c;
a = T1 + d;
```

- Conditional Expressions
  - a = b ? c : d;
- Becomes:

```
if (b)
    T1 = c;
else
    T1 = d;
a = T1;
```

GNU GCC: RTL

- Three address code
- Example:
  - (set:SI (reg:SI 140) (plus:SI (reg:SI 138) (reg:SI 139)))
  - Equivalent to: Reg 140 ← Reg 138 + Reg 139;
- (reg:m n),
  - *n*: is a register (hard or pseudo)
  - *m* : is the machine mode of the reference

https://gcc.gnu.org/onlinedocs/gccint/RTL.html#RTL

Three address code: https://en.wikipedia.org/wiki/Three-address_code

Low-Level Intermediate Representation (LIR)

THREE-ADDRESS CODE

Three Address Code Example

```
int dotprod(int x[], int y[], int nx)
{
    int sum = 0, i;

    for (i = 0; i < nx; i++)
        sum += x[i] * y[i];

    return sum;
}
```

```
            sum=0;
            i=0;
cont_l:     If(i >= nx) goto end_l;
            t1=x[i];
            t2=y[i];
            t3=t1+t2;
            sum = sum +t3;
            i=i+1;
            goto cont_l;
end_l:
            return sum;
```

Three Address Code Example

```
int DSP_dotprod_c(const int *x, const
    int *y, int nx)
{
   int sum = 0, i;

   for (i = 0; i < nx; i++)
      sum += x[i] * y[i];

   return sum;
}
```

```
        sum=0;
        i=0;
cont_l: If(i >= nx) goto end_l;
        t1=load x, i;
        t2=load y, i;
        t3=t1+t2;
        sum = sum +t3;
        i=i+1;
        goto cont_l;
end_l:
        return sum;
```

Three Address Code Example

```
int DSP_dotprod_c(const int *x, const
    int *y, int nx)
{
   int sum = 0, i;

   for (i = 0; i < nx; i++)
      sum += x[i] * y[i];

   return sum;
}
```

```
        sum=0;
        i=0;
cont_l: If(i >= nx) goto end_l;
        a1=4*i+x;
        t1=load a1;
        a2=4*i+y;
        t2=load a2;
        t3=t1+t2;
        sum = sum +t3;
        i=i+1;
        goto cont_l;
end_l:
        return sum;
```

Other Examples of Three-Address Code

- ILOC from the book: “Engineering a Compiler” by Keith Cooper, Linda Torczon