C-DAC Four Days Technology Workshop

ON

Hybrid Computing – Coprocessors/Accelerators
Power-Aware Computing – Performance of Applications Kernels

hyPACK-2013
Mode 3 : OpenMP 4.0

Lecture Topic :
OpenMP 4.0- An Overview

***Venue** : CMSD, UoHYD ; **Date** : October 15-18, 2013*

An Overview of OpenMP 4.0

Lecture Outline

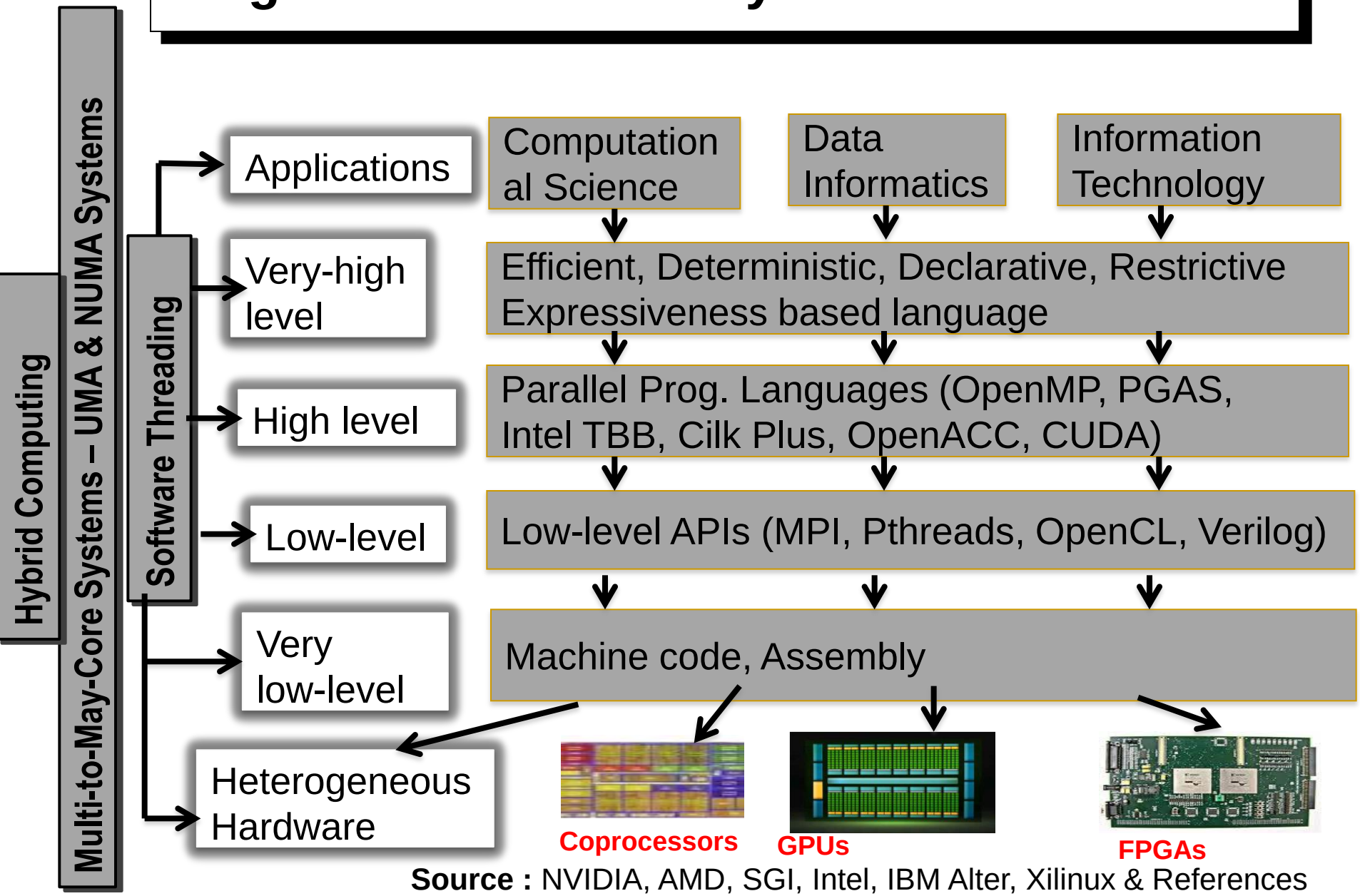
Following topics will be discussed

- Understanding of Xeon-Phi Architecture- OpenMP
- Programming on Devices using “Accelerator Prog.” & OpenMP 4.0
- Tuning & Performance – Software Threading-OpenMP 4.0

Programming on Systems with Co-processors - OpenMP 4.0

Systems with Devices - Overview

Prog.API - Multi-Core Systems with Devices



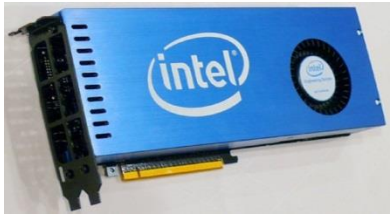
Source : NVIDIA, AMD, SGI, Intel, IBM Alter, Xilinux & References

Multi-Core Systems with Accelerator Types

- **FPGA**
  - Xilinx, Alter

- **GPU**
  - Nvidia (Kepler),
  - AMD Trinity APU

- **MIC (Intel Xeon-Phi)**
  - Intel Xeon-Phi (MIC)



Source : NVIDIA, AMD, SGI, Intel, IBM Alter, Xilinux References

Prog.API - Multi-Core Systems with Devices

DO Parallel
DO Synchronize
Get Maximum of all values
Give to Compiler

DO TRANSFER from Host to Device
Perform C omp. On Device

Use as Linux OS
DO TRANSFER from Host to Device

Parallel Prog. Languages (OpenMP, PGAS, Intel TBB, Cilk Plus, OpenACC, CUDA)

Programming with High Level APIs

Host : Multi-Core Systems OR ARM Multi-core Systems

CPU- Multi-Core Sys With

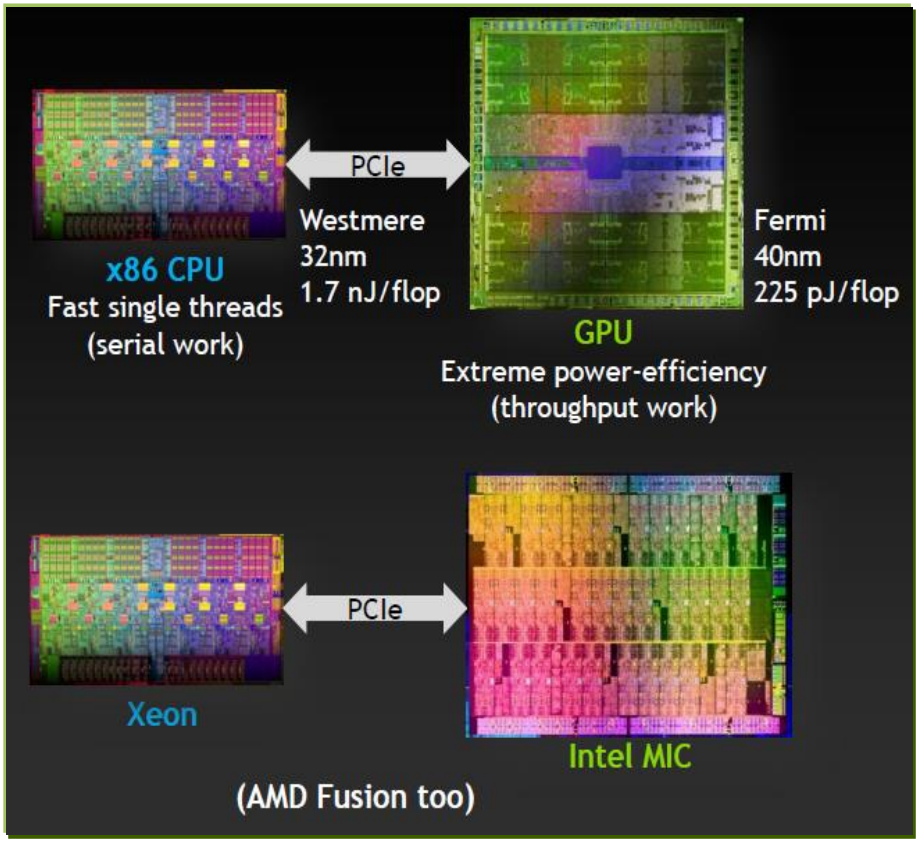
FPGA (Xilinx, Alter)

GPU - Nvidia (Kepler), AMD Trinity APU

MIC (Intel Xeon-Phi)

Source : NVIDIA, AMD, SGI, Intel, IBM Alter, Xilinux References

HPC Going Hybrid



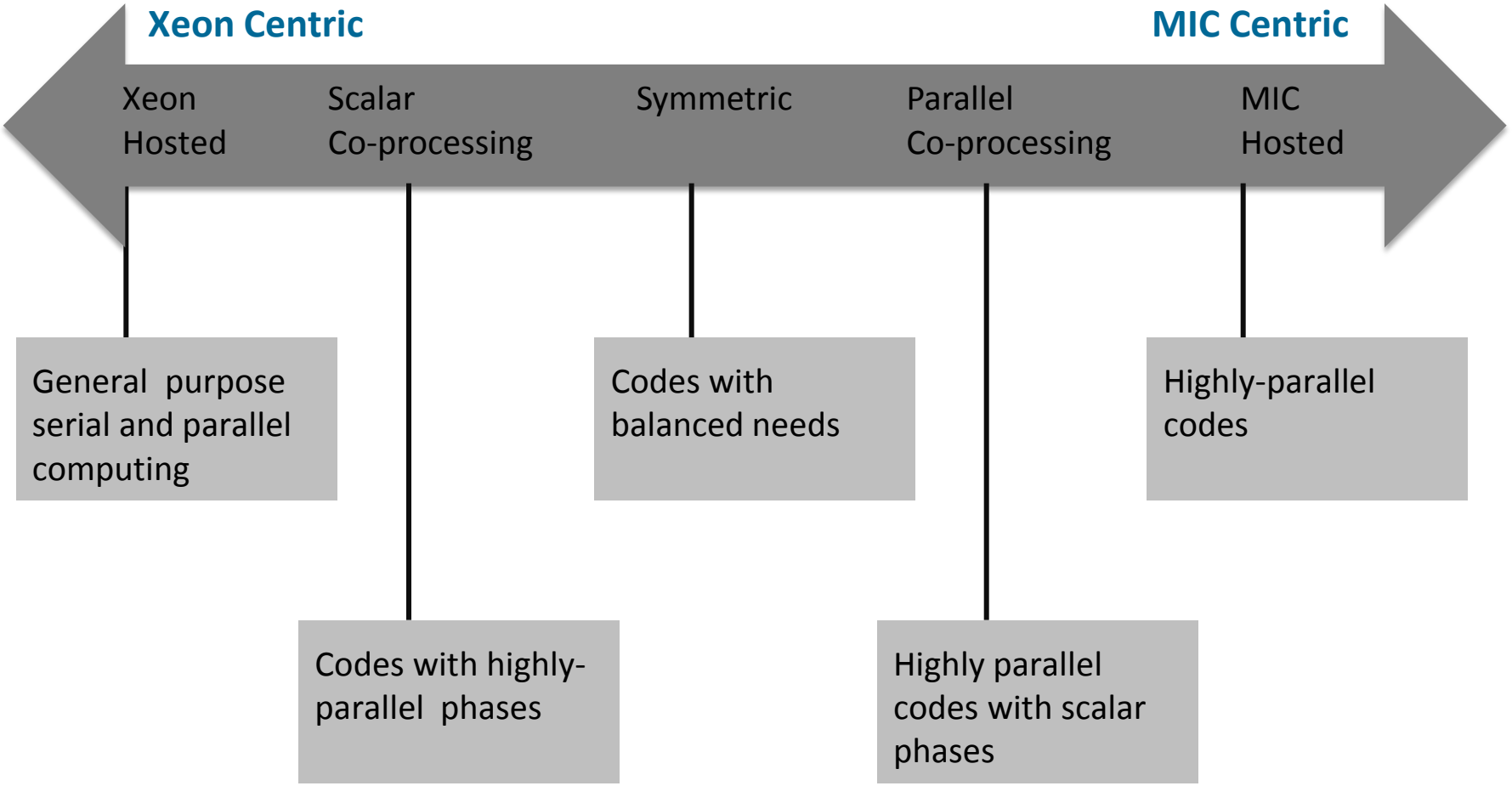
- Do most work by cores optimized for extreme energy efficiency
- Still need a few cores optimized for fast serial work

- And memory hierarchies are getting deeper…
  - More levels
  - Large impact on energy usage

Source : NVIDIA, PGI & References given in the presentation

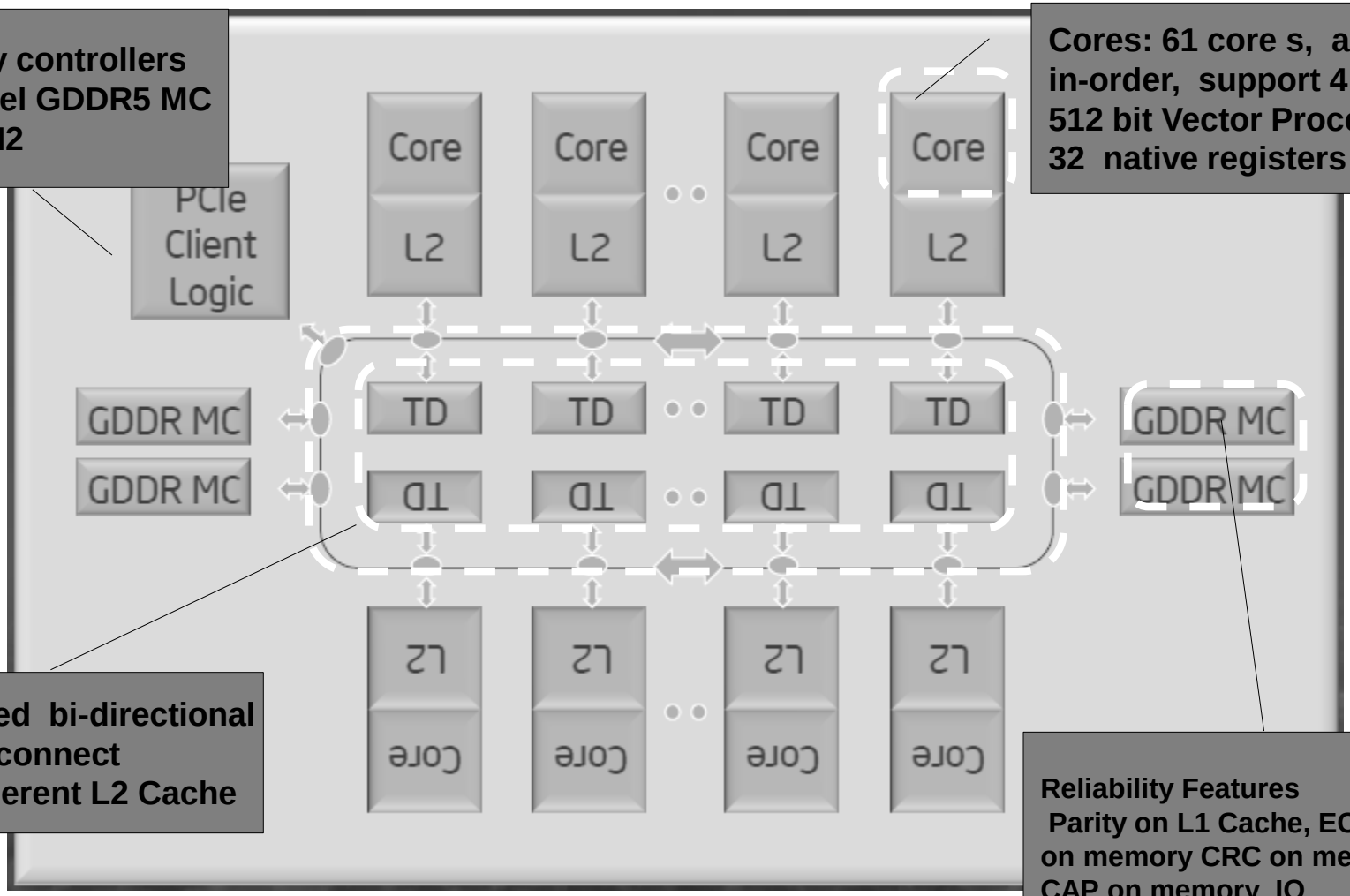
MIC Architecture, System Overview

Compute modes vision



Source : References & Intel Xeon-Phi; http://www.intel.com/

Intel® Xeon Phi™ Architecture Overview



8 memory controllers
16 Channel GDDR5 MC
PCIe GEN2

Cores: 61 core s, at 1.1 GHz
in-order, support 4 threads
512 bit Vector Processing Unit
32 native registers

High-speed bi-directional ring interconnect
Fully Coherent L2 Cache

Reliability Features
Parity on L1 Cache, ECC on memory CRC on memory IO, CAP on memory IO

Source : References & Intel Xeon-Phi; http://www.intel.com/

OpenMP : SIMD Constructs

`simd` construct

Summary

The **`simd`** construct can be applied to a loop to indicate that the loop can be transformed into a SIMD loop (that is, multiple iterations of the loop can be executed concurrently using SIMD instructions).

Syntax

C/C++

The syntax of the **`simd`** construct is as follows:

```
#pragma omp simd [clause[[,] clase] … ] new-line
        for-loops
```

Source : NVIDIA, PGI & References given in the presentation

OpenMP : SIMD Constructs

Syntax

C/C++

The syntax of the **`simd`** construct is as follows:

```
#pragma omp simd [clause[[,] clause] …] new-line
        for-loops
```

where *clause* is one of the following:

`safelen`*(length)*
`linear`(list[:linear-step])
`aligned`(list[:alignment])
`private`(list)
l**astprivate**(list)
reduction(reduction-identifier:list)
collapse(n)

The **`simd`** directive places restrictions on the structure of the associated *for-loops*. Specifically, all associated *for-loops* must have canonical loop form

Source : http:/www.openmp.org; References of OpenMP

OpenMP : `declare simd` Construct

Summary

The **`declare simd`** construct can be applied to a function (C, C++ and Fortran) or a subroutine (Fortran) to enable the creation of one or more versions that can process multiple arguments using SIMD instructions from a single invocation from a SIMD loop. The **`declare simd`** directive is a declarative directive. There may be multiple **`declare simd`** directives for a function (C, C++, Fortran) or subroutine (Fortran 90).

Source : http:/www.openmp.org; References of OpenMP

OpenMP : `declare simd` Construct

Syntax

C/C++

The syntax of the **`declare simd`** construct is as follows:

```
#pragma omp declare simd [clause[[,] clause] …] new-line
/#pragma omp declare simd [clause[[,] clause] …] new-line
[…]
        function definition or declaration
```

where *clause* is one of the following:

- **`simdlen`***(length)*
- **`linear`***(argument-list[:constant-linear-step])*
- **`aligned`***(argument-list[:alignment])*
- **`private`***(argument-list)*
- **`inbranch`**
- **`notinbranch`**

Source : http:/www.openmp.org; References of OpenMP

OpenMP : `Loop SIMD` Constructs

Summary

The loop SIMD construct specifies a loop that can be executed concurrently using SIMD instructions and that those iterations will also be executed in parallel by threads in the team.

Syntax

C/C++

Description

The loop SIMD construct will first distribute the iterations of the associated loop(s) across the implicit tasks of the parallel region in a manner consistent with any clauses that apply to the loop construct. The resulting chunks of iterations will then be converted to a SIMD loop in a manner consistent with any clauses that apply to the **`simd`** construct. The effect of any clause that applies to both constructs is as if it were applied to both constructs separately.

Source : http:/www.openmp.org; References of OpenMP

OpenMP : `Device` Construct

Summary

Create a device data environment for the extent of the region.

Syntax

C/C++

The syntax of the **`target data`** construct is as follows:

```
#pragma omp target data [clause[[,] clase] … ] new-line
        structured-block
```

Where *clause* is one of the following:

`device`(integer-expression)

`map`(*[map-type :] list*))

`if` (*scalar-expression*)

OpenMP `Device` Construct

Binding

The binding task region for a **`target data`** construct is the encountering task. The target region binds to the enclosing parallel or task region.

Description

When a **`target data`** construct is encountered, a new device data environment is created, and the encountering task executes the **`target data`** region. If there is no **`device`** clause, the default device is determined by the *default-device-var* ICV. The new device data environment it constructed form the enclosing device data environment, the data environment of the encountering task and any data-mapping clauses on the construct. When an **`if`** clause is present and the **`if`** clause expression evaluates to false, the device is the host.

Restrictions

A program must not depend on any ordering of the valuations of the clauses of the **`target data`** directive, or any side effects of the evaluations of the clauses.

At most one **`device`** clause can appear on the directive. The **`device`** expression must evaluate to a non-negative integer value.

At most one **`if`** clause can appear on the directive

OpenMP `target` Construct

Summary

Create a device data environment and execute the construct on the same device.

Syntax

C/C++

The syntax of the **`target`** construct is as follows:

```
#pragma omp target data [clause[[,] clase] … ] new-line
        structured-block
```

Where *clause* is one of the following:

`device`(*integer-expression*)

`map`(*[map-type :] list*))

`if` (*scalar-expression*)

Source : http:/www.openmp.org; References of OpenMP

OpenMP `target` Construct

Binding

The binding task region for a **`target`** construct is the encountering task. The target region binds to the enclosing parallel or task region.

Description

When a **`target`** construct provides a superset of the functionality and restrictions provided by the **`target data`** directive. The functionality added to the **`target`** directive is the inclusion of an executable region to be executed by a device. That is, the **`target`** directive is an executable directive. The encountering task waits for the device to complete the target region. When an **`if`** clause is present and the **`if`** clause expression evaluated to *false*, the target region is executed by the host device.

Restrictions

- If a **`target, target update`**, or **`target data`** construct appears within a target region then the behaviour is unspecified.
- The result of an **`omp_set_default_device, omp_get_default_device`**.

OpenMP `target update` Construct

Summary

The **`target update`** directive makes the corresponding list item in the device data environment consistent with their original list items, according to the specified motion clauses. The **`target update`** construct is a stand-alone directive

Syntax

C/C++

The syntax of the **`target`** construct is as follows:

```
#pragma omp target data [clause[[,] clase] … ] new-line
```

Where *motion-clause* is one of the following:

`to`(*list*)

`from`(*list*)

and where clause is motion-clause or one of the of following:

`device`(*integer-expression*)

`from`(*scalar-expression*)

OpenMP `target update` Construct

Binding

The binding task for a **`target update`** construct is the encountering task. The **`target update`** directive is a stand-alone directive.

Description

For each list item in a **`to`** or **`from`** clause there is a corresponding list item and an original list item. If the corresponding list item is not present in the device data environment, the behaviour is unspecified. Otherwise, each corresponding list item in the device data environment has an original list item in the current task's data environment.

For each list item in a **`from`** clause the value of the corresponding list item is assigned to the original list item.

The list items that appear in the to or from clauses may include array sections.

The device is specified in the **`device`** clause. If there is no **`device`** clause, the device is determined by the *default-device-var* ICV. When an **`if`** clause is present and the **`if`** clause expression evaluates to false then no assignments occur.

Restrictions

- A program must bod depend on any ordering of the evaluations of the clauses of the **`target update`** directive, or on any side effects of the evaluations of the clauses.

OpenMP `Declare target` Directive

Summary

The **`declare target`** directive specifies that variables, functions (C, C++ and Fortran), and subroutines (Fortran) are mapped to a device. The **`declare target`** directive is a declarative directive.

Syntax

C/C++

The syntax of the **`declare target`** directive is as follows:

```
#pragma omp declare target new-line
declarations-definition-seq
#pragma omp end declare target new-line
```

Source : http:/www.openmp.org; References of OpenMP

Description

OpenMP `Declare target` Directive

C/C++

Variable and routine declarations that appear between the **`declare target`** and **`end declare target`** directives form an implicit list where each list item is the variable or function name.

C/C++

Fortran

If a declare target does not have an explicit list, then an implicit list of one item is formed from the name of the enclosing subroutine, subprogram, function subprogram or interface body to which it applies.

Fortran

If a list item is a function (C, C++, Fortran) subroutine (Fortran) then a device-specific version of the routine is created that can be called from a target region.

If a list item is a variable then the original variable is mapped to a corresponding variable in the initial deivce data environment for all devices. If the original variable is initialized the corresponding variable in the device data environment is initialized with the same value.

Restrictions

- A threadprivate variable cannot appear in a **`declare target`** directive
- A variable declared in a **`declare target`** directive must have a mappable type.

OpenMP teams Construct

Summary

The **teams** construct creates a league of thread teams and the master thread of each team executes the region.

Syntax

The syntax of the **team** construct is as follows:

C/C++

```
#pragma omp teams[clause[[,] clase] … ] new-line
structured-block
```

and where clause is one of the of following:

num_teams(*integer-expression*)

thread_limit(*integer-expression*)
default(***shared*|*none***)
private (list)
firstprivate (list)
shared (list)
reduction (reduction-identifier : list)

OpenMP teams Construct

Binding

The binding thread set for a **teams** region is the encountering thread.

Description

When a thread encounters a teams construct, a league of thread teams is created and the master thread of each thread team executes the teams region.

The number of teams created in implementation defined, but is less than or equal to the value specified in the **num_teams** clause.

The maximum number of threads participating in the contention group that each team initiates is implementation defined, but is less than or equal to the value specified in the **thread_limit** clause.

Once the **teams** are created, the number of teams remains constant for the duration of the teams region.

Within a teams region, team numbers uniquely identify each team. Team numbers are consecutive whole numbers ranging from zero to one less than the number of teams. A thread may obtain its own team number by a call to the **omp_get_team_num** library routine.

The threads other than the master thread do not begin execution until the master thread encounters a **parallel** region.

After the teams have completed execution of the **teams** region, the encountering thread resumes execution of the enclosing **target** region. There is no implicit barrier at the end of a **teams** construct.

OpenMP `distribute` Construct

Summary

The **`distribute`** construct specifies that the iterations of one or more loops will be executed by the thread teams in the context of their implicit tasks. The iterations are distributed across the master threads of all teams that execute the **`teams`** region to which the **`distribute`** region binds..

Source : http:/www.openmp.org; References of OpenMP

OpenMP `distribute` Construct

Syntax

C/C++

The syntax of the **`distribute`** construct is as follows:

```
#pragma omp distribute [clause[[,] clase] … ] new-line
      for-loops
```

Where *clause* is one of the following:

`private` (*list*)
`firstprivate` (*list*)
`collaspe` (*n*)
`dist_schedule` (*kind[, chunk_size]*)

All associated for – loops must have the canonical form described in Section 2.6 on page 51

OpenMP `distribute` Construct

Binding

The binding thread set for a **`distribute`** region is the set of master threads created by a **`teams`** construct. A **`distribute`** region binds to the innermost enclosing **`teams`** region. Only the threads executing the binding **`teams`** region participate in the execution of the loop iterations.

Description

The **`distribute`** construct is associated with a loop nest consisting of one or more loops that follow the directive.

There is no implicit barrier at the end of a **`distribute`** construct.

The **`collapse`** clause may be used to specify how many loops are associated with the **`distribute`** construct. The parameter of the **`collapse`** clause must be a constant positive integer expression. If no **`collapse`** clause is present, the only loop that is associated with the **`distribute`** construct is the one that immediately follows the **`distribute`** construct.

OpenMP `distribute` Construct

If more that one loop is associated with the **`distribute`** construct, then the iteration of all associated loops are collapsed into one larger iteration space. The sequential execution of the iterations in all associated loops determines the order of the iterations in the collapsed iteration space.

If **`dist_schedule`** is specified kind must be static. If specified, iterations are divided into chunks of size *chunk_size*, chunks are assigned to the teams of the league in a round-robin fashion in the order of the team number. When no *chunk_size* is specified, the iteration space is divided into chunks that are approximately equal in size, and at most one chunk is distributed to each team of the league. Note that the size of the chunks is unspecified in this case.

When no **`dist_schedule`** clause is specified, the schedule is implementation defined.

OpenMP `distribute simd` Construct

Summary

The **`distribute simd`** construct specifies a loop that will be distributed across the master threads of the teams region and executed concurrently using SIMD instructions.

Syntax

The syntax of the **`team`** construct is as follows:

C/C++

```
#pragma omp distribute simd[clause[[,] clase] … ]
      for-loops
```

Where clause can be any of the clauses accepted by the **`distribute`** or **`simd`** directives with identical meaning and restrictions:

C/C++

Fortran

```
!$omp distribute simd[clause[[,] clase] … ]
      do-loops
[ !$omp and distribute simd ]
```

OpenMP `distribute simd` Construct

Description

The **`distribute simd`** construct will first distribute the iterations of the associated loop(s) according to the semantics of the **`distribute`** construct and any clauses that apply to the distribute construct. The resulting chunks of iterations will then be converted to a SIMD loop in a manner consistent with any clauses that apply to the **`simd`** construct. The effect of any clause that applies to both constructs is as if it were applied to both constructs separately.

Restrictions

The restrictions for the **`distribute`** and **`simd`** constructs apply.

Cross References

- **`simd`** construct, see Section 2.8.1 on page 68
- **`distribute`** construct, see Section 2.9.6 on page 88
- Data attribute clauses

OpenMP Distribute Parallel Loop Construct

Summary

The distribute parallel loop construct specifies a loop that can be executed in parallel by multiple threads that are members of multiple teams.

Syntax

The syntax of the distribute parallel loop construct is as follows:

C/C++

```
#pragma omp distribute parallel for[clause[[,] clause] … ]
      for-loops
```

Where clause can be any of the clauses accepted by the **`distribute`** or parallel loop directives with identical meaning and restrictions:

C/C++

Source : http:/www.openmp.org; References of OpenMP

OpenMP `distribute simd` Construct

Description

The distribute parallel loop construct will first distribute the iterations of the associated loop(s) according to the semantics of the **`distribute`** construct and any clauses that apply to the **`distribute`** construct. The resulting loops will then be distributed across the threads contained within the **`teams`** region to which the **`distribute`** construct binds in a manner consistent with any clauses that apply to the parallel loop construct. The effect of any clause that applies to both the **`distribute`** and parallel loop constructs is as if it were applied to both constructs separately.

Restrictions

The restrictions for the **`distribute`** and parallel loop constructs apply.

Cross References

- **`distribute`** construct, Parellel loop construct, Data attribute clauses

OpenMP `Distribute Parallel Loop SIMD` Construct

Summary

The distribute parallel loop SIMD construct specifies a loop that can be executed in concurrently using SIMD instruction in parallel by multiple threads that are members of multiple teams.

Syntax

The syntax of the distribute parallel loop SIMD construct is as follows:

C/C++

```
#pragma omp distribute parallel for simd [clause[[,] clause] … ]
    for-loops
```

Where *clause* can be any of the clauses accepted by the **`distribute`** or parallel loop SIMD directives with identical meaning and restrictions:

C/C++

OpenMP `Distribute Parallel Loop SIMD` Construct

Description

The distribute parallel loop construct will first distribute the iterations of the associated loop(s) according to the semantics of the **`distribute`** construct and any clauses that apply to the **`distribute`** construct. The resulting loops will then be distributed across the threads contained within the **`teams`** region to which the **`distribute`** construct binds in a manner consistent with any clauses that apply to the parallel loop construct. The resulting chunks of iterations will then be converted to a SIMD loop in a manner consistent with any clauses that apply to the **`simd`** construct. The effect of any clause that applies to both the **`distribute`** and parallel loop SIMD constructs is as if it were applied to both constructs separately.

Source : http:/www.openmp.org; References of OpenMP

OpenMP Combined Construct

Description

Combined constructs are shortcuts for specifying one construct immediately nested inside another construct. The semantics of the combined constructs are identical to that of explicitly specifying the first construct containing one instance of the second construct and no other statements.

Some combined constructs have clauses that are permitted on both constructs that were combined. Where specified, the effect is as if applying the clauses to one or both constructs. If not specified and applying the clause to one to one construct would result in different program behaviour than applying the clause to the other construct then the program's behaviour is unspecified.

Source : NVIDIA, PGI & References given in the presentation

OpenMP `Parallel for` Loop Construct

Summary

The parallel loop construct is a shortcut for specifying a **`parallel`** construct containing one or more associated loops and no other statements.

Syntax

The syntax of the parallel loop construct is as follows:

C/C++

```
#pragma omp parallel for [clause[[,] clause] … ] new-line
        for-loops
```

where *clause* can be any of the clauses accepted by the **`parallel`** or **`for`** directives, except the **`nowait`** clause, with identical meanings and restrictions.

C/C++

Fortran

OpenMP `parallel section` Construct

Summary

The parallel sections construct is a shortcut for specifying a **`parallel`** construct containing one **`sections`** construct and no other statements.

Syntax

The syntax of the **`parallel sections`** construct is as follows:

C/C++

```
#pragma omp parallel for [clause[[,] clause] … ] new-line
      {
       [#pragma omp section new-line]
           structured-block
       [#pragma omp section new-line
           structured-block]
      …
      }
```

where *clause* can be any of the clauses accepted by the **`parallel`** or **`sections`** directives, except the **`nowait`** clause, with identical meanings and restrictions.

C/C++

OpenMP : `parallel workshare` Construct

Syntax

The syntax of the **`parallel workshare`** construct is as follows:

```
!$omp parallel for [clause[[,] clause]
        structured-block
!$omp end parallel workshare
```

where *clause* can be any of the clauses accepted by the **`parallel`** directives, with identical meanings and restrictions. **`nowait`** may not be specified on an **`end parallel workshare`** directive.

Description

The semantics are identical to explicitly specifying a **`parallel`** directive immediately followed by a **`workshare`** directive, and an **`end workshare`** directive immediately followed by an **`end parallel`** directive.

OpenMP `Parallel for SIMD` Loop Construct

Summary

The parallel loop SIMD construct is a shortcut for specifying a **`parallel`** construct containing one loop SIMD construct and no other statement.

Syntax

C/C++

```
#pragma omp parallel for simd [clause[[,] clause] … ] new-line
        for-loops
```

where *clause* can be any of the clauses accepted by the **`parallel`**, **`for`** or **`simd`** directives, except the **`nowait`** clause, with identical meanings and restrictions.

C/C++

Fortran

OpenMP `Parallel for SIMD` Loop Construct

Summary

The semantics of the parallel loop SIMD construct are identical to explicitly specifying a **`parallel`** directive immediately followed by a loop SIMD directive. The effect of any clause that applies to both constructs is as if it were applied to the loop SIMD construct and not to the **`parallel`** construct.

Source : NVIDIA, PGI & References given in the presentation

OpenMP `target teams` Construct

Summary

The target teams construct is a shortcut for specifying a **`target`** construct containing a **`teams`** construct

Syntax

The syntax of the target teams construct is as follows:

C/C++

```
#pragma omp parallel for [clause[[,] clause] … ]
      structured-block
```

where *clause* can be any of the clauses accepted by the **`target`** or **`teams`** directives with identical meanings and restrictions

C/C++

OpenMP `teams distribute` Construct

Summary

The **`teams distribute`** construct is a shortcut for specifying a **`team`** construct containing a **`distribute`** construct

Syntax

The syntax of the **`teams distribute`** construct is as follows:

C/C++

```
#pragma omp team distribute [clause[[,] clause] … ]
        for-loops
```

where *clause* can be any of the clauses accepted by the **`teams`** or **`distribute`** directives with identical meanings and restrictions

C/C++

OpenMP `teams distribute simd` Construct

Summary

The **`teams distribute simd`** construct is a shortcut for specifying a **`teams`** construct containing a **`distribute simd`** construct

Syntax

The syntax of the **`teams distribute simd`** construct is as follows:

C/C++

```
#pragma omp team distribute [clause[[,] clause] … ]
        for-loops
```

where *clause* can be any of the clauses accepted by the **`teams`** or **`distribute simd`** directives with identical meanings and restrictions

C/C++

Fortran

```
!$omp teams distribute simd [clause[[,] clause] … ]
        for-loops
[!$ompand end teams distribute simd]
```

OpenMP `teams distribute simd` Construct

`!$omp teams distribute simd` *[clause[[,] clause] …]*
do-loops
*[*__`!$ompand end teams distribute simd`__*]*

where *clause* can be any of the clauses accepted by the **`teams`** or **`distribute simd`** directive with identical meanings and restrictions.

If an **`end teams distribute`** directive is not specified, an **`end teams distribute`** directive is assumed at the end of the *do-loops*.

Fortran

Description

The semantics are identical to explicitly specifying a **`teams`** directive immediately followed by a **`distribute simd`** directive. Some clauses are permitted on both constructs.

Source : http:/www.openmp.org; References of OpenMP

OpenMP `target teams distribute` Construct

Summary

The **`target teams distribute`** construct is a shortcut for specifying a **`target`** construct containing a **`teams distribute`** construct

Syntax

The syntax of the **`target teams distribute`** construct is as follows:

C/C++

```
#pragma omp target team distribute [clause[[,] clause] … ]
      for-loops
```

where *clause* can be any of the clauses accepted by the **`target`** or **`team distribute`** directives with identical meanings and restrictions

C/C++

OpenMP `target teams distribute simd` Construct

Summary

The **`target teams distribute`** construct is a shortcut for specifying a **`target`** construct containing a **`teams distribute`** construct

Syntax

The syntax of the **`target teams distribute`** construct is as follows:

C/C++

```
#pragma omp target teams distribute simd [clause[[,] clause] … ]
      for-loops
```

where *clause* can be any of the clauses accepted by the **`target`** or **`team distribute simd`** directives with identical meanings and restrictions

C/C++

OpenMP `teams distribute parallel for` Construct

Summary

The teams distribute parallel loop construct is a shortcut for specifying a **`teams`** construct containing a distribute parallel loop construct.

Syntax

The syntax of the teams distribute parallel loop construct is as follows:

C/C++

```
#pragma omp teams distribute parallel for [clause[[,] clause] … ]
      for-loops
```

where *clause* can be any of the clauses accepted by the **`teams`** or **`distribute parallel for`** directives with identical meanings and restrictions

C/C++

Source : http:/www.openmp.org; References of OpenMP

OpenMP : Target Teams Distribute Parallel Loop Construct

Summary

The target teams distribute parallel loop construct is a shortcut for specifying a **`target`** construct containing a teams distribute parallel loop construct.

Syntax

The syntax of the target teams distribute parallel loop construct is as follows:

C/C++

```
#pragma omp target teams distribute parallel for [clause[[,] clause] … ]
    for-loops
```

where *clause* can be any of the clauses accepted by the **`target`** or **`teams distribute parallel for`** directives with identical meanings and restrictions

C/C++

Source : http:/www.openmp.org; References of OpenMP

OpenMP : Target Teams Distribute Parallel Loop Construct

Summary

The **`teams distribute`** parallel construct is a shortcut for specifying a **`teams`** construct containing a distribute parallel loop SIMDconstruct

Syntax

The syntax of the **`teams distribute simd`** construct is as follows:

C/C++

```
#pragma omp team distribute [clause[[,] clause] … ]
      for-loops
```

where *clause* can be any of the clauses accepted by the **`teams`** or **`distribute parallel for simd`** directives with identical meanings and restrictions

C/C++

Fortran

```
!$omp teams distribute parallel do simd [clause[[,] clause] … ]
      for-loops
[!$omp and end teams distribute parallel do simd]
```

OpenMP : Target Teams Distribute Parallel Loop Construct

Summary

The **`teams distribute`** parallel construct is a shortcut for specifying a **`teams`** construct containing a distribute parallel loop SIMD construct

Syntax

The syntax of the **`teams distribute simd`** construct is as follows:

C/C++

```
#pragma omp team distribute parallel for simd [clause[[,] clause] … ]
        for-loops
```

where *clause* can be any of the clauses accepted by the **`teams`** or **`distribute parallel for simd`** directives with identical meanings and restrictions

C/C++

Source : http:/www.openmp.org; References of OpenMP

OpenMP:Target Teams Distribute Parallel Loop SIMD Construct

Summary

The target **`teams`** distribute parallel loop SIMD construct is a shortcut for specifying a **`target`** construct containing a teams distribute parallel loop SIMD construct.

Syntax

The syntax of the target teams distribute parallel loop SIMD construct is as follows:

C/C++

```
#pragma omp team distribute [clause[[,] clause] … ]
        for-loops
```

where *clause* can be any of the clauses accepted by the **`target`** or **`teams distribute parallel for simd`** directives with identical meanings and restrictions

C/C++

OpenMP Tasking Construct

Summary

The **`teams`** construct defines an explicit task.

Syntax

The syntax of the target teams distribute parallel loop SIMD construct is as follows:

C/C++

```
#pragma omp task [clause[[,] clause] … ] new-line
        structured-block
```

where *clause* is one of the following:

`if` (*scalar-expression*)
`final` (*scalar-expression*)
`untied`
`default`(**`shared | none`**)
`mergeable`
`private` (*list*)
`firstprivate` (*list*)
`shared` (*list*)
`depend` (*dependence-type : list*)

OpenMP :Tasking Construct

Description

The encountering thread may immediately execute the task, or defer its execution. In the latter case, any thread in the team may be assigned the task. Completion of the task can be guaranteed using task synchronization constructs. A **`task`** construct may be nested inside an outer task, but the **`task`** region of the inner task is not a part of the **`task`** region of the outer task.

When an **`if`** clause is present on a **`task`** construct, and the **`if`** clause expression evaluates to *false*, an undeferred task is generated, and the encountering thread must suspend the current task region, for which execution cannot be resumed until the generated task is completed. Note that the use of a variable in an **`if`** clause expression of a **`task`** construct causes an implicit reference to the variable in all enclosing constructs.

When a **`final`** clause is present on a **`task`** construct and the **`final`** clause expression evaluates to true, the generated task will be a final task. All **`task`** constructs encountered during execution of a final task will generate final and included tasks. Note that the use of a variable in a **`final`** clause expression of a **`task`** construct cause an implicit reference to the variable in all enclosing constructs.

OpenMP : `depend` Clause

Summary

The **`depend`** clause enforces additional constraints on the scheduling of tasks. These constraints establish dependences only between sibling tasks. The clause consists of a *dependence-type* with one or more list items.

Syntax

The syntax of the target teams distribute parallel loop SIMD construct is as follows:

```
depend( dependence-type : list )
```

Description

Task dependences are derived from the dependence-type of a **`depend`** clause and its list items, where *dependence-type* is one of the following:

OpenMP : `depend` Clause

Description

Task dependences are derived from the dependence-type of a **`depend`** clause and its list items, where *dependence-type* is one of the following:

The **`in`** *dependence-type*. The generated task will be a dependent task of all previously generated sibling tasks that reference at least one of the list items in an **`out`** or **`inout`** dependence-type list.

The **`out`** and **`inout`** dependence-types. The generated task will be a dependent task of all previously generated sibling tasks that reference at least one of the list items in an **`in`**, **`out`**, or **`inout`** dependence-type list.

The list items that appear in the **`depend`** clause may include array sections.

Note – The enforced task dependence establishes a synchronization of memory accesses performed by a dependent task with respect to accesses performed by the predecessor tasks. However, it is the responsibility of the programmer to synchronize properly with respect to other concurrent accesses that occur outside of those tasks.

OpenMP : `taskyield` Clause

Summary

The **`taskyield`** construct specifies that the current task can be suspended in favour of execution of a different task. The taskyield construct is a stand-along directive.

Syntax

C/C++

The syntax of the **`taskyield`** construct is as follows:

```
#pragma omp taskyield new-line
```

C/C++

Fortran

The syntax of the **`taskyield`** construct is as follows:

```
!$omp taskyield
```

OpenMP : `task Scheduling` Clause

Whenever a thread reaches a task scheduling point, the implementation may cause it to perform a task switch, beginning or resuming execution of a different task bound to the current team. Task scheduling points are implied as the following locations:

- the point immediately following the generation of an explicit **`task`** region
- in a **`taskyield`** region
- in a **`taskwait`** region
- at the end of a **`taskgroup`** region
- in an implicit and explicit **`barrier`** region
- the point immediately following the generation of a **`target`** region
- at the beginning and end of a **`target data`** region
- in a **`target update`** region

Source : http:/www.openmp.org; References of OpenMP

OpenMP : Data Environment

This section presents a directive and several clauses for controlling the data environment during the execution of **`parallel`**, **`task`**, **`simd`**, and worksharing regions.

- how the data-sharing attributes of variables referenced in **`parallel, task, simd`**, and worksharing regions are determined.
- The **`threadprivate`** directive, which is provided to create threadprivate memory
- Clauses that may be specified on directives to control the data-sharing attributes of variables referenced in **`parallel, task, simd`** or worksharing constructs
- Clauses that may be specified on directives to copy data values from private or threadprivate variables on one thread to the corresponding variables on other threads in the team
- Clauses that may be specified on directives to map variables to devices

OpenMP : `threadprivate` Directive

Summary

The **`threadprivate`** directive specifies that variable are replicated, with each thread having its own copy. The **`threadprivate`** directive is a declarative directive.

Syntax

C/C++

The syntax of the **`threadprivate`** directive is as follows:

```
#pragma omp threadprivate (list) new-line
```

Where list is a comma-separated list of file-scope, namespace-scope, or static block-scope variables that do not have incomplete types.

C/C++

OpenMP : Data-Sharing Attribute Clauses

Several constructs accept clauses that allow a user to control the data-sharing attributes of variables referenced in the construct. Data-sharing attribute clauses apply only to variables for which the names are visible in the construct on which the clause appears.

Not all of the clauses listed in this section are valid on all directives. The set of clauses that is valid on a particular directive is described with the directive.

Most of the clauses accept a comma-separated list of list items (see Section 2.1 on age 26). All list items appearing in a clause must be visible, according toe the scoping rules of the base language. With the exception of the default clause, clauses may be repeated as needed. A list item that specifies a give variable may not appear in more than one clause on the same directive, except that a variable may be specified in both firstprivate and lastprivate clauses.

C/C++

If a variable referenced in a data-sharing attribute clause has a type derived from a template, and there are no other references to that variable in the program, then any behaviour related to that variable is unspecified

C/C++

OpenMP : Data Copying Clauses

This section describes the **`copyin`** clause (allowed on the **`parallel`** directive and combined parallel worksharing directives) and the **`copyprivate`** clause (allowed on the **`single`** directive).

These clauses support the copying of data values from private or threadprivate variables on one implicit task or thread to the corresponding variables on other implicit tasks or threads in the team.

The clauses accept a comma-seperated list of list items (see Section 2.1 on page 26). All list items appearing in a clause must be visible, according to the scoping rules of the base language. Clauses may be repeated as needed, but a list item that specifies a given variable may not appear in more than one clause on the same directive.

Source : http:/www.openmp.org; References of OpenMP

OpenMP : `copypriavate` clause

Summary

The **`copyprivate`** clause provides a mechanism to use a private variable to broadcast a value from the data environment of one implicit task to be data environments of the other implicit tasks belonging to the **`parallel`** region.

To avoid race conditions, concurrent reads or updates of the list item must be synchronized with the update of the list item that occurs as a result of the **`copyprivate`** clause.

Syntax

The syntax of the **`copyprivate`** clause is as follows:

```
copyprivate (list)
```

Description

The effect of the **`copypriate`** clause on the specified list items occurs after the execution of the structured block associated with the single construct (see Section 2.7.3 on page 63), and before any of the threads in the team have left the barrier at the end of the construct.

OpenMP : `map` clause

Summary

The **`map`** clause maps a variable from the current task's data environment to the device data environment associated with the construct.

Syntax

The syntax of the **`copyprivate`** clause is as follows:

```
map (list)
```

Description

The list items that appear in a **`map`** clause may include array sections.

For list items that appear in a **`map`** clause, corresponding new list items are created in the device data environment associated with the construct.

The original and corresponding list items may share storage such that write to either item by one task followed by a read or write of the other item by another task without intervening synchronization can result in data races.

OpenMP : `declare reduction` Directive

Summary

The following section describes the directive for declaring user-defined reductions. The **`declare reduction`** directive declares a reduction-identifier that can be used in **`reduction`** clause. The **`declare reduction`** directive is a declarative directive.

Syntax

C/C++

`#pragma omp declare reduction` *(reduction-identifier : typename-list : combiner) [initializer-clause] new-line*

where:

- *reduction-identifier* is either a base language identifier or one of the following operators **`+, -, *, &, |, ^, &&`** and **`||`**
- *typename-list* in list of type names
- *combiner* is an expression
- *Initializer-clause* is initializer (*initializer-expr*) where i*nitializer-expr* is omp_priv * *initializer* or *function-name* (*argument-list*)

C

Conclusions

- Discussed An overview of Programming for Multi-Core Systems with Coprocessors OpenMP 4.0

Source : OpenMP Web Sites and References

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Thank You

Any questions ?