# OpenMP 6.0 Outlook: TR12 and Beyond

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# OpenMP 6.0 will be released in November 2024

- TR12 demonstrates appropriate progress for second TR of a major version
- Major new feature targets have been clearly identified and are on track for 2024
  - → Free-agent threads significantly change execution model, implementations
  - → User-defined induction and `induction` clause expand parallelism support
  - → Many significant device support improvements (e.g., `memscope(all)`) added or planned
  - → Several other additions and improvements planned, including:
    - → Rationalization of definition of combined constructs
    - → Task dependences between concurrently generated tasks
  - → Significant improvements to usability and correctness of specification
  - → TR12 includes 153 completed issues, considering over 300 others (2 more already passed)
  - → TR13 (final comment draft) will be released in summer 2024

# Major new features will characterize OpenMP 6.0

- Free-agent threads
  - → Support for top-level task parallelism (i.e., explicit `parallel` directive not needed)
  - → "Any" thread can execute explicit tasks for which `threadset` clause evaluates is `omp_pool`
  - → Adds associated runtime routines, environment variables and ICVs
- Major improvements for use of a single device
  - → Explicit progress guarantee adopted in TR11
  - → Default device and visible devices to simplify control of device use and availability
  - → Mechanisms to simplify use of device memory (by providing greater certainty or clarity)
    - → New `groupprivate` directive in TR11 is an initial mechanism in this direction
    - → Added `selfmap` modifier to ensure no copy is created when possible
    - → Unified host and device allocators and added significant cross-device improvements
  - → TR12 added `coexecute` directive (i.e., descriptive array language offload support)

# Recall the tasking execution model

- Supports unstructured parallelism
  - → unbounded loops

```
while ( <expr> ) {
  ...
}
```

  - → recursive functions

```
void myfunc( <args> ) {
  ...; myfunc( <newargs> ); ...;
}
```

- Why are the **`parallel`** and **`single`** directives needed?

- Example (unstructured parallelism)

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#pragma omp parallel
#pragma omp single
while (elem != NULL) {
  #pragma omp task
    compute(elem);
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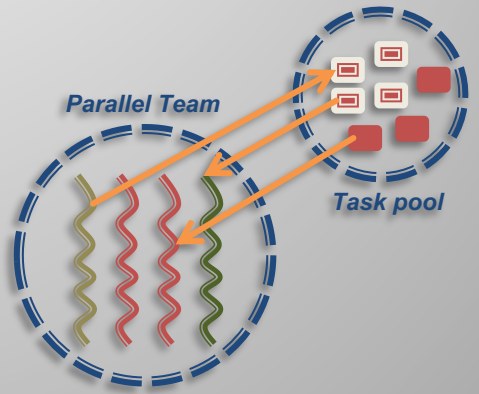

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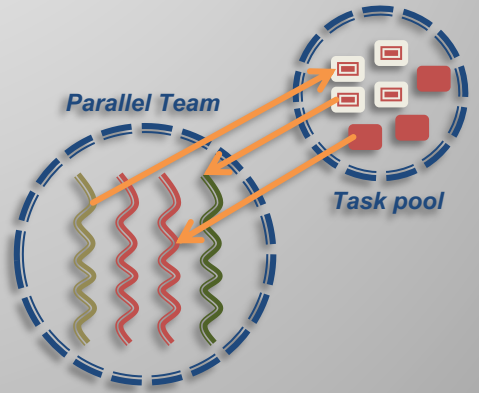


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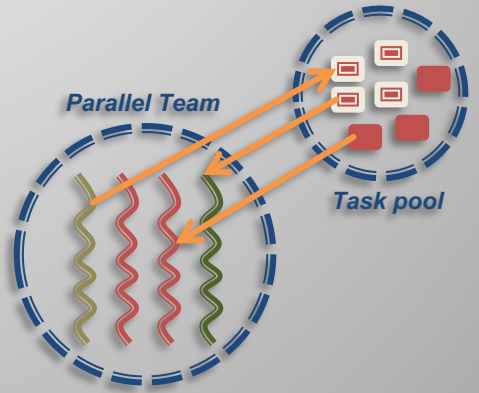


- Why are the **`parallel`** and **`single`** directives needed?
  - → Otherwise all threads in the team generate (duplicate) tasks
  - → Only threads in the team may execute tasks

# Is restricting tasks to a team good?

- Positive aspects
  - → Simplifies resource management
  - → Clear semantics with respect to other teams
- Negative aspects
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- Example (no **`parallel`** directive needed)

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while (elem != NULL) {
  #pragma omp task threadset(omp_pool)
    compute(elem);
  elem = elem->next;
}
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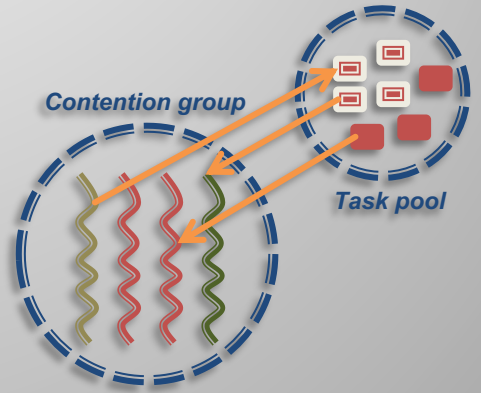

# Some details for free-agent threads

- Existing behavior is preserved by default
  - → As if **`threadset`** clause is specified with value of **`omp_team`**

```
#pragma omp task threadset(omp_team)
  structured-block
```

  - → Tasks are still tied by default so free-agent thread executes the task completely if at all
  - → Task synchronization (e.g., dependences, **`taskwait`** and **`taskgroup`**) unchanged

- Can use environment variables to control ICVs to reserve threads

```
Setenv OMP_THREADS_RESERVE "structured(2),free_agent(2)"
```

  - → At least two threads available for structured parallelism, at least two available to act as free-agents
  - → Minimum for structured parallelism is one (the initial thread)
  - → Sum of reservations should not exceed *thread-limit-var* ICV

# OpenMP 6.0 will include other significant new features

- A more complete set of loop transforming directives
  - → TR12 includes `fuse`, `reverse` and `interchange` directives
  - → Considering other transformations that include `fission` and `nestify`
  - → Can now transform generated loops using the `apply` clause
- Clauses and directives to support generalized induction
  - → Capture computation that follows a well-defined sequence across loop iterations
  - → Generalizes behavior of `linear` clause and of loop iteration variables
  - → Related to reductions, including addition of `declare induction` directive

# Extending `parallel` directive to support complete user control of number of threads

- The `parallel` directive will accept a new modifier and two "new" clauses

```
#pragma omp parallel [num_threads(prescriptiveness: nthreads)] \
                     [severity(fatal|warning)][message(msg-string)]
  structured-block
```

- Using `strict` *prescriptiveness* requires `nthreads` to be provided
- Clauses, previously available on `error` directive, effective with `strict` if cannot provide `nthreads`
  - → Display `msg-string` as part of implementation-defined message
  - → If `severity` is `fatal` execution is terminated
  - → If `severity` is `warning` message is displayed but execution continues
- Also now allowed to provide a list for `nthreads` to support nested parallelism

# Some other improvements expected in OpenMP 6.0

- May further extend descriptive and prescriptive control
- Removal of features that were deprecated in 5.0, 5.1 or 5.2
- Dependences and affinity for the `taskloop` construct
- Wider use of C++ attribute syntax: Make C++ support "more C++-like"
  - → Likely to include improvements for `threadprivate` and `declare target`
  - → Also clarified conditions for implicitly declared reduction operators for class types
  - → Will also be supported in C
- Adding latest versions of base languages (C23, C++23, Fortran 2023)
- Continuing to extend support for tool interfaces

# Some other improvements expected in OpenMP 6.0

- Expect to define combined constructs based on properties (a priority)
- Strengthening task-oriented execution changes begun in OpenMP 3.0
- Extending specification improvements begun in OpenMP 5.2
  - → Includes making all clauses accept arguments
  - → All clauses will take a directive name modifier for better control of combined constructs
- Immediate focus is several high priority, nearly completed issues
  - → More single device and tasking improvements
  - → Better control of number of threads
  - → Simpler, broader user control of defaults

# Things likely to be deferred to beyond 6.0

- True support for using multiple devices
  - → Device-to-device scoping support for atomic and other memory operations
  - → Support for bulk launch
  - → Support to update data on multiple devices (broadcast/multicast, other collectives)
  - → Support for work distribution across devices
  - → Considering relaxing restrictions on nested `target` regions
- Efficient use of multiple compilation units (i.e., support for efficient IPO)
- Characterizing loop-based work distribution constructs as transformations
- Support for pipelining, data-flow, other parallelization models
- Support for event-based parallelism

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