Bag of Tasks Parallelism

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Slides at:

https://github.com/timkphd/slides

Examples at:

To get examples:

```
mkdir examples
cd examples
git clone https://github.com/timkphd/examples.git
mv -f examples/mpi .
mv -f examples/array .
rm -rf examples
```

- This particular example is in the array/bot/simple.py
- It actually has more/better comments then show here.

What if you have?

- A bunch of tasks to do
- They are all independent
- Similar, maybe just different input files
- Often called bag of task parallelism or embarrassingly parallel

simple.py

- Starts MPI
- Splits the processors into two groups/communicators 0-(N-2) and (N-1)
- Processor (N-1) waits for "ready" from other processors, then sends work
- Rest of processors loop
  - send requests for work
  - do work (in this case generate plots)
  - send results

Bag of Tasks

simple.py
This is a bag-of-tasks program.

We define a manager task that distributes work to workers. Actually, the workers request input data. The manager sits in a loop calling Iprobe waiting for requests for work.
In this case the manager reads input. The input is a list of file names. It will send a entry from the list as requested. When the worker is done processing it will request a new file name from the manager. This continues until the manager runs out of files to process. The manager subroutine is just "manager"

The worker subroutine is "worker". It receives file names form the manager.

The 201 files in this case are outputs from an optics program tracking a laser beam as it propagates through the atmosphere. The workers read in the data and then create an image of the data by calling the routine mkview.plotit. This should worker with arbitrary 2d files except the size in mkview.plotit is currently hard coded to 64 x 64.

We use the call to "Split" to create a separate communicator for the workers. This is not important in this example but could be if you wanted multiple workers to work together.

- MPI.COMM_WORLD
- Get_rank()
- Get_size()
- comm.gather
- comm.Send()
- comm.Recv()
- MPI.Status()
- comm.Iprobe()
- gotfrom=status.source
- MPI.Get_processor_name()
- MPI_COMM_WORLD.barrier()
- MPI.Finalize

To get the data...

```
curl https://raw.githubusercontent.com/timkphd/examples/master/r/laser.tgz | tar -xz
```

```
#!/usr/bin/env python
from mpi4py import MPI
import numpy
global numnodes,myid,mpi_err
global mpi_root
import sys
mpi_root=0
. . .
. . .
. . .
. . .
#
if __name__ == '__main__':
# do init
   global numnodes,myid,mpi_err
   comm=MPI.COMM_WORLD
   myid=comm.Get_rank()
   numnodes=comm.Get_size()
   name = MPI.Get_processor_name()
   print("hello from %d of %d on %s" % (myid,numnodes,name))
```

- Do initialization

- Create a communicator that contains everyone but the one process

```
num_used=numnodes-1
mannum=0;
MPI_COMM_WORLD=MPI.COMM_WORLD
if(myid == mannum):
   group=0
else:
   group=1
# Split will create a set of communicators.  All of the
# tasks with the same value of group will be in the same
# communicator.  In this case we get two sets one for the
# manager and one for the workers.  The manager's version
# of the communicator is not used.

   DEFINED_COMM=MPI_COMM_WORLD.Split(group,myid)
#
   new_id=DEFINED_COMM.Get_rank()
   worker_size=DEFINED_COMM.Get_size()
   print("old id = %d   new id = %d   worker size = %d" %
(myid,new_id,worker_size))
#
```

- Manager is not part of “worker group”so she manages

```
   if(group == 0):
      todo=1000
# if not part of the new group do management. #
      manager(num_used,todo)
      print("manager finished")
      #mpi_err =  MPI_Barrier(MPI_COMM_WORLD)
      MPI_COMM_WORLD.barrier()
      MPI.Finalize()
   else:
# part of the new group do work. #
      mannum=0;
      ts=MPI.Wtime()
      idid=worker(DEFINED_COMM,mannum)
      te=MPI.Wtime()
      print("worker (%d,%d) finished  did %d tasks in %8.2f seconds"
%(myid,new_id,idid,te-ts))
      MPI_COMM_WORLD.barrier()
      MPI.Finalize()
```

- Workers tell manager they are ready
- Get work
- Do work
- Send Results

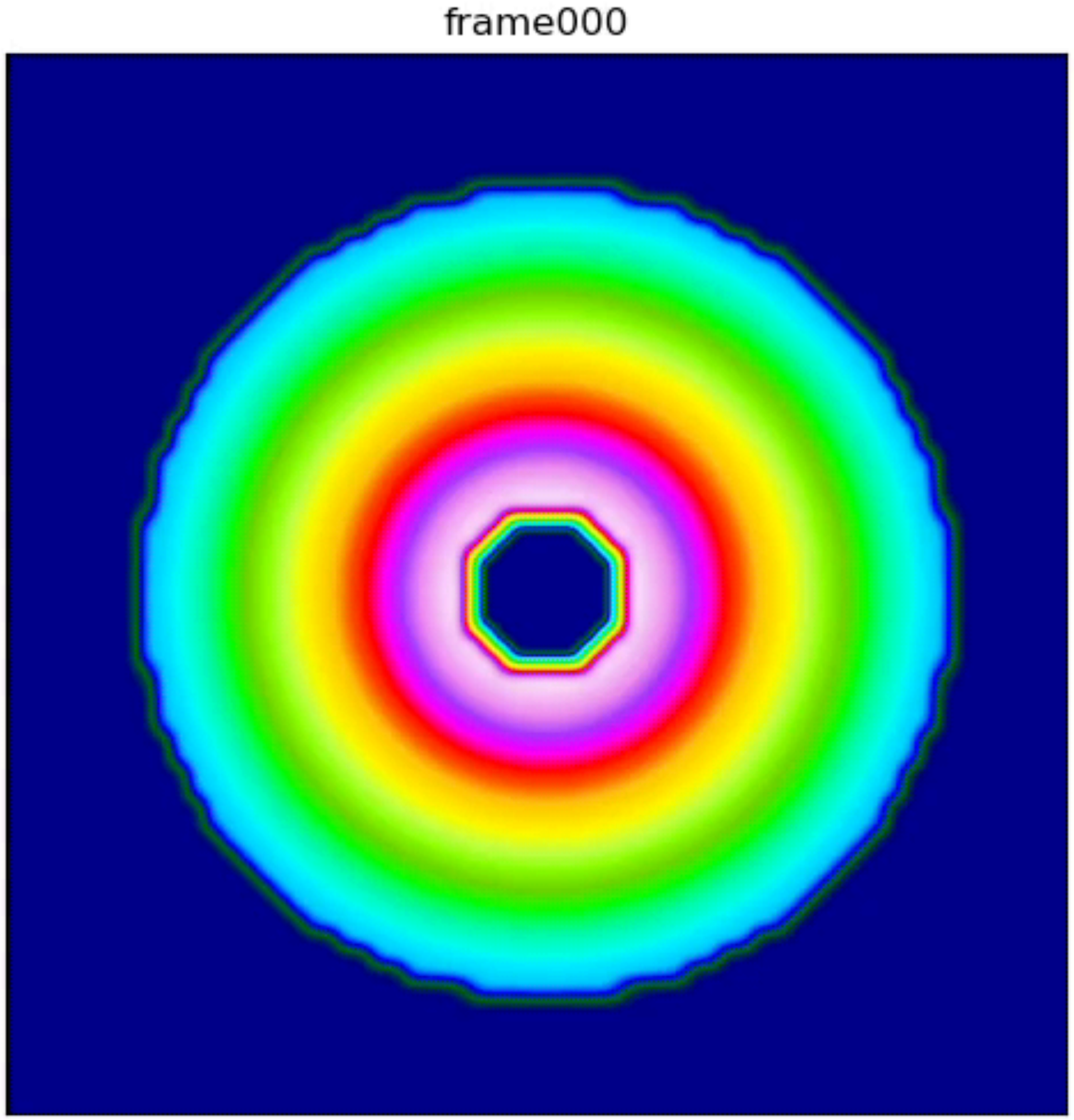
```
def worker(THE_COMM_WORLD,managerid):
    import mkview
    x=0
    comm=MPI.COMM_WORLD
    send_msg = numpy.arange(1, dtype='i')
    recv_msg = numpy.zeros_like(send_msg)
    ic=0
    while(True) :
# send message says I am ready for data #
        send_msg[0]=x
        comm.Send([send_msg, MPI.INT], dest=managerid, tag=1234)
# get a message from the manager #
        buffer=numpy.array((1), dtype=str)
        comm.Recv([buffer,MPI.CHAR], source=managerid, tag=2345)
#       print(buffer)
        x=str(buffer).split()
        fname=x[0]
        x=int(x[1])
        if(x < 0):
            return ic
        print(THE_COMM_WORLD.Get_rank(),fname,x)
        ic=ic+1
        mkview.plotit(fname,x)
#
```

```
def manager(num_used,TODO):
     global numnodes,myid,mpi_err
     global mpi_root
     comm=MPI.COMM_WORLD
     send_msg = numpy.arange(1, dtype='i')
     recv_msg = numpy.zeros_like(send_msg)
     status = MPI.Status()
# our "data"
# Our worker is expecting a single word  followed
# by a manager appended integer
     data=sys.stdin.readlines()
     todo=len(data)
# counters
     igot=0
     isent=0
     while(isent < todo):
# wait for a request for work #
          flag=comm.Iprobe(source=MPI.ANY_SOURCE, tag=MPI.ANY_TAG,status=status)
          if(flag):
# where is it comming from #
               gotfrom=status.source
               sendto=gotfrom
               comm.Recv([recv_msg, MPI.INT], source=gotfrom, tag=1234)
               x=recv_msg[0]
               print("worker %d sent %d" % (gotfrom,x))
               if(x > -1):
                    igot=igot+1
                    print("igot "+str(igot))
               if(isent < TODO):
# send real data #
                    d=data[isent]
                    d=d.strip()
                    send_msg=numpy.array([d+" "+str(isent)], dtype=str)
                    comm.Send([send_msg, MPI.CHAR], dest=sendto, tag=2345)
                    isent=isent+1
# tell everyone to quit #
     for i in range(1,num_used+1):
          send_msg=numpy.array(["stop -1000"], dtype=str)
          comm.Send([send_msg, MPI.CHAR], dest=i, tag=2345)
     return None
```

- Gets input from stdin
- Manager waits for ready
- Sends work
- Tells everyone to quit when work is finished

Running

- Get the data
  - curl https://raw.githubusercontent.com/timkphd/examples/master/r/laser.tgz | tar -xz
  - Data is the cross section of a laser beam propagating through the atmosphere
- Need to run this outside of Jupyter
  - run -n 4 ./simple.py < list
- Generates 201 png files
  - mymovie(laser,set=[200,201])


frame000

MPI4py builtin BoT

- MPI4py has a built in Bag of Tasks feature
- You create a routine to run
- Stuff tasks in queue and magic happens in parallel
- Have had issues with Intel MPI on multiple nodes

Our Example function:

```
#!/usr/bin/env python3
import mpi4py
from mpi4py.futures import MPIPoolExecutor
from random import random

def task(*args, **kargs) :
    import time
    myval = 0
    # Iterating over the Python args tuple
    st=time.asctime()
    for x in args:
        myval += x
    time.sleep(5)
    et=time.asctime()
    return st+" "+et+" "+str(myval)+" "+mpi4py.MPI.Get_processor_name()
```

nput values

5 seconds

summed value, processor name

Our driver

- Creates an "executor"
- Appends tasks (15 in this case) to it
- In this case, (not what you would normally do) we wait for the tasks to finish and print results
- Note that they are run in blocks of N-1

```
if __name__ == '__main__' :
    import time
    now1=time.time()
    print("start time ",time.asctime())
    future=[]
    nruns=15
    with MPIPoolExecutor() as executor:
        for i in range(0,nruns) :
            future.append(executor.submit(task, i, i/100.0))
        for f in future:
            print(f)
        for i in range(0,nruns) :
            f=future[i]
            # We can check on [running,done,cancelled]
            # or just wait for the result as we do here.
            result1=f.result()
            # This will force a synchronous termination
            # which is most likely not what you want in
            # a real simulation.
            print(result1)
now2=time.time()
print(" end time ",time.asctime(),now2-now1)
```

[14]:
```
%%capture out
srun -n 8  python3 -m mpi4py.futures ./future.py
```

[17]:
```
for x in clist(out) : print(x)
```

```
start time  Thu May  6 14:05:19 2021
<Future at 0xffffa8650340 state=pending>
<Future at 0xffffa864fb50 state=pending>
<Future at 0xffffa864fac0 state=pending>
<Future at 0xffffa864fa30 state=pending>
<Future at 0xffffa864f730 state=pending>
<Future at 0xffffa864f6a0 state=pending>
<Future at 0xffffa864f610 state=pending>
<Future at 0xffffa864f580 state=pending>
<Future at 0xffffa864f4f0 state=pending>
<Future at 0xffffa864f460 state=pending>
<Future at 0xffffa864f3d0 state=pending>
<Future at 0xffffa864f340 state=pending>
<Future at 0xffffa864f2b0 state=pending>
<Future at 0xffffa864f220 state=pending>
<Future at 0xffffa864f190 state=pending>
Thu May  6 14:05:19 2021 Thu May  6 14:05:24 2021 0.0 blk
Thu May  6 14:05:19 2021 Thu May  6 14:05:24 2021 1.01 blk
Thu May  6 14:05:19 2021 Thu May  6 14:05:24 2021 2.02 blk
Thu May  6 14:05:19 2021 Thu May  6 14:05:24 2021 3.03 clr
Thu May  6 14:05:19 2021 Thu May  6 14:05:24 2021 4.04 clr
Thu May  6 14:05:19 2021 Thu May  6 14:05:24 2021 5.05 clr
Thu May  6 14:05:19 2021 Thu May  6 14:05:24 2021 6.06 clr
Thu May  6 14:05:24 2021 Thu May  6 14:05:29 2021 7.07 blk
Thu May  6 14:05:24 2021 Thu May  6 14:05:29 2021 8.08 blk
Thu May  6 14:05:24 2021 Thu May  6 14:05:29 2021 9.09 blk
Thu May  6 14:05:24 2021 Thu May  6 14:05:29 2021 10.1 clr
Thu May  6 14:05:24 2021 Thu May  6 14:05:29 2021 11.11 clr
Thu May  6 14:05:24 2021 Thu May  6 14:05:29 2021 12.12 clr
Thu May  6 14:05:24 2021 Thu May  6 14:05:29 2021 13.13 clr
Thu May  6 14:05:29 2021 Thu May  6 14:05:34 2021 14.14 blk
 end time  Thu May  6 14:05:34 2021 15.021350145339966
```

Ran on two nodes
clr & blk
Work done in blocks of N-1.
We did 75 seconds of work in 15 seconds