An OpenMP source to source compiler for Kaapi and StarPU

Philippe Virouleau

INRIA - MOAIS team

Friday, July 11th

Plan

1. ADT KStar
2. Overview of the compiler
3. Introducing KASTORS benchmark suite
4. Future works

Plan

Context : HPC

Applications

- CPU intensive
- Dense Linear Algebra
- Simulations

Architectures

- Multi-cores/Multi-accelerators
- + Xeon Phi (Many Integrated Core)

Existing runtimes

- StarPU [Runtime]
- XKaapi [MOAIS]
- OMPSS [BSC]

Objectives

Use these architectures

- Existing standard : OpenMP (C/C++/Fortran)
  - OMP 3.1 : tasks and loops
  - OMP 4.0 : dependent tasks, accelerators, SIMD
- + extensions

Execution

- StarPU (http://starpu.gforge.inria.fr)
- XKaapi (http://kaapi.gforge.inria.fr)

OpenMP => Runtime

- Source to source compiler (Clang)
- Support for OpenMP 3.1 + dependencies + accelerators

Who is involved

- Lead
  - T. Gautier [MOAIS] (Grenoble)
- Bordeaux [RUNTIME]
  - O. Aumage (Local lead)
  - N. Furmento
  - S. Thibault
  - ???, IJD
- Grenoble [MOAIS]
  - F. Broquedis
  - P. Brunet, IJD, ADT K'Star
  - P. Virouleau, IJD, ADT Kawah

Plan

Description

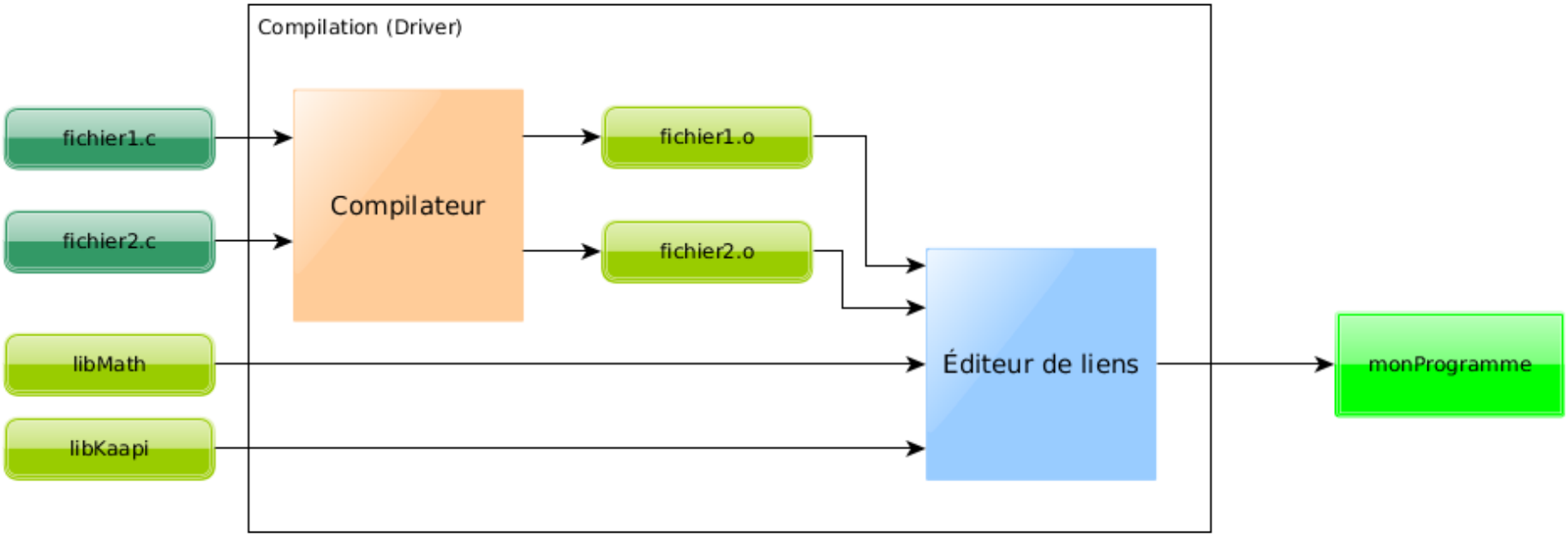
Flow

- Input : C/C++ code with OpenMP.
- Intermediary file : C/C++ code with call to runtime
- Output : program for target platform

Tools

- Code transformation : Clang
- Final program : user-defined backend compiler (gcc/clang/icc tested)

The driver


Compilation (Driver)
fichier1.c
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libKaapi
Compilateur
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Éditeur de liens
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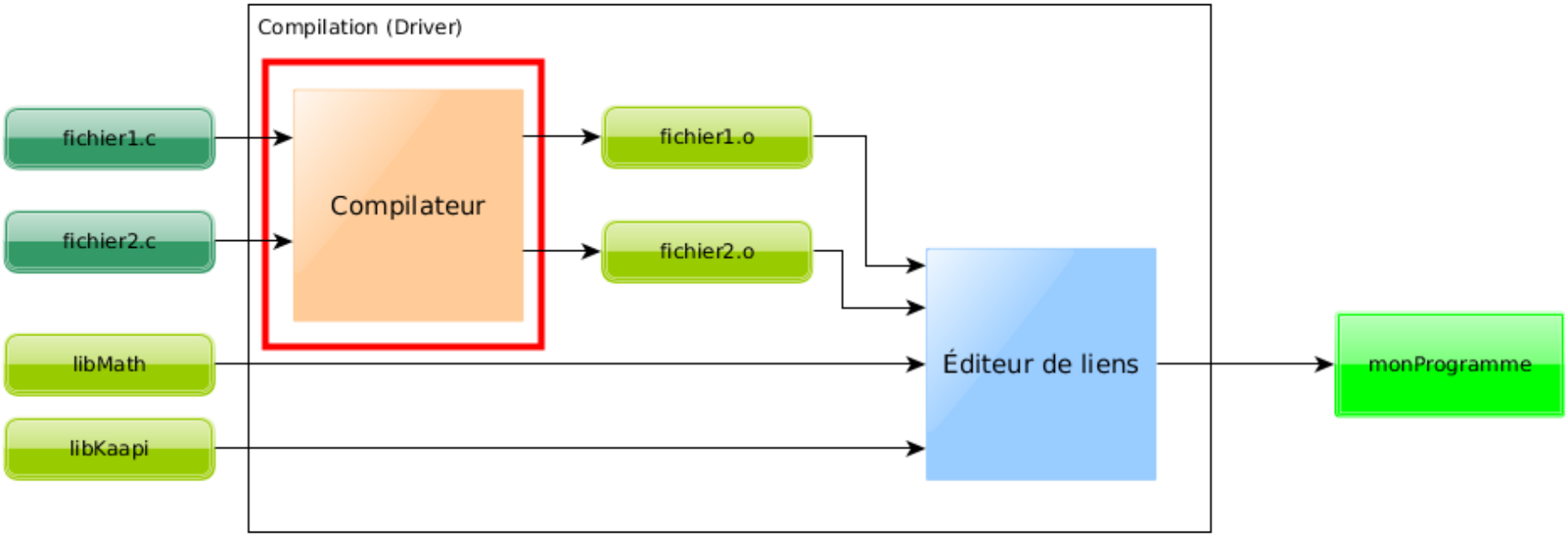
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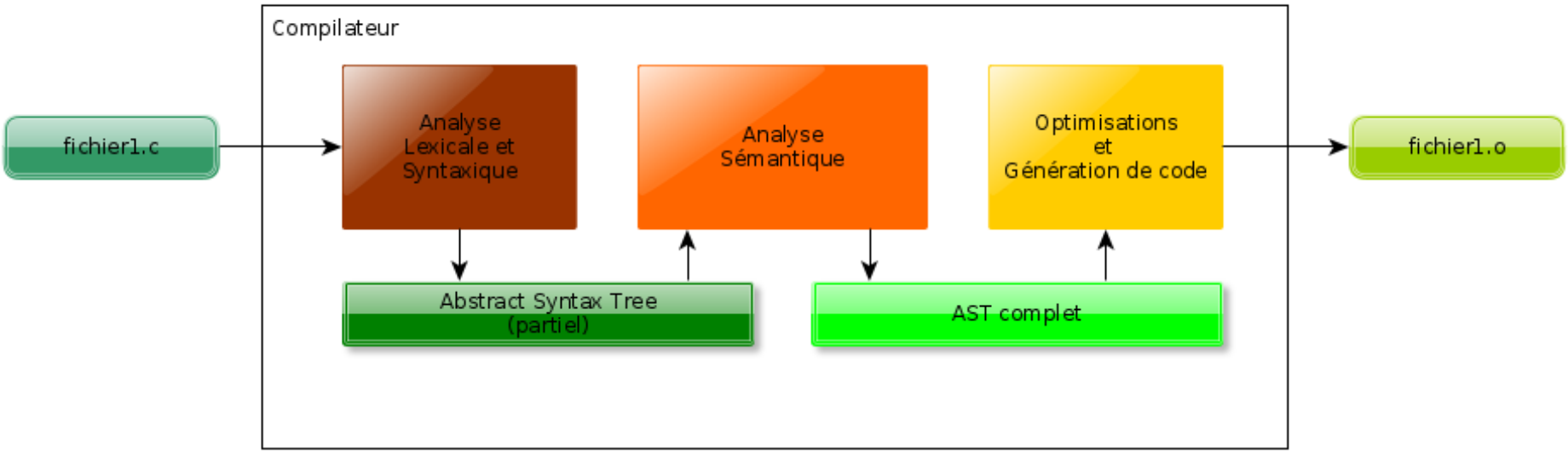

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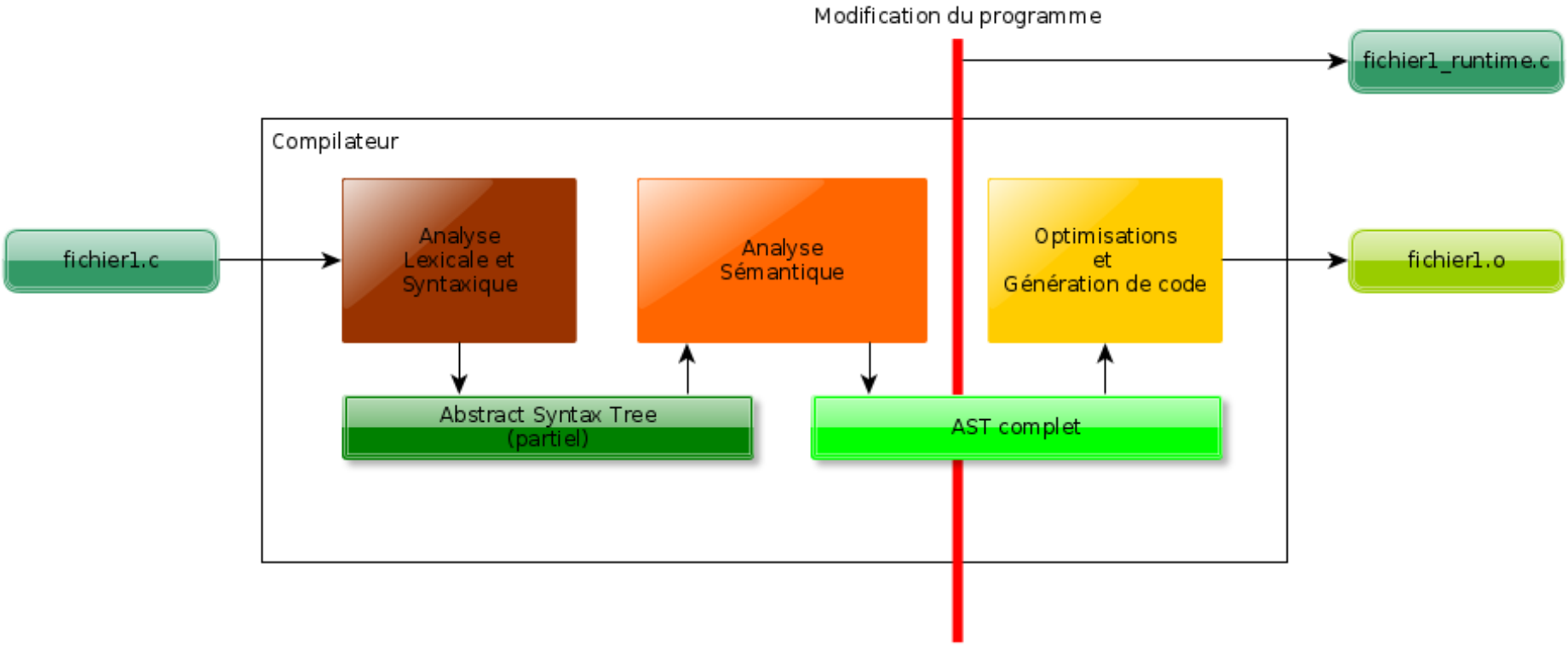

A small example

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int main()
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    int x = 3;
    x += 4;
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|-TypedefDecl 0x2ff5af0 <<invalid sloc>> __int128_t '__int128'
|-TypedefDecl 0x2ff5b50 <<invalid sloc>> __uint128_t 'unsigned __int128'
|-TypedefDecl 0x2ff5ea0 <<invalid sloc>> __builtin_va_list '__va_list_tag [1]'
`-FunctionDecl 0x2ff5f40 <example.c:2:1, line:8:1> main 'int ()'
  `-CompoundStmt 0x2ff6168 <line:3:1, line:8:1>
    |-DeclStmt 0x2ff6068 <line:4:5, col:14>
    | `-VarDecl 0x2ff5ff0 <col:5, col:13> x 'int'
    |   `-IntegerLiteral 0x2ff6048 <col:13> 'int' 3
    |-CompoundAssignOperator 0x2ff60c8 <line:5:5, col:10> 'int' '+=' ComputeLHSTy='
        int' ComputeResultTy='int'
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Visiting the AST

```
class RuntimeVisitor : public clang::RecursiveASTVisitor<RuntimeVisitor>
{
    public:
    /*...*/
        bool VisitOMPTaskDirective(clang::OMPTaskDirective *s);
        bool VisitOMPTaskwaitDirective(clang::OMPTaskwaitDirective *s);
        bool VisitFunctionDecl(clang::FunctionDecl *f);
    /*...*/
};
```

What's next ?

Modify the AST ?

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Use the Rewriter

- Many ways to visit the AST ...
- With some constraints.
- Does the job !

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class Rewriter {
    /*...*/
    bool InsertTextAfter(SourceLocation Loc, StringRef Str);
    bool InsertTextBefore(SourceLocation Loc, StringRef Str);
    /*...*/
    bool RemoveText(SourceLocation Start, unsigned Length,
                    RewriteOptions opts = RewriteOptions());
    /*...*/
    bool ReplaceText(SourceRange range, StringRef NewStr);
};
```

Basic rewriting example

```
void print(const char *msg) {
    printf("%s\n", msg);
}

int main( int argc, char** argv) {
    char mon_msg[] = "Hello !";
#pragma omp task
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void print(const char *msg) {
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/* Generated arg struct */
struct __gen_argstruct {
  char [8] mon_msg;
};

int main( int argc, char** argv) {
    char mon_msg[] = "Hello !";
  /* Generated task spawn */
  omp_push_task(wrapper, args);
  /* Generated taskwait */
  omp_sched_sync();
  return 0;
}

/* Generated wrapper */
void wrapper(void *_k_arg) {
  // The captured stmts param
  __gen_argstruct *args = (__gen_argstruct
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Rewriting steps

- Runtime-specific type creation
- Code wrapper creation
- Task creation in the runtime

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/* ... */
```

Code outlining and data sharing

```
int main (int argc, char *argv[])
{
int i, n;
float a[100], b[100], sum;

#pragma omp parallel for reduction(+:sum) firstprivate(n) shared(sum, a, b)
    for (i=0; i < n; i++) {
        int toto = 5;
        sum = sum + (a[i] * b[i]);
    }
}
```

```
[...]
|   `-OMPParallelDirective 0x2e3c638 <line:6:9, col:42>
|     `-CapturedStmt 0x2e3c598 <col:9, col:42>
|       |-Capture byref Var 0x2df41a0 'i' 'int'
|       |-Capture byref Var 0x2df4210 'n' 'int'
|       |-Capture byref Var 0x2e388f0 'sum' 'float'
|       |-Capture byref Var 0x2e387e0 'a' 'float [100]'
|       |-Capture byref Var 0x2e38880 'b' 'float [100]'
[...]
```

Summary

Steps

- Build an AST through Clang
- Visit and extract informations from it
- Generate correct calls to runtime (XKaapi + StarPU)
- Output final code

Support

Support for OpenMP 3.1 + dependent tasks and SIMD

On the web

http://kstar.gforge.inria.fr

Plan

Motivations

Existing benchmark suite

- BOTS (Barcelona OpenMP Task Suite [BSC])
- NAS, SPECOMP, ...
- No benchmark for dependent tasks yet !

Objectives

- Evaluate the OpenMP dependent task paradigm
- Show OpenMP 4.0 limits for dependent task
- Compare runtimes

OpenMP Dependent Task Suite

Applications

- Jacobi/Poisson2D
- SparseLU (BOTS[a])
- Strassen (BOTS)
- Plasma (2 kernels)

[a] Barcelona OpenMP Task Suite

OpenMP Dependent Task Suite

Jacobi/Poisson2D

Solve poisson equation on a [0,1]x[0,1] square, divided in NxN points.

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Dense matrix multiplication by bloc decomposition

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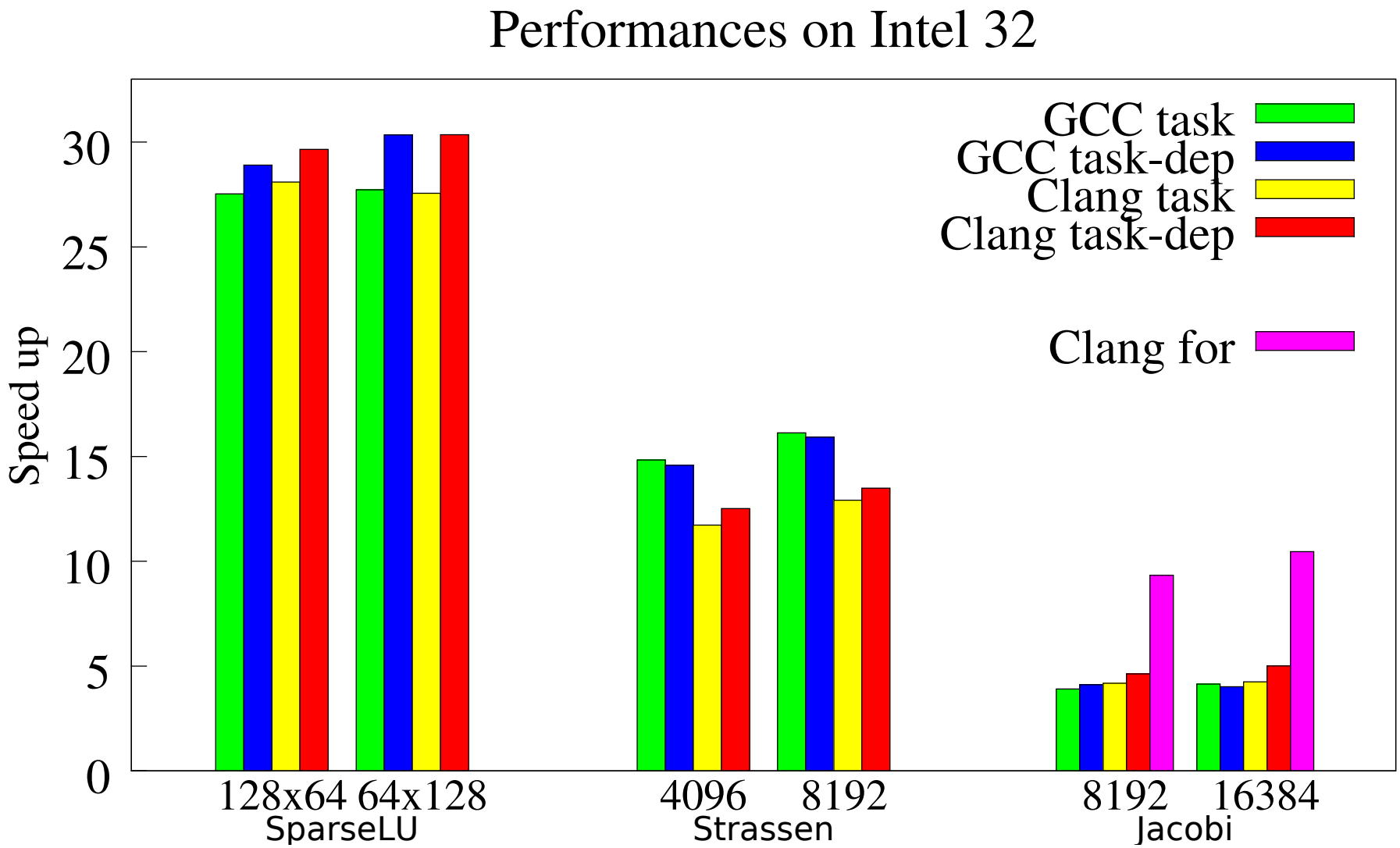
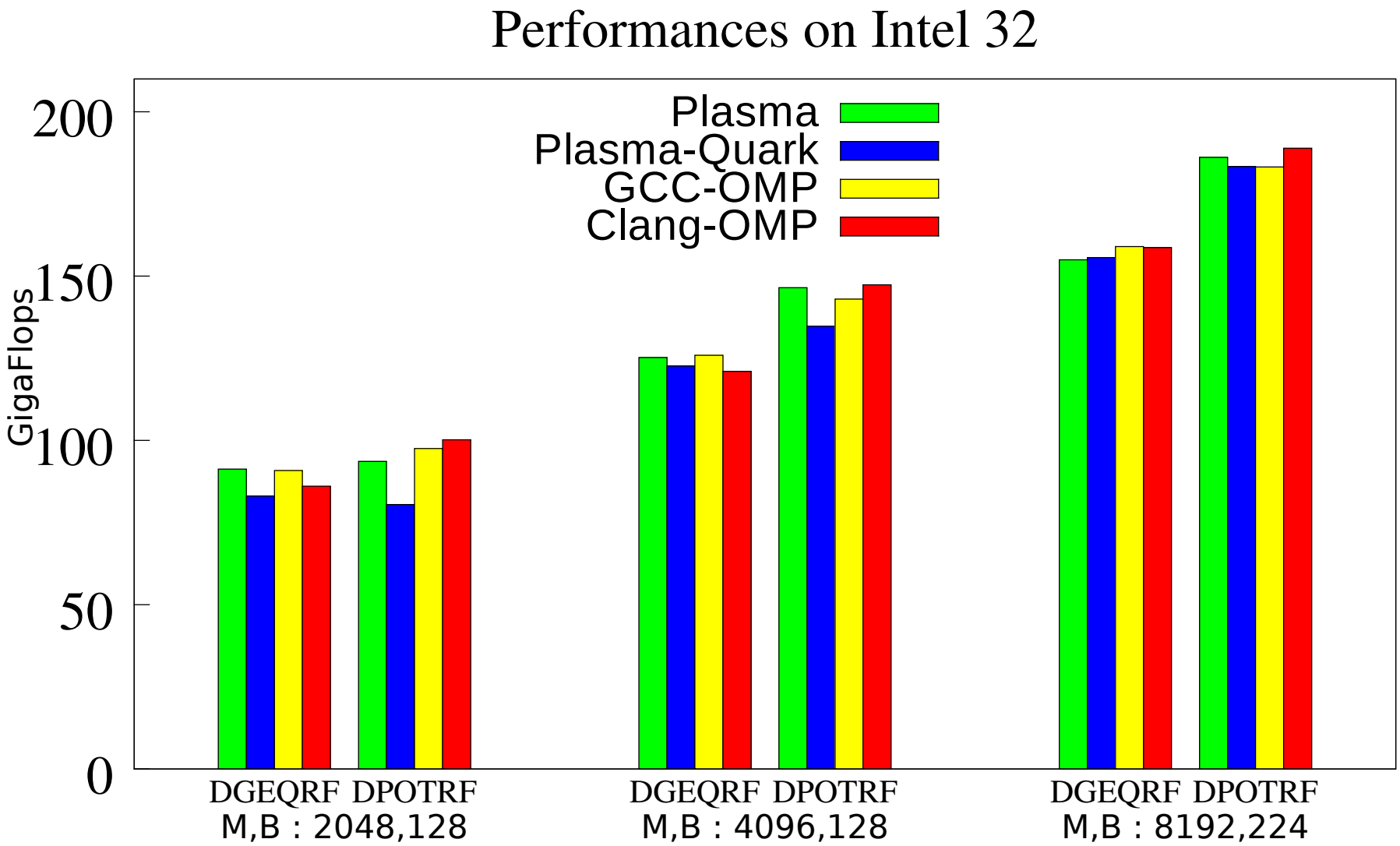
Plasma

- Refactor of the library
- Cholesky and QR factorization on double (dpotrf & dgeqrf)

Performances for SparseLU, Strassen, and Jacobi



Performances for Plasma



Conclusion

Results are quite encouraging

- Better performances with dependent tasks
- Jacobi : scheduling issue (for is better)
- OpenMP 4.0 is a good alternative to QUARK
- Others dedicated runtimes worth a look

On the web

http://kastors.gforge.inria.fr

Plan

Klang improvements

Language

- C++ (support templates)
- Fortran

OpenMP support

- omp target
- leading dimension (avoid VLA)
- reduction in task (Comitee discussion)

KASTORS improvements

Kernels

- Include non Linear Algebra applications
- Improve some performances on Plasma

Papers

- Accepted @ IWOMP2014
- Submission to LLVM/Clang workshop @SC'14 ?

Questions ?