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X-KAAPI *C programming interface*

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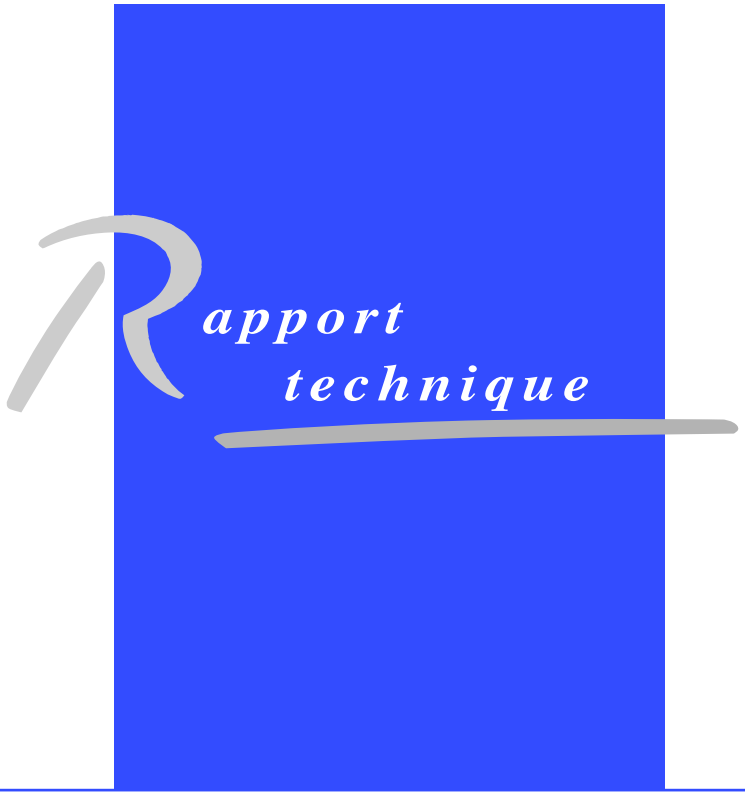

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Abstract: This report defines the X-Kaapi C programming interface.

Key-words: parallel computing, X-Kaapi, C

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X-Kaapi C programming interface

Résumé : The rapport dcrit l'interface de programmation C pour X-Kaapi

Mots-clés : calcul parallel, X-Kaapi, C

Contents

1 Software installation

X-Kaapi is both a programming model and a runtime for high performance parallelism targeting multicore and distributed architectures. It relies on the work stealing paradigm. X-Kaapi was developed in the MOAIS INRIA project by Thierry Gautier, Fabien Le Mentec, Vincent Danjean and Christophe Laferrire in the early stage of the library.

In this report, only the programming model based on the C API is presented. The runtime library comes also with a full set of complementary programming interfaces: C, C++ and STL-like interfaces. The C++ and STL interfaces, at a higher level than the C interface, may be directly used for developing parallel programs or libraries.

Supported Platforms

X-Kaapi targets essentially SMP and NUMA platforms. The runtime should run on any system providing:

- a GNU toolchain (4.3),
- the pthread library,
- Unix based environment.

It has been extensively tested on the following operating systems:

- GNU-Linux with x86_64 architectures,
- MacOSX/Intel processor.

There is no version for Windows yet.

X-Kaapi Contacts

If you wish to contact the XKaapi team, please visite the web site at:

`http://kaapi.gforge.inria.fr`

2 Initialization and termination

2.1 Synopsis

```
int kaapic_init(int flags)
int kaapic_finalize(void)
```

2.2 Description

kaapic_init initializes the runtime. It must be called by the program before using any of the other routines. If successful, there must be a corresponding *kaapic_finalize* at the end of the program.

2.3 Parameters

- *flags*: if not zero, start only the main thread to avoid disturbing the execution until tasks are actually scheduled. The other threads are suspended waiting for a parallel region to be entered (refer to kaapic_begin_parallel).

2.4 Return value

0	in case of success
else	an error code

2.5 Example

```
int main()
{
  int err = kaapic_init(1);

  ...

  kaapic_finalize();
}
```

3 Concurrency

3.1 Synopsis

```
int  kaapic_get_concurrency(void)
int kaapic_get_thread_num(void)
```

3.2 Description

Concurrency related routines.

3.3 Return value

kaapic_get_concurrency returns the number of parallel thread available to the X-KAAPI runtime.

kaapic_get_thread_num returns the current thread identifier. Note it should only be called in the context of a X-KAAPI thread.

3.4 Example

```
int main()
{
  int err = kaapic_init(1);

 printf("#available threads: %i\n",
    kaapic_get_concurrency() );
 printf("My thread identifier is: %i\n",
    kaapic_get_thread_num() );
  ...

  kaapic_finalize();
}
```

4 Performance

4.1 Synopsis

```
double kaapic_get_time(void)
```

4.2 Description

Capture the current time. Used to measure the time spent in a code region.

4.3 Parameters

None.

4.4 Return value

Time in seconds since an arbitrary time in the past.

4.5 Example

```
int main()
{
  double start, stop;
  int err = kaapic_init(1);
  start = kaapi_get_time();
  ...
  stop = kaapi_get_time();


  printf("Time : %f (us)\n", stop-start );
  kaapic_finalize();
}
```

5 Independent loops

5.1 Synopsis

```
int kaapic_foreach(
  int first,
  int last,
  kaapic_foreach_attr_t* attr,
  int32_t nparam,
  ...
 )

int kaapic_foreach_withformat(
  int first,
  int last,
  kaapic_foreach_attr_t* attr,
  int32_t nparam,
  ...
 )
```

5.2 Description

Those routines run a parallel loop over the range [*first*, *last*)[1] The loop is given as function with its parameters. The body function has *nparam* parameters and it is passed in the ... optional effective parameter list of the foreach interface.

At runtime, the initial interval is dynamically split in K disjoint intervals $[b_i, e_i)$ such that $\cup_{i=0..K-1}[b_i, e_i) = [first, last)$. For each of this sub-interval, X-KAAPI calls by several threads *body(b_i, e_i, tid, e_0, ..., $e_{nparam-1}$)* where *tid* is the thread identifier that made the call.

If not null, *attr* is a pointer to an attribut that can be pass tuning parameter to the runtime. Please see *kaapic_foreach_attr_set_grains*.

5.3 Parameters

For *kaapi_foreach* interface, the format of the optional parameter list is:

body : the function with signature
void (*)(int, int, int [,$type_0$, .., $type_{nparam-1}$]).
Each type $type_i$ could be:

- a pointer to a memory data
- a scalar value with size not bigger that the size of a pointer.

[1] This is an **exclusive** interval in the C interface and an **inclusive** interval in the Fortran interface.

e_0 : first effective parameter passed to *body*.

...

$e_{nparam-1}$: last effective parameters passed to *body*.

For *kaapi_foreach_with_format* interface extend *kaapi_foreach* interface in order to pass the size, the type and the access mode of each of the effective parameter. The format of the optional parameter list is:

body : the function with signature
void (*)(int, int, int [,type$_0$, .., type$_{nparam-1}$]).
Each type *type$_i$* could be:

- a pointer to a memory data
- a scalar value with size not bigger that the size of a pointer.

mode, e_0, count, type : access mode, first effective parameter passed to *body*, the number of type elements pointed by e_0 and the type of each element.

...

mode, $e_{nparam-1}$, count, type : access mode, last effective parameter passed to *body*, the number of type elements pointed by $e_{nparam-1}$ and the type of each element.

Please refer to the data flow programming section to have a description of *mode* and *type* informations.

5.4 Return value

In case of success the function return 0, else it returns an error code.

5.5 Example

Refer to examples/kaapic

```
/* loop body */
static void body(
  int i, int j, int tid, double* array, double* value
)
{
  int k;
  for (k = i; k < j; ++k)
    array[k] += *value;
}
```

```
int main()
{
  double* array;
  double value;
  int err = kaapic_init(1);
  start = kaapi_get_time();
  /* apply body on array[0..size-1] */
  kaapic_foreach( 0, size, 2, body, array, &value );
  stop = kaapi_get_time();

  printf("Time : %f (us)\n", stop-start );
  kaapic_finalize();
}
```

The next example is equivalent to the previous:

```
/* loop body */
static void body(
  int i, int j, int tid, double* array, double* value
)
{
  int k;
  for (k = i; k < j; ++k)
    array[k] += *value;
}

int main()
{
  double* array;
  double value;
  int err = kaapic_init(1);
  start = kaapi_get_time();
  /* apply body on array[0..size-1] */
  kaapic_foreach_with_format( 0, size, 2, body,
      KAAPIC_MODE_RW, array, size, KAAPIC_TYPE_DOUBLE
      KAAPIC_MODE_V, &value, 1,  KAAPIC_TYPE_DOUBLE
  );
  stop = kaapi_get_time();

  printf("Time : %f (us)\n", stop-start );
  kaapic_finalize();
}
```

6 Dataflow programming

6.1 Synopsis

```
int kaapic_spawn(int32_t nargs, ... )
```

6.2 Description

Create a new computation task implemented by a call to a function *body* with effective parameters e_i.

The function *body* as well as its effective parameters are pass in the optional parameter list of *kaapic_spawn*. The format of the optional parameter list is:

body : the function with signature
void (*)([type$_0$, .., type$_{nparam-1}$]).
Each type *type$_i$* could be:

- a pointer to a memory data
- a scalar value with size not bigger that the size of a pointer.

body is called with the user specified arguments, there is no argument added by X-KAAPI:

```
body(e0, e1, ..., )
```

6.2.1 Format of each 4 successive arguments

Each task parameter is described by 4 successive arguments including:

- the access *mode*.
- the argument *value*,
- the element *cound*,
- the parameter *type*

6.2.2 Mode information

The parameter *mode* is one of the following:

- KAAPIC_MODE_R=0 for a read access,
- KAAPIC_MODE_W=1 for a write access,
- KAAPIC_MODE_RW=2 for a read write access,
- KAAPIC_MODE_V=3 for a parameter passed by value.

6.2.3 Type information

The *type* is one of the following:

- KAAPIC_TYPE_CHAR=0,
- KAAPIC_TYPE_INT=1,
- KAAPIC_TYPE_REAL=2,
- KAAPIC_TYPE_DOUBLE=3.

If a parameter is an array, *count* must be set to the number of the element of the array. For a scalar value, it must be set to 1.

6.3 Parameters

- *nargs*: the argument count.
- ...: the *body* followed by a *mode*, *value*, *count* , *type* tuple list.

6.4 Return value

None.

6.5 Example

Refer to examples/kaapif/dfg

```
/* computation task entry point */
void fibonacci(int n, int* result)
{
  /* task user specific code */
  if (n <2)
    *result = n;
   else
   {
      int result1, result2;
      kaapic_spawn( 2, fibonacci,
        KAAPIC_MODE_V, n-1, 1, KAAPIC_TYPE_INT
        KAAPIC_MODE_W, &result1, 1,  KAAPIC_TYPE_INT
      );
      kaapic_spawn( 2, fibonacci,
        KAAPIC_MODE_V, n-2, 1, KAAPIC_TYPE_INT
        KAAPIC_MODE_W, &result2, 1,  KAAPIC_TYPE_INT
      );
      kaapic_sync();
      *result = result1 + result2;
   }
}
```

```
int main()
{
  int n = 30;
  int result= 0;
  int err = kaapic_init(1);

  start = kaapi_get_time();
  /* apply body on array[0..size-1] */
  kaapic_spawn( 2, fibonacci,
      KAAPIC_MODE_V, n, 1, KAAPIC_TYPE_INT
      KAAPIC_MODE_W, &result, 1,  KAAPIC_TYPE_INT
  );
  stop = kaapi_get_time();

  printf("Time : %f (us)\n", stop-start );
  kaapic_finalize();
}
```

7 Parallel regions

7.1 Synopsis

```
int kaapic_begin_parallel(void)
int kaapic_end_parallel( int flag )
```

7.2 Description

kaapic_begin_parallel and *kaapic_end_parallel* mark the start and the end of a parallel region. Regions are used to wakeup and suspend the X-KAAPI system threads so they avoid disturbing the application when idle. This is important if another parallel library is being used. Wether threads are suspendable or not is controlled according by the *kaapi_init* parameter.

7.3 Parameters

- *falg*: if zero, an implicit synchronization is inserted before leaving the region.

7.4 Return value

None.

7.5 Example

```
int main()
{
  int err = kaapic_init(1);

  kaapic_begin_parallel();
  ...
  kaapic_end_parallel();
  ...

}
```

8 Synchronization

8.1 Synopsis

```
void kaapic_sync(void)
```

8.2 Description

Synchronize the sequential with the parallel execution flow. When this routine returns, every computation task has been executed and memory is consistent for the processor executing the sequential flow.

8.3 Return value

None.

8.4 Example

Refer to the Fibonacci example in section 6.5.

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