Interface et extension de Open Research Compiler

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Présentation générale

L'entreprise et l'encadrement:

- INRIA Rocquencourt
- Projet A3
- Encadrement: Albert Cohen
- Durée: 13 semaines (du 3 juin au 30 août)

Présentation du stage

Buts du stage:

- Découvrir le compilateur Open64/ORC
- Documenter le compilateur
- Implémenter une passe dans le générateur de code.

Structure du compilateur

1. FE (Front-ends)
2. WHIRL (Intermediate Representation)
3. IPA (Inter Procedural Analysis)
4. LNO (Loop Nest Optimizer)
5. WOPT (Global Optimizer)
6. CG (Code Generator)
7. ORC (Open Research Compiler)

Front Ends

- Front-ends C et C++ de GCC
- Fortran 90 de Cray
- Chaque front-end a ses propres AST
- Traduction des AST vers WHIRL

WHIRL

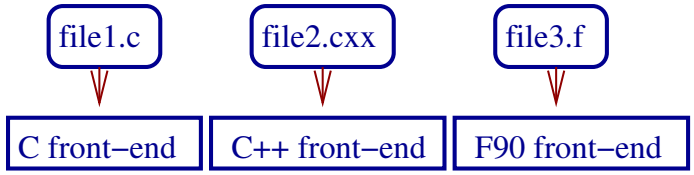
Winning Hierarchical Intermediate Representation Language

- 5 niveaux: VH, H, M, L, VL
- *lowering* entre niveaux.
- Chaque optimization au bon niveau.

Inter Procedural Analysis

file1.c file2.cxx file3.f

Inter Procedural Analysis



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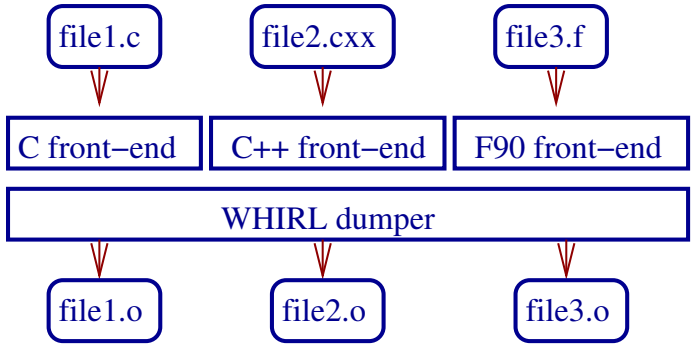

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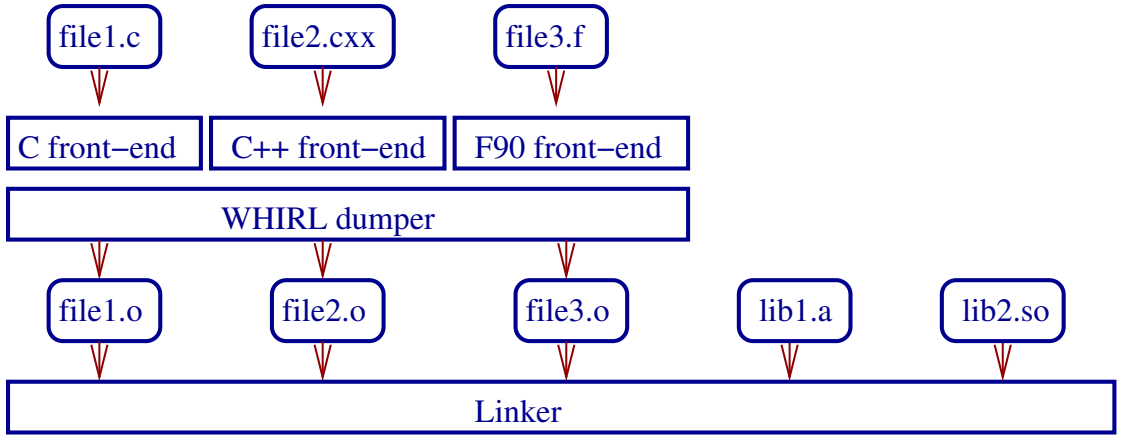

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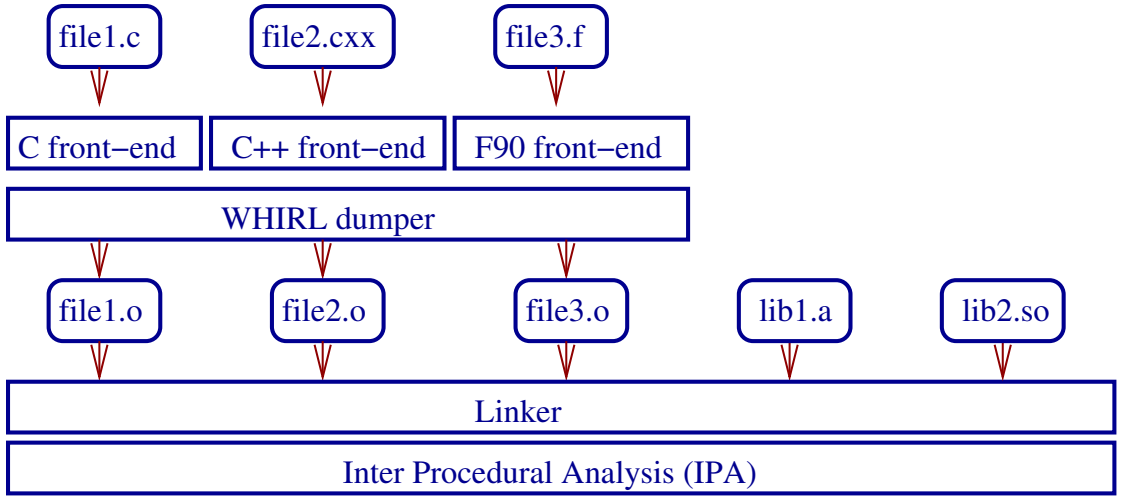

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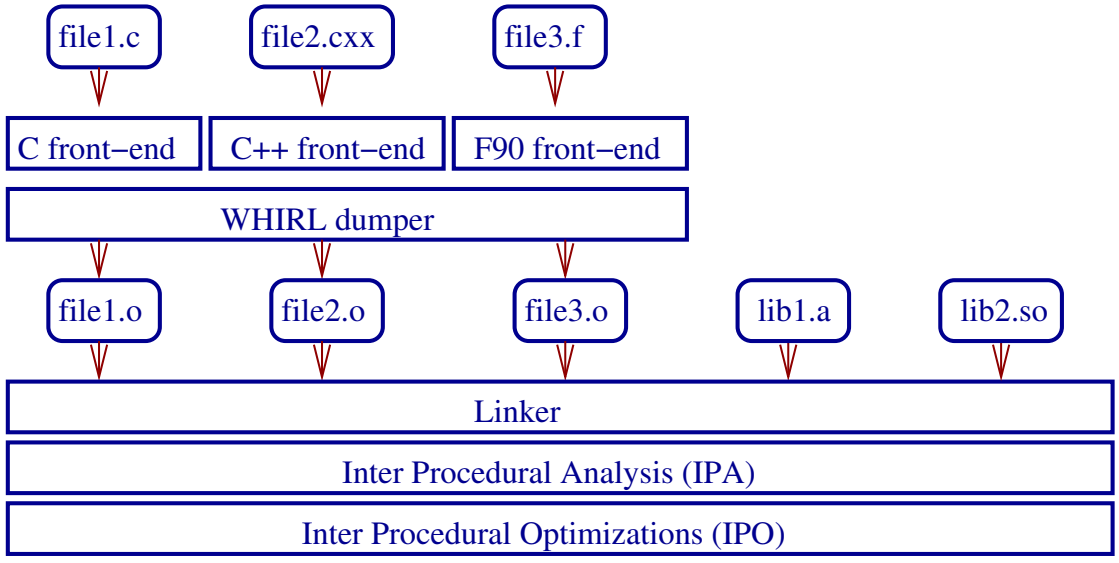

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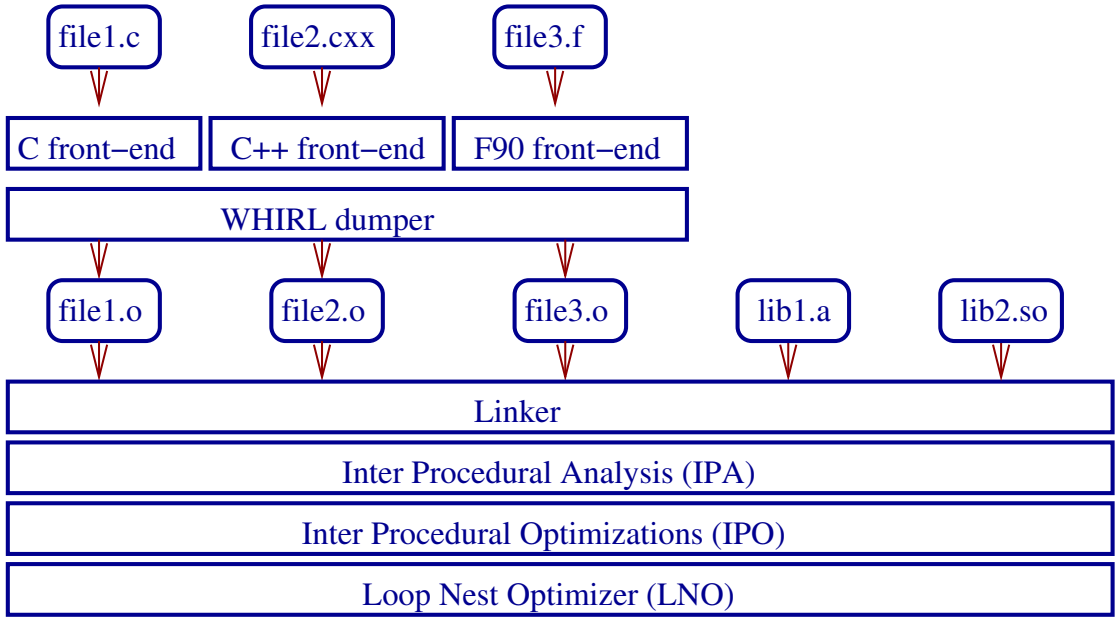

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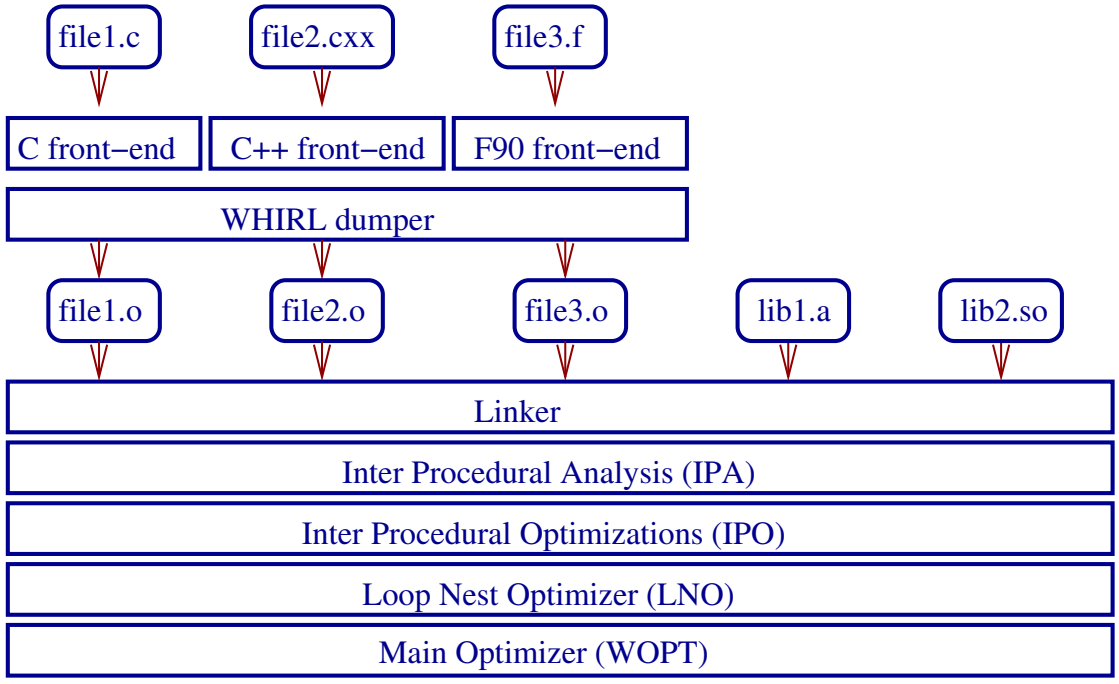

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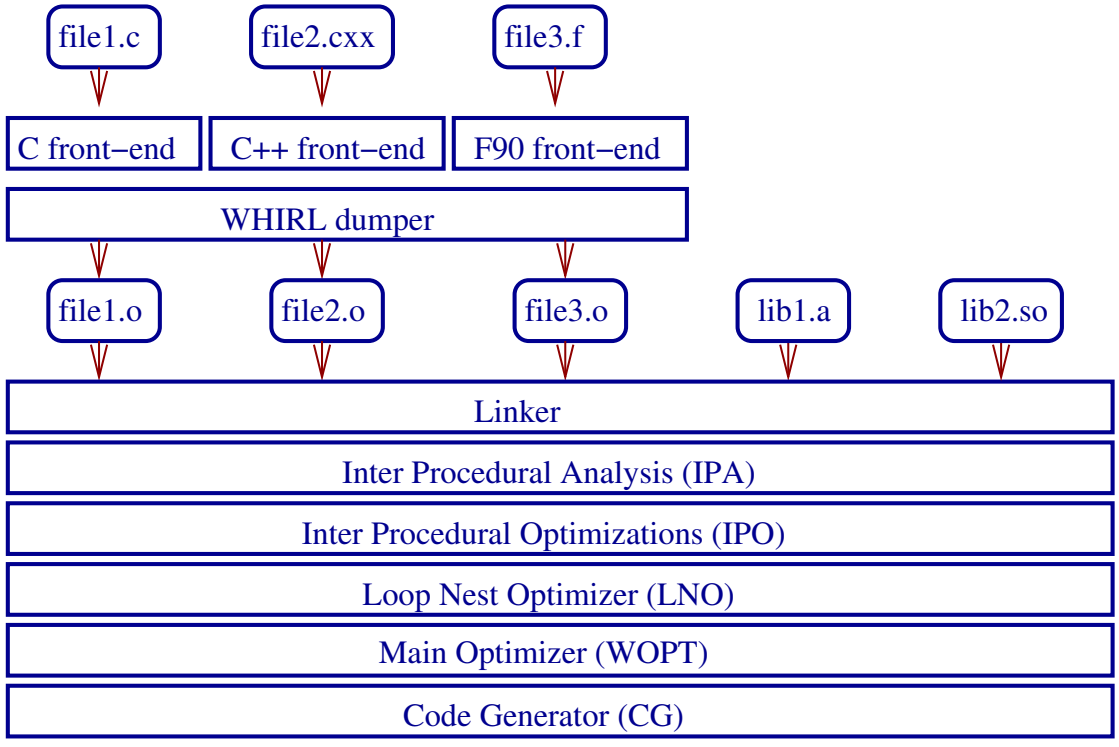

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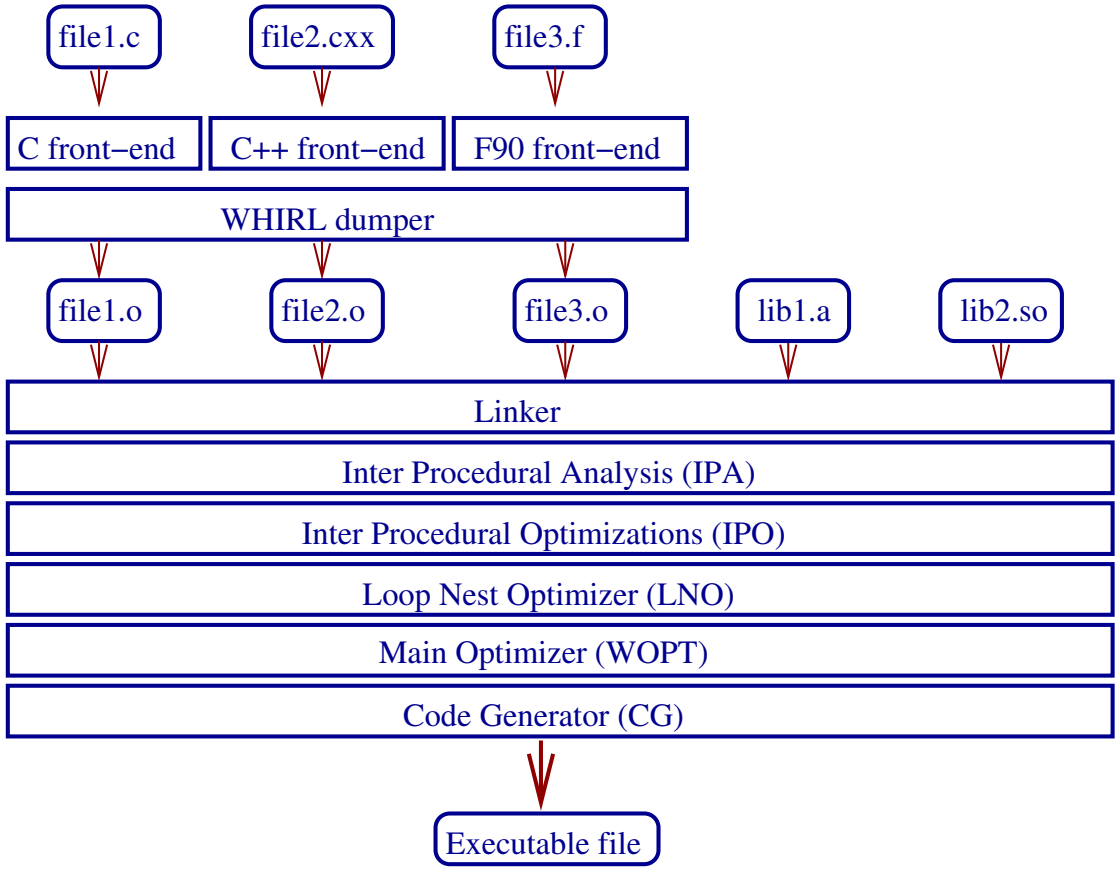


Inter Procedural Analysis

Rassembler l'information sur l'ensemble du projet.

Inter Procedural Analysis

Rassembler l'information sur l'ensemble du projet.
Solution:

- sauver la WHIRL dans les .o
- reconstruire un AST global

Loop Nest Optimizer

LNO travaille sur le *High level WHIRL*.

Loop Nest Optimizer

Représentations intermédiaires spécifiques:

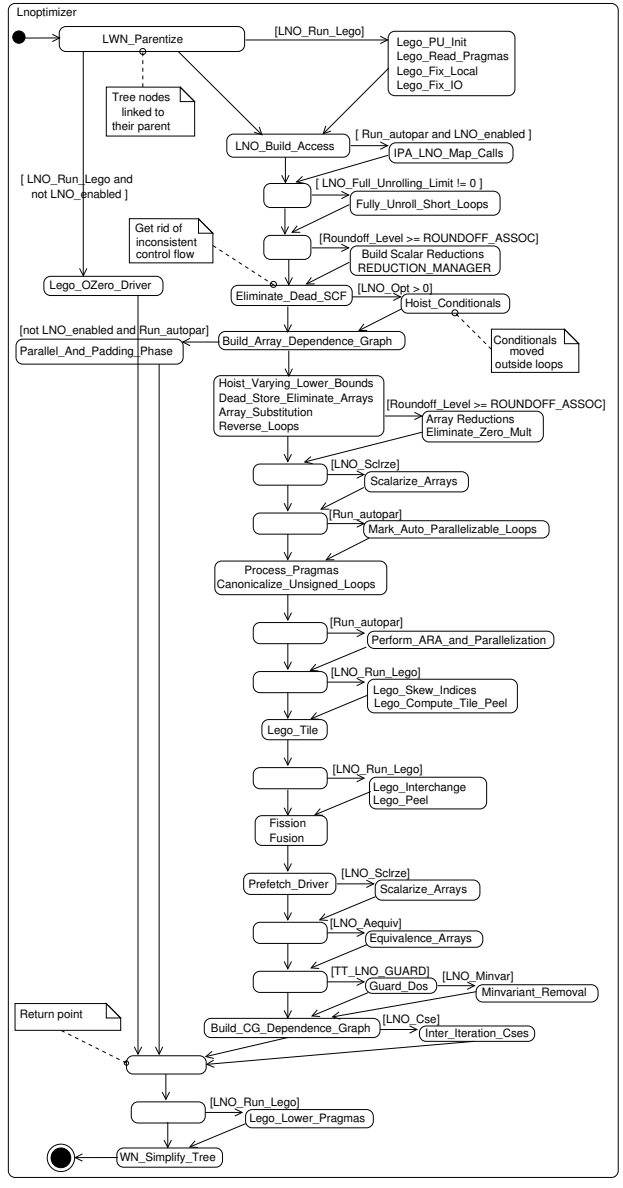
- Array Dependence Graph
- LEGO: for data distributions
- Array and vectors accesses
- Vector space
- Systems of equations
- Polytopes

Loop Nest Optimizer

Quelques optimiseurs du LNO:

- Loop unrolling
- Hoist conditionals
- Hoist varying lower bounds
- Dead store eliminate arrays
- Loop reversal / fission / fusion / tiling
- Array scalarization
- Prefetch
- Inter iteration Common Subexpression Elimination

Loop Nest Optimizer



Global Optimizer

WOPT travaille sur le *Medium-level WHIRL*.

Global Optimizer

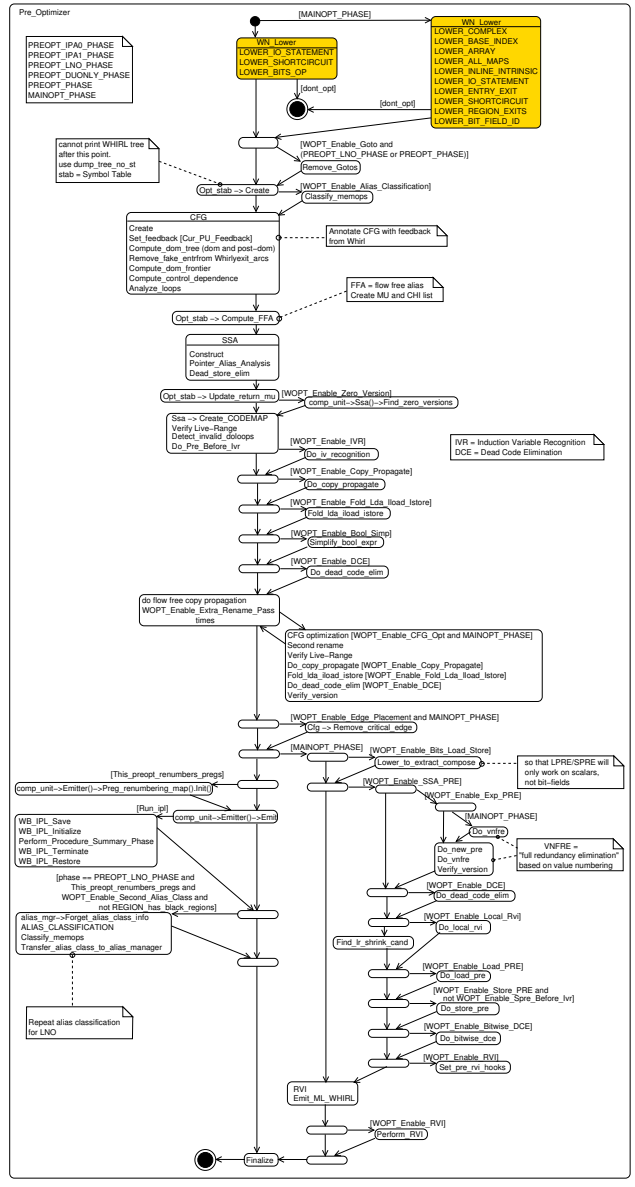
Principales représentations intermédiaires:

- CFG (Control Flow Graph)
- SSA (Static Single Assignement)

Quelques optimiseurs:

- SSA-PRE (Partial Redundancy Elimination)
- DCE (Dead Code Elimination)
- IVR (Induction Variable Recognition)
- VNFRE (Value Numbering based Full Redundancy Elimination)
- Copy propagation

Global Optimizer



Code Generator

Le générateur de code travaille sur la CGIR.

- CFG explicite
- chaque BB contient une liste d'instructions
- chaque instruction est sous la forme:
  OP_result
  OP_code
  OP_opnd

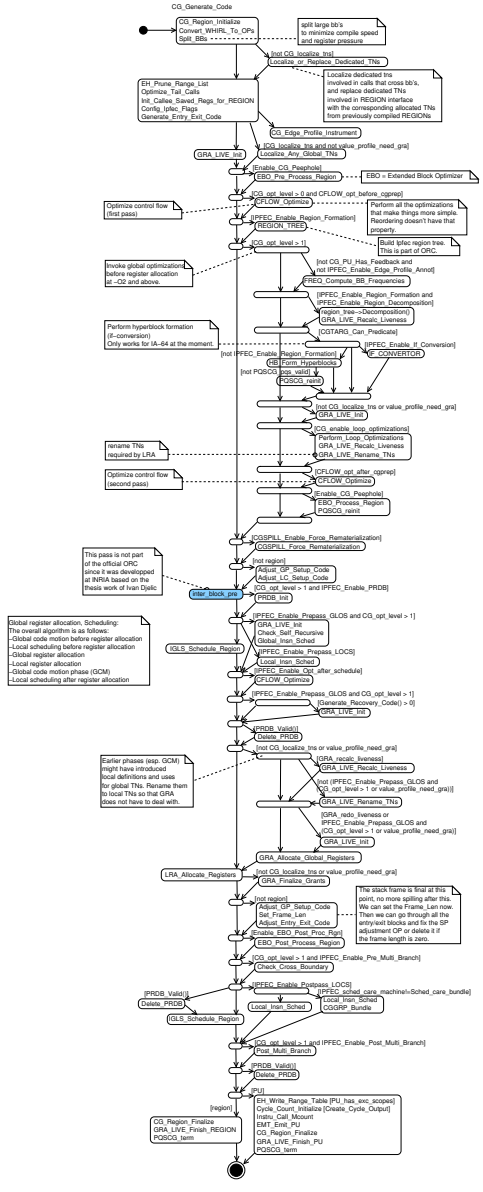
Représentation proche du code assembleur.

Code Generator

Principales passes du CG:

- EBO: Extended Block Optimizer
- GRA: Global Register Allocation
- LRA: Local Register Allocation
- GCM: Global Code Motion
- SWP: Software Pipelining
- CIO: Cross Iteration loop Optimizations
- FREQ: fréquences d'execution des BBs

Code Generator



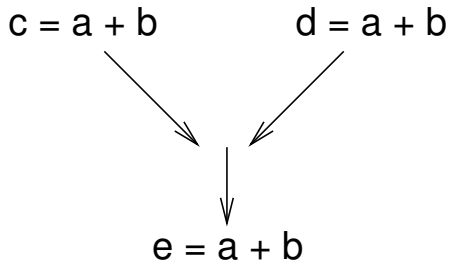
Open Research Compiler

ORC est une extension du générateur de code.

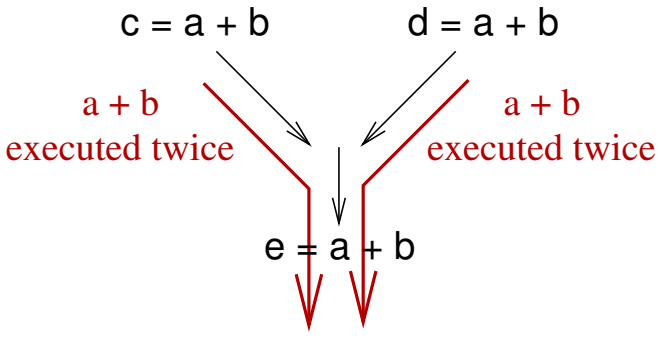
- IPFEC Regions
- If-conversion
- Predicate Relation DataBase
- Microscheduler
- Local/Global instruction scheduling

Partial Redundancy Elimination

Partial Redundancy Elimination



Partial Redundancy Elimination



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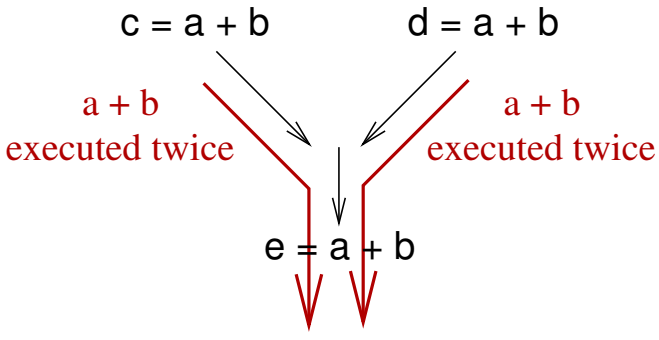
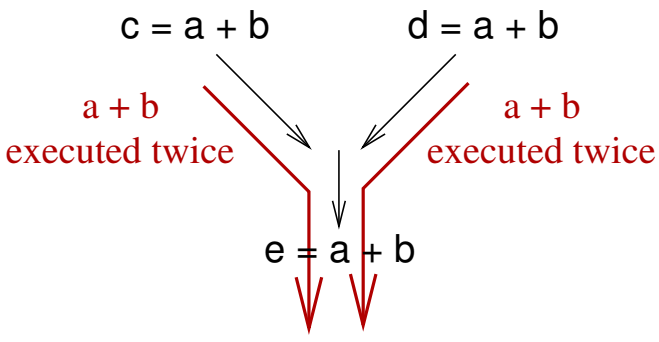


a + b is fully available

Partial Redundancy Elimination



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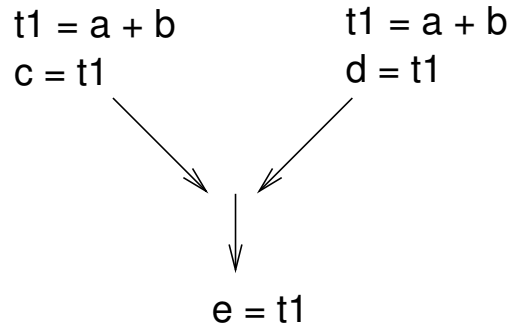
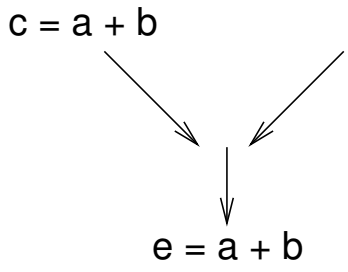


elimination of common subexpression

Partial Redundancy Elimination



Expression a + b is
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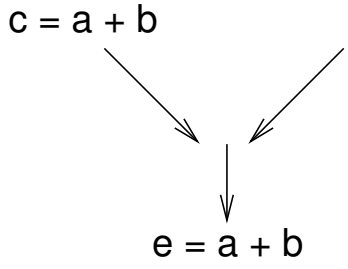
Partial Redundancy Elimination



Expression a + b is
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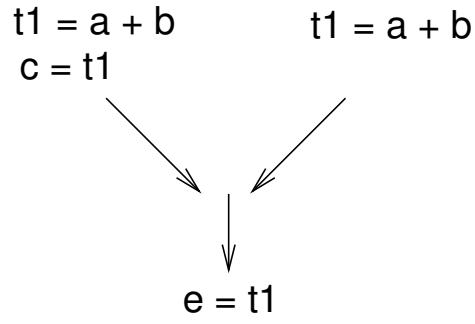
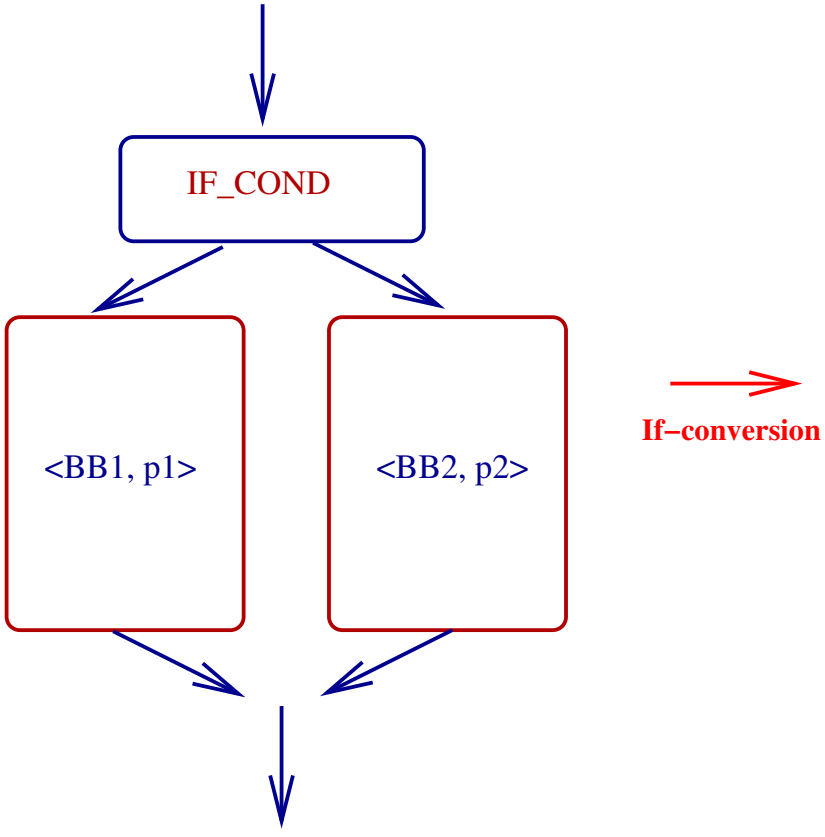


elimination of partial
redundancy

Code Prédicaté



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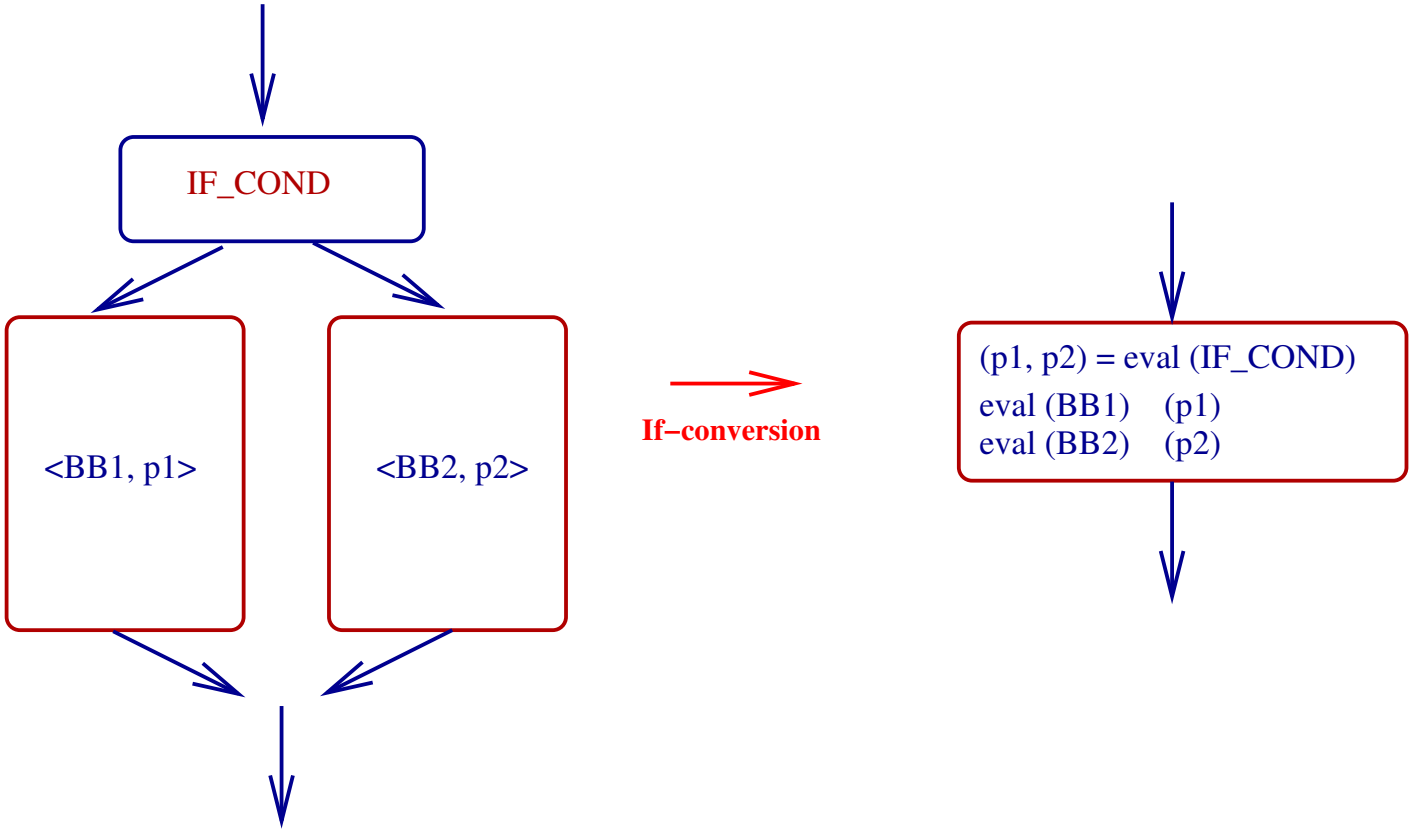
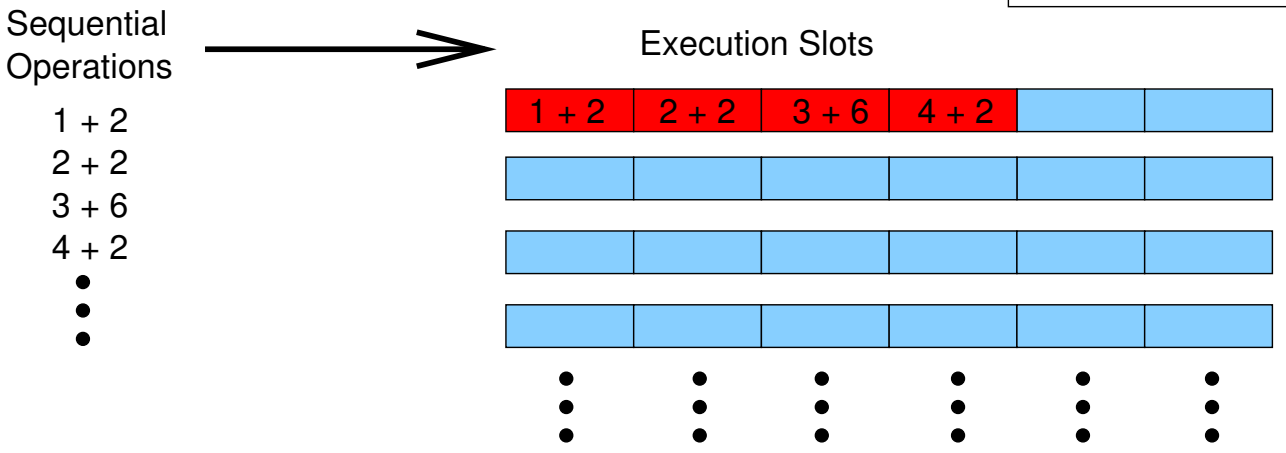


Code Prédicaté

6 instructions can be executed in parallel on Itanium

ILP = Instruction Level Parallelism



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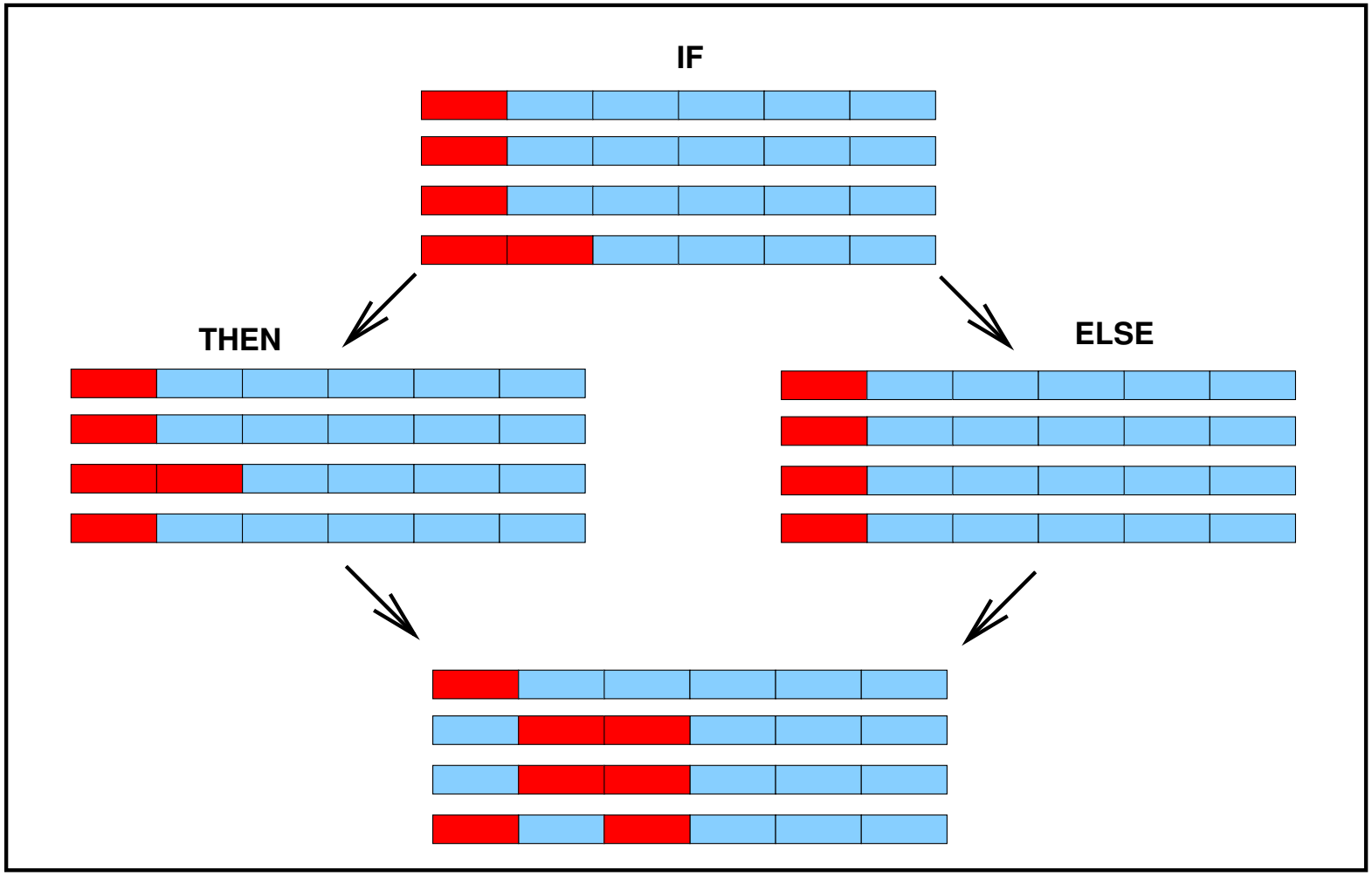

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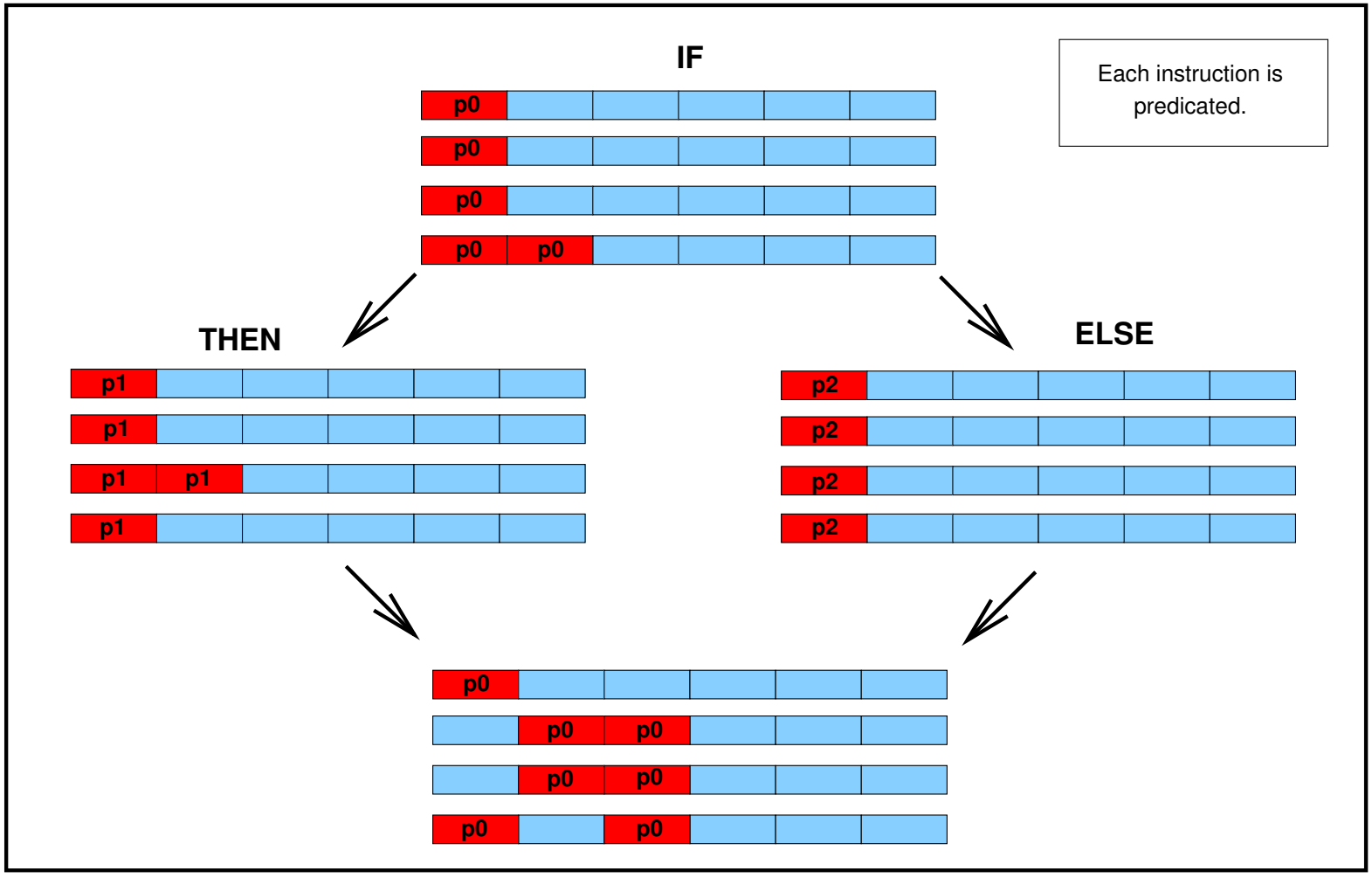

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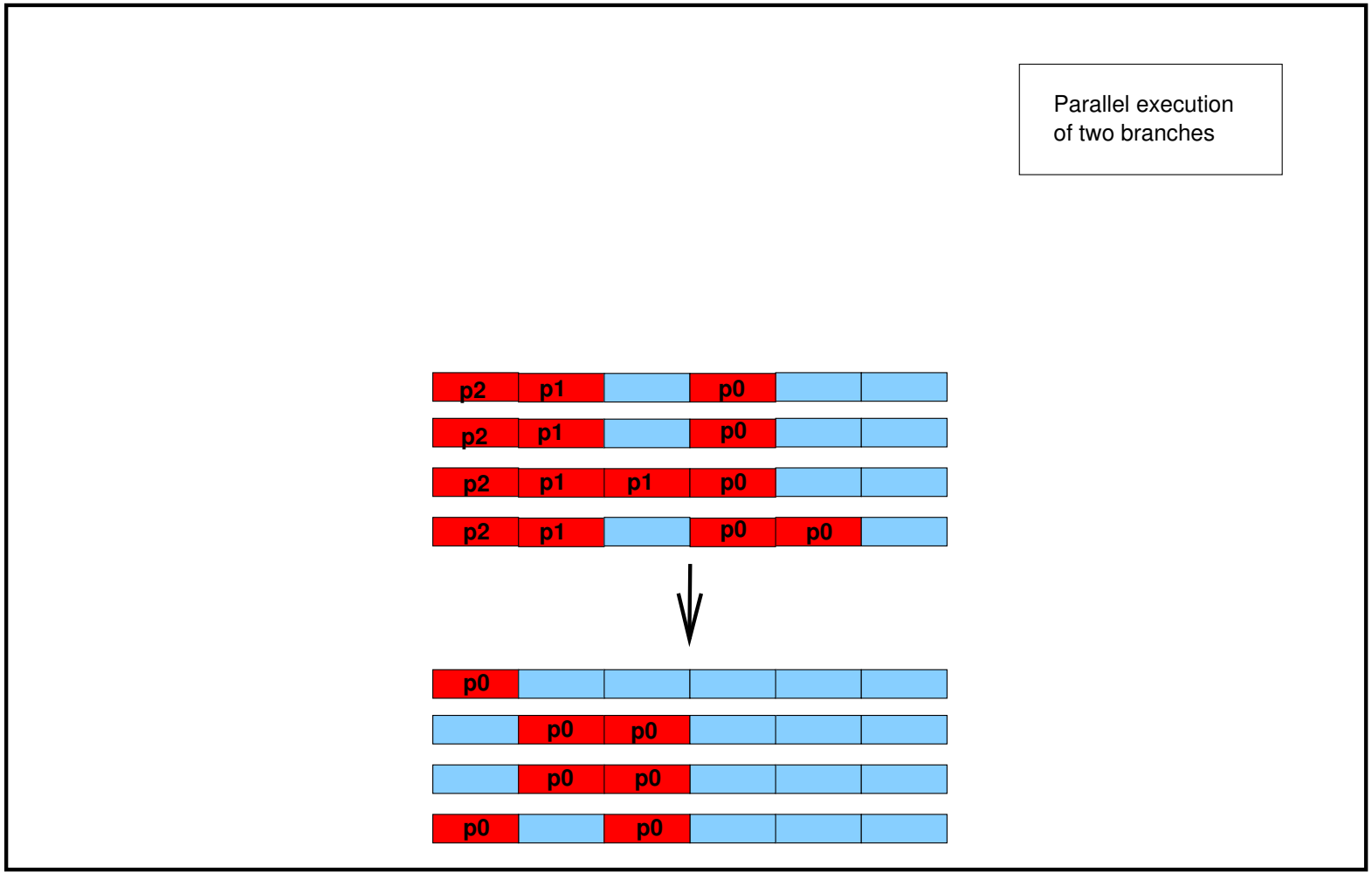
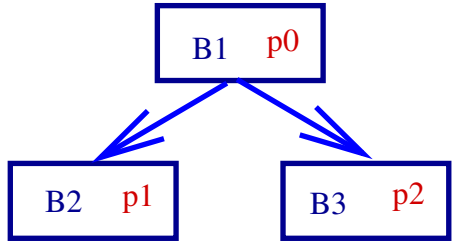


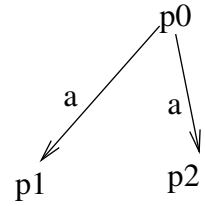
Predicate Partition Graph

p0

Atomic Predicates = {p0}

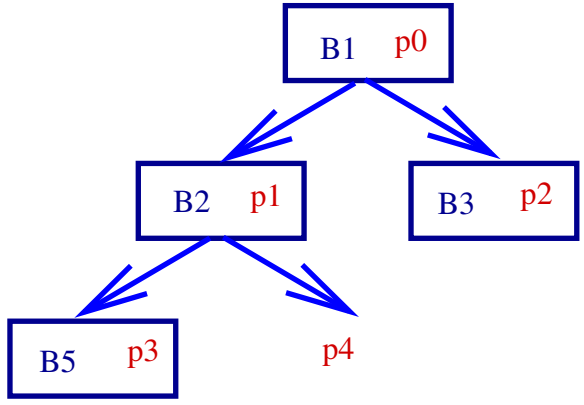
Predicate Partition Graph

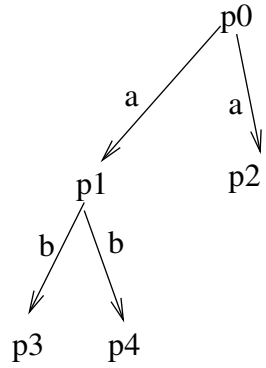




Atomic Predicates = {p1, p2}

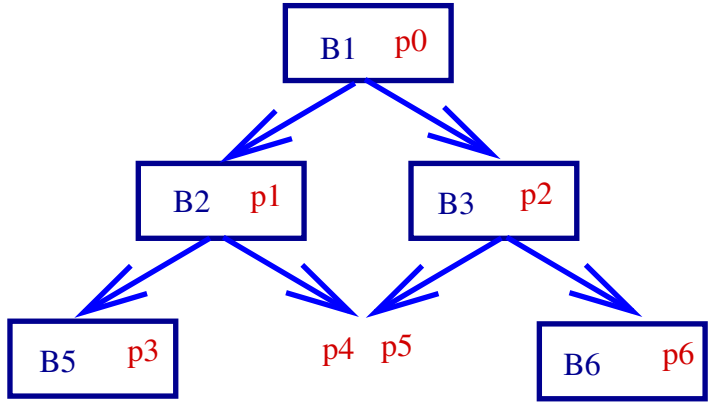
Predicate Partition Graph

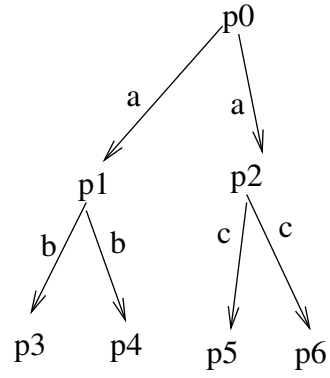




Atomic Predicates = {p3, p4, p2}

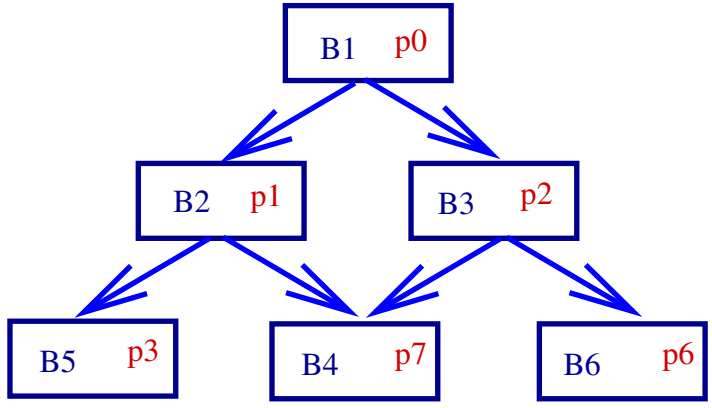
Predicate Partition Graph

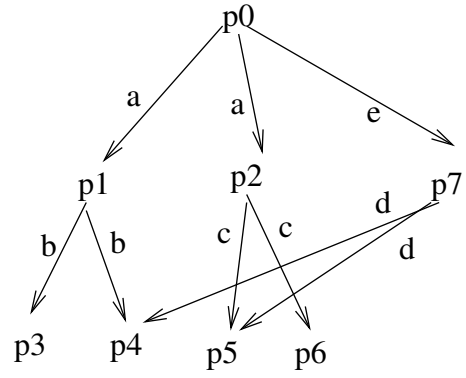




Atomic Predicates = {p3, p4, p5, p6}

Predicate Partition Graph





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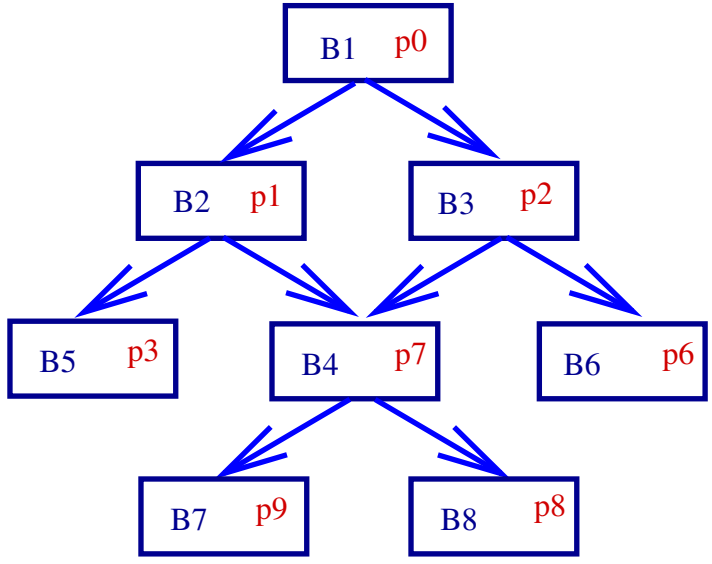
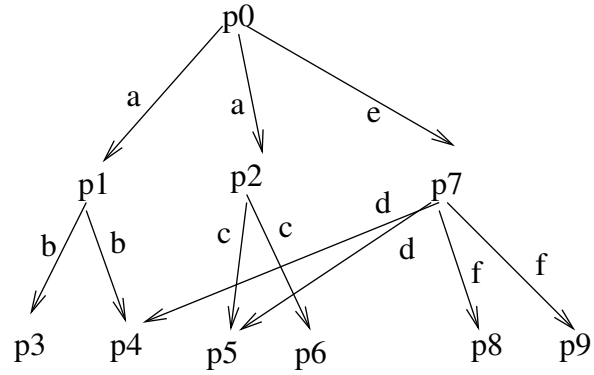
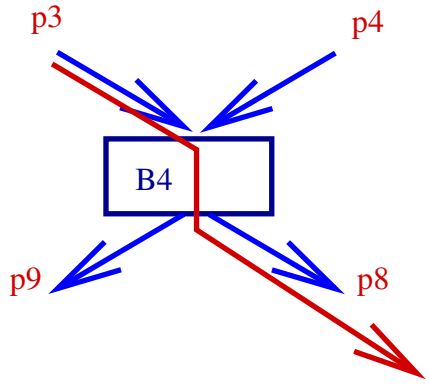




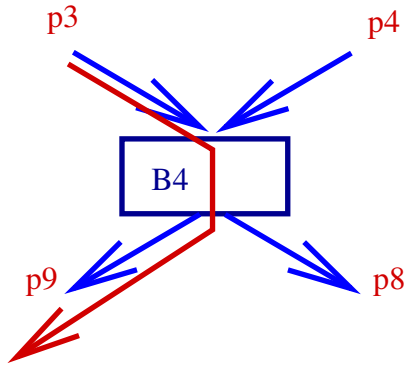
Atomic Predicates = {p3, p4 inter p8, p5 inter p8, p4 inter p9, p5 inter p9, p6}

Prédicats atomiques



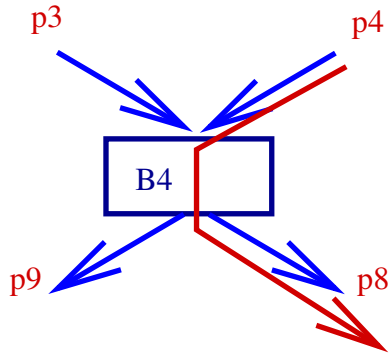
Atomic Predicates = {p3 inter p8,

Prédicats atomiques



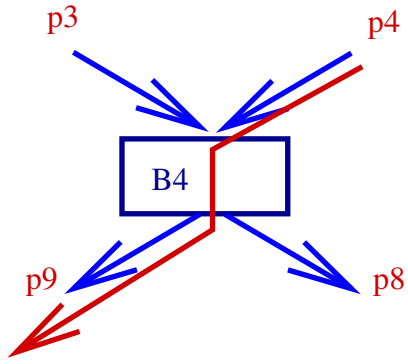
Atomic Predicates = {p3 inter p8, p3 inter p9,

Prédicats atomiques



Atomic Predicates = {p3 inter p8, p3 inter p9, p4 inter p8,

Prédicats atomiques



Atomic Predicates = {p3 inter p8, p3 inter p9, p4 inter p8, p4 inter p9}

PRE sur code prédicaté

1. L'analyse du flot de données propage des ensembles de prédicats.
2. Deux propriétés sont calculées pour chaque BB:
   - *anticipability*
   - *availability*
3. Insertion de variables temporaires aux points au plus tôt.
4. Supression des expression redondantes des BB où *avail* est vraie.

Résultats

Documentation du compilateur:

- Une présentation générale sous forme de slides
- Le rapport de stage
- Une page web http://www-rocq.inria.fr/~pop/

Résultats

Implémentation:

- Spécification algébrique
- Raffinement en C++
- Intégration dans ORC

Spécification Algébrique

- Outil de communication
- Typage évite des erreurs
- Raffinements ultérieurs
- Difficultés du domaine séparés des difficultés de l'intégration dans un système complexe.

Conclusion

- Découverte d'un nouveau compilateur
- Idées pour améliorer GCC
- Travail dans une équipe de recherche

Conclusion

Remerciements:

- Merci à l'équipe du projet A3 pour m'avoir proposé ce stage intéressant.
- Un grand merci à Albert Cohen pour son temps et pour son aide pendant le stage.

Open64 vs. GCC

“state of the art” compilers

Open64 vs. GCC

Open64:

- LNO, IPA
- un excellent paralléliseur de code
- architecture complètement modulaire

Open64 vs. GCC

GCC:

- support pour plus de 40 architectures
- 5 front-ends (C, C++, Java, Fortran, Ada)
- multitude d'autres langages portés (Pascal, Cobol, CLisp, Mercury, . . .)
- support pour le développement:
  - bug database
  - test-suites
  - documentation
  - mailing lists de développement actives
- pas (encore) de support pour LNO ou IPA.