XcalableMP(XMP) https://xcalablemp.org

- **What's XcalableMP (XMP for short)?**
  - A PGAS programming model and language for distributed memory , proposed by **XMP Spec WG**
  - XMP Spec WG is a special interest group to design and draft the specification of XcalableMP language. It is now organized under **PC Cluster Consortium**, Japan. Mainly active in Japan, but open for everybody.
- **Project status (as of June 2019)**
  - XMP Spec **Version 1.4** is available at XMP site. new features: mixed OpenMP and OpenACC, libraries for collective communications.
  - Reference implementation by U. Tsukuba and Riken R-CCS: **Version 1.3 (C and Fortran90)** is available for PC clusters, Cray XT and K computer, and Fugaku. Source-to-Source compiler to code with the runtime on top of MPI and GASNet.
- **HPCC class 2 Winner 2013, 2014**

The spec of XcalableMP 1.x is now converged.
We are now moving to XcalableMP 2.0 with global task-based parallel programming and PGAS

- **Language Features**
  - Directive-based language extensions for Fortran and C for PGAS model
  - Global view programming with global-view distributed data structures for data parallelism
    - SPMD execution model as MPI
    - pragmas for data distribution of global array.
    - Work mapping constructs to map works and iteration with affinity to data explicitly.
    - Rich communication and sync directives such as "gmove" and "shadow".
    - Many concepts are inherited from HPF
  - Co-array feature of CAF is adopted as a part of the language spec for local view programming (also defined in C).

Code example

```
int array[YMAX][XMAX];

#pragma xmp nodes p(4)
#pragma xmp template t(YMAX)
#pragma xmp distribute t(block) on p
#pragma xmp align array[i][*] to t(i)

main(){
  int i, j, res;
  res = 0;

#pragma xmp loop on t(i)  reduction(+:res)
  for(i = 0; i < 10; i++)
    for(j = 0; j < 10; j++){
      array[i][j] = func(i, j);
      res += array[i][j];
    }
}
```

data distribution

add to the serial code : incremental parallelization

work sharing and data synchronization

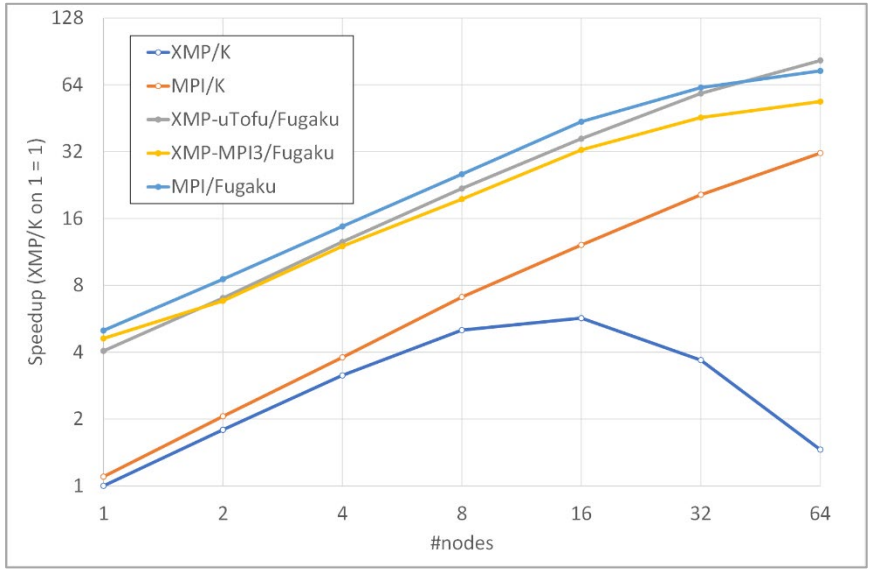
XcalableMP as evolutional approach

- **We focus on migration from existing codes.**
  - Directive-based approach to enable parallelization by adding directives/pragma.
  - Also, should be from MPI code. Coarray may replace MPI.
- **Learn from the past**
  - Global-view for data-parallel apps. Japanese community had experience of HPF for Global-view model.
- **Specification designed by community**
  - Spec WG is organized under the PC Cluster Consortium, Japan.
- **Design based on PGAS model and Coarray (from CAF)**
  - PGAS is an emerging programming model for exascale!
- **Used as a research vehicle for programming language/model research**
  - XMP 2.0 for task programming and PGAS
  - Extension to accelerator (XACC)

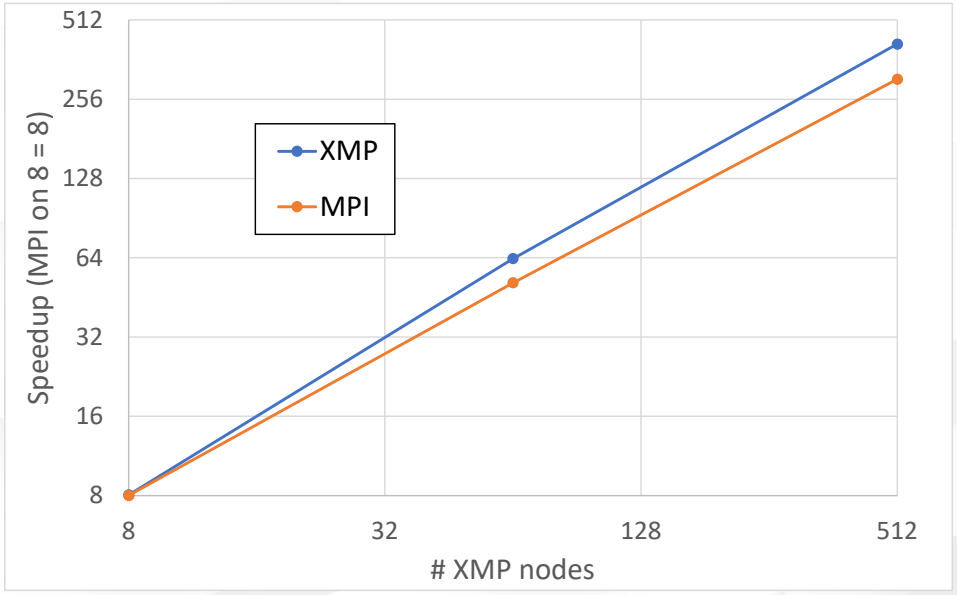
- **XMP applications Experiences**
  - IMPACT-3D: 3D Eulerian fluid code, which performs compressible and inviscid fluid computation to simulate converging asymmetric flows related to laser fusion (NIFS)
  - RTM code: Reverse-time Migration Method for Remote Sensing applications (Total, France)
  - SCALE-LES: Next-generation Climate Code developed by AICS Tomita's Team
  - GTC-P: Gyrokinetic Toroidal Code , which is a 3D PIC code to study the micro turbulence phenomenon in magnetically connected fusion plasma (Princeton Univ. and Univ. Tsukuba)
  - CloverLeaf: a hydrodynamics mini-application
  - Fiber mini-apps

Performance of XcalableMP on Fugaku

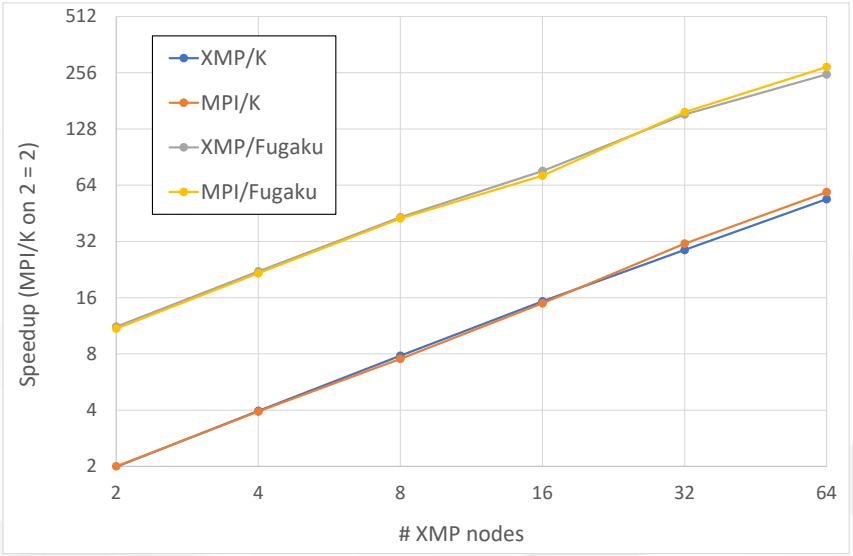
- XcalableMP was taken as a parallel programming language project for improving the productivity and performance of parallel programing.
- XcalableMP is now available on Fugaku and the performance is enhanced by the Fugaku interconnect, Tofu-D.



QCD (Local-view, Coarray)



Impact-3D (Global-view, Directives)
Fusion simulation code, stencil apps



NT-Chem (Local-view, Coarray)