use MPI;
A Status Report

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Why Chapel + MPI?

- Co-existence with MPI-based libraries, legacy code.
- Performance for certain communication patterns
  - This should get progressively less important with time as Chapel gets its own libraries for communication patterns.
  - But enables users to not sacrifice performance in this intermediate stage
- A gateway to Chapel
  - MPI+X, where X=Chapel

Chapel + MPI : Two modes

- **SPMD**
  - MPI + X model
  - Chapel sees only one locale, all communication is through MPI
  - Similar to usual MPI programming
- **Multi-Locale**
  - Both Chapel and MPI coexist
  - Chapel locales <----> MPI ranks
    - We might want more general models
  - Mix legacy codes with Chapel -- use Chapel to simplify codes

Chapel + MPI : Status

- MPI module since v1.14
- All (….well, almost all) of MPI-1
  - Some non-blocking routines from MPI-3 included for convenience
- **NEW**: Now supports qthreads as well as fifo
- **NEW**: Tested on ugni, gasnet+aries as well as gasnet+mpi. (gasnet+infiniband coming soon)
- Chapel+MPI is ready to be used!
  - There may be a few rough edges, but we need experience using it.

Chapel + MPI + qthreads

- "CHPL_TASKS=fifo" used to be the only supported mode.
  - Fret about performance being left behind
- Problem – MPI is not qthreads aware, so can deadlock on blocking MPI calls
  - Indeed, "Hello Chapel" used to deadlock due to an MPI_Barrier call.
- Solution :
  - Use non-blocking calls whenever possible (we are slowly providing safe replacements, so that the user isn't burdened. WIP!)
  - All blocking MPI calls must be preceded by a "Barrier()" (MPI module wrapped MPI_Ibarrier + MPI_Test)
  - No concurrent blocking calls allowed!

MPI Threading Support

- Used to require MPI_THREAD_MULTIPLE
  - For gasnet+mpi
  - Support in MPI flavors can be spotty (OpenMPI has/had? Issues)
- With gasnet+!mpi support, we can relax to MPI_THREAD_SERIALIZED
  - Of course, then user cannot make concurrent MPI calls.
  - Experimental support already exists

Chapel + MPI : Two examples

- Ring
- FFTW

See https://github.com/npadmana/chiuw2017-chpl-mpi

Ring

```
use MPI;
use C_MPI;
```

```
cobegin {
  send();
  recv();
}
```

```
proc send() {
  coforall loc in Locales do on loc {
    var rank = commRank(CHPL_COMM_WORLD) : c_int,
        size = commSize(CHPL_COMM_WORLD) : c_int;
    var dest : c_int;
    dest = (rank + 1)%size;

    writef("Rank %i sending to %i \n",rank, dest);
    Send(rank, 1, MPI_INT, dest, 0, CHPL_COMM_WORLD);
    writef("Rank %i done sending...\n",rank);
  }
}
```

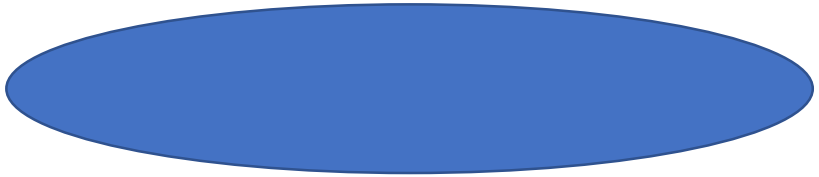
FFTW

```
use MPI;
use C_MPI;
```

```
use SysCTypes;
use FFTW;
use Random;
use PrivateDist;
use BlockDist;
require "fftw3-mpi.h";
```

```
extern proc fftw_mpi_init();
extern proc fftw_mpi_cleanup();
extern proc fftw_mpi_plan_dft_r2c_3d(n0 : c_ptrdiff, n1 : c_ptrdiff, n2 : c_ptrdiff,
                                     ref inarr , ref outarr,
                                     comm : MPI_Comm, flags : c_uint) : fftw_plan;
extern proc fftw_mpi_plan_dft_c2r_3d(n0 : c_ptrdiff, n1 : c_ptrdiff, n2 : c_ptrdiff,
                                     ref inarr, ref outarr,
                                     comm : MPI_Comm, flags : c_uint) : fftw_plan;
```

```
forall loc in PrivateSpace {
  fftw_mpi_init();
}
```



```
forall loc in PrivateSpace {
  fftw_mpi_cleanup();
}
writeln("Goodbye, Brad! I hope you enjoyed this distributed FFTW example");
```

```
const DSpace={0..#Ng,0..#Ng,0..#Ng2};
var targets : [0..#numLocales,0..0,0..0] locale;
targets[..,0,0]=Locales;
const D : domain(3) dmapped Block(boundingBox=DSpace, targetLocales=targets) = DSpace;
```

```
forall loc in PrivateSpace {
  var idx = B.localSubdomain().low;
  Barrier(CHPL_COMM_WORLD);
  {
    // MPI calls
    var fwd = fftw_mpi_plan_dft_r2c_3d(Ng, Ng, Ng, B[idx], B[idx], CHPL_COMM_WORLD, FFTW_ESTIMATE);
    execute(fwd);
    destroy_plan(fwd);
  }
}
```

```
var ksum2 : real;
ksum2 = 2*(+ reduce B[..,..,2..(Ng-1)]**2);
ksum2 += (+ reduce B[..,..,0..1]**2);
ksum2 += (+ reduce B[..,..,Ng..(Ng+1)]**2);
ksum2 *= invNg3;
writef("Total sum B^2 = %er , error= %er\n",ksum2, ksum2/sum2 - 1);
```