A Modern Compiler for the French Tax Code

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Compiler Construction, March 3rd, 2021

Income Tax in France

Each year

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Trusting the computation?

- Correct computation with respect to the law
- Reproducibility of the computation
- Accurate simulation of tax reforms

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```
IRNETTER = max(0,
  IRNET2
  + (TAXASSUR + PTAXA - min(TAXASSUR+PTAXA+0,max(0,INE-IRB+AVFISCOPTER))
  - max(0,TAXASSUR + PTAXA  - min(TAXASSUR + PTAXA + 0,max(0,INE-IRB+AVFISCOPTER))+ min(0,IRNET2)))
  + (IPCAPTAXT + PPCAP - min(IPCAPTAXT + PPCAP,max(0,INE-IRB+AVFISCOPTER -TAXASSUR-PTAXA))
  - max(0,IPCAPTAXT+PPCAP -min(IPCAPTAXT+PPCAP,max(0,INE-IRB+AVFISCOPTER- TAXASSUR - PTAXA ))+ min(0,TAXANEG)))
  + (TAXLOY + PTAXLOY - min(TAXLOY + PTAXLOY,max(0,INE-IRB+AVFISCOPTER -TAXASSUR-PTAXA-IPCAPTAXT-PPCAP))
  - max(0,TAXLOY+PTAXLOY -min(TAXLOY+PTAXLOY,max(0,INE-IRB+AVFISCOPTER- TAXASSUR - PTAXA-IPCAPTAXT-PPCAP ))+ min(0,PCAPNEG)))
  + (IHAUTREVT + PHAUTREV +CHRPVIMP- max(0,IHAUTREVT+PHAUTREV +CHRPVIMP+ min(0,LOYELEVNEG))));
```

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March 2019: we started our open-source compiler for the income tax computation.

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- `undef` value

Example

Variable declaration

```
IRNETBIS : computed primrest = 0 : "net income tax before 8ZI hack";
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```

Computation rule

```
rule 221220:
application : iliad  ;
IRNETBIS = max(0, IRNETTER -
                  PIR * positive(THRESHOLD_12 - IRNETTER + PIR)
                      * positive(THRESHOLD_12 - PIR)
                      * positive_or_zero(IRNETTER - SEUIL_12));
```

A formal semantics for M

We reverse-engineered the semantics:

- At first, using the online simulator[1]
- Later, using the private tests DGFiP sent us (August 7, 2019)

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The `undefined` value

- Used for: default inputs, runtime errors & missing cases in inline conditionals
- Fun facts: $f + \texttt{undef} = f$, $f \div 0 = 0$, $x[|x| + 1] = \texttt{undef}$, $x[-1] = 0$...
- Full semantics in the paper

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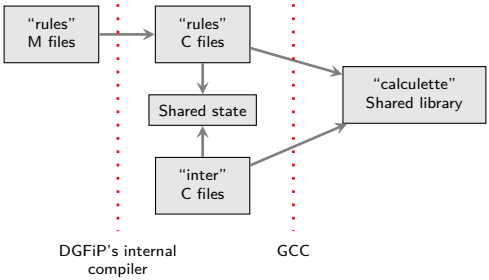
Patience is the key

- Aug. 2019 Sent official technical questions to DGFiP
- Jan. 2020 Meeting with DGFiP (5 levels of hierarchy involved!)
- Apr. 2020 Agreement signed
- Jun. 2020 First access to the unpublished sources!

DGFiP's legacy architecture

Discovered in June 2020:



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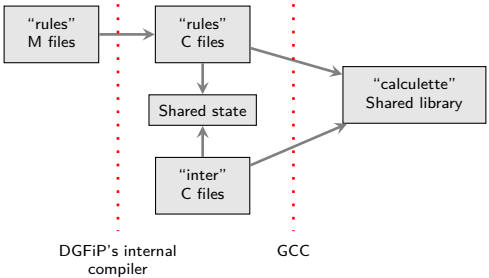

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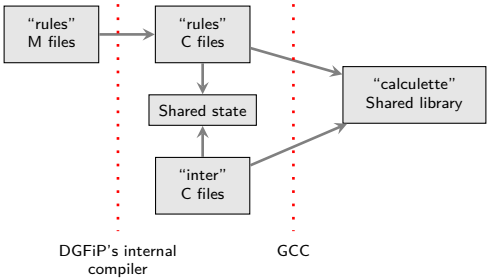

"inter" files : 35k lines of C code written to compensate M's lack of functions.

Security concerns meant no publication possible. How to extract the logic of the code, without publishing the "inter" code itself?

Introducing a new DSL: M++

```
compute_benefits():
 if exists_deposit_defined_variables() or exists_taxbenefit_ceiled_variables():
    partition with var_is_taxbenefit:
      V_INDTEO = 1
      V_CALCUL_NAPS = 1
      NAPSANSPENA, IAD11, INE, IRE, PREM8_11 <- call_m()
      V_CALCUL_NAPS = 0
      iad11 = cast(IAD11)
      ire = cast(IRE)
      ine = cast(INE)
      prem = cast(PREM8_11)
      PREM8_11 = prem
    V_IAD11TEO = iad11
    V_IRETEO = ire
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      PREM8_11 = prem
    V_IAD11TEO = iad11
    V_IRETEO = ire
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- High-level, no mutable state under the hood
- Tailored for the needs of the “inter” files and DGFiP devs
- 6,000 lines of “inter” C code $\Rightarrow$ 100 lines of M++

MLANG's architecture

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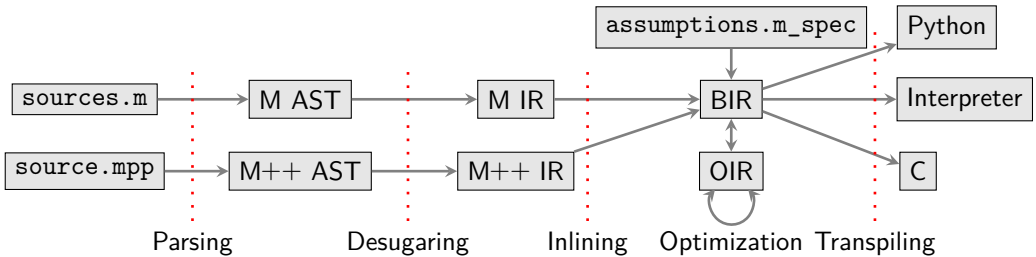
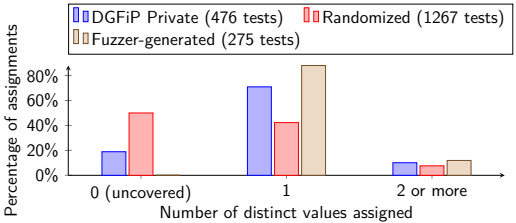


MLANG's correctness

It works (precise down to the euro)!

- All backends validated on DGFiP's tests for 2018 and 2019
- Generate more test cases via random pick or fuzzing (AFL)



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Compiler optimizations

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- Partial evaluation
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Spec. name	# inputs	# outputs	# instructions	% reduction
All	2,459	10,411	129,683	80.2%
Selected outs	2,459	11	99,922	84.8%
Tests	1,635	646	111,839	83.0%
Simplified	228	11	4,172	99.4%
Basic	3	1	553	99.9%

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Component	Published	Replacement
M code	yes	–
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⇒ Income tax computation now reproducible outside DGFiP!

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From research to production

DGFiP is moving to MLANG. Transition planned for 2021-2022.

Looking ahead

- Income tax studies based on the official code now possible
- Semantic analyses of the income tax code
- A success story, encouraging further opening of critical “state software”
- Deriving correct-by-construction implementations from the law

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Paper, source code, etc: `rmonat.fr/cc21`

Thanks to DGFiP and in particular bureau SI-1E for the collaboration!