XcalableACC

Abstract
XcalableACC (XACC) is a PGAS language for accelerated clusters, which is a directive-based language extension of C and Fortran.

- High productivity by directives
- High performance by direct communication between accelerators

Components
- XcalableMP (XMP) for distributed-memory parallelism
- OpenACC for offloading works for accelerators
- OpenACC is another directive-based language extension for heterogeneous CPU/accelerator systems
- XACC extensions for communication of data on accelerators

Evaluation

Productivity
- Comparison of the source lines of code (SLOC)
  - XACC v.s. OpenACC + MPI as a typical programming
  - SLOCs of XACC are smaller than those of OpenACC + MPI

Example: HIMENO Benchmark

Stencil application
- Evaluates the performance of incompressible fluid analysis code
- Programmer only adds XMP and OpenACC directives into the sequential Himeno benchmark

```
static float p[MIMAX][MJMAX][MKMAX];
#pragma acc loop vector reduction(+:gosa) private(s0, ss)
for(j=1 ; j<jmax−1 ; ++j){
    for(i=1 ; i<imax−1 ; ++i){
        #pragma acc parallel loop collapse(2) reduction(+:gosa) ...
        #pragma xmp loop (k,j,i) on t(k,j,i)
            ...
            ...

        #pragma acc data copy(p, i, j)
            ...
        #pragma xmp distribute t(k, j, i) onto n
            ...
        #pragma xmp nodes n(NDY, NDX)
            ...
        static float p[MIMAX][MJMAX][MKMAX];
        
        #pragma acc loop (k, j, i) on t(k, j, i)
            ...
        #pragma xmp loop vector reduction(+:gosa) private(i, k)
            ...
            ...

        #pragma acc loop (k, j, i) on t(k, j, i)
            ...
        #pragma xmp loop vector reduction(+:gosa) private(i, k)
            ...
            ...
```

Memory Model

```
XMP function defines “Template” as a dummy array that represents a global index space.

XACC function enables users to transfer data between accelerators and between accelerator and host memory directly.
```

Source Lines of Codes

<table>
<thead>
<tr>
<th></th>
<th>HIMENO</th>
<th>NPB-CG</th>
<th>HPL</th>
<th>STREAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>XcalableACC</td>
<td>198(34.9)</td>
<td>809(48.9)</td>
<td>437(54.6)</td>
<td>908(3.6)</td>
</tr>
<tr>
<td>MPI + OpenACC</td>
<td>328(13)</td>
<td>772(24)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>XcalableMP</td>
<td>—</td>
<td>—</td>
<td>343(54)</td>
<td>78(8)</td>
</tr>
</tbody>
</table>

Performance on HA-PACS/TCA

```
HIMENO

- 6.90TFlops
- 6.87TFlops

NPB-CG

- 246.2Gops
- 236.2Gops

HPL

- 34.6TFlops
- 11.6TFlops
- 3.3TFlops

STREAM

- 18.9TB/s
- 6.1TB/s
```

Reference