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Department of Computer Science

2021 Code Performance Series: From analysis to insight

Third session

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March 2021

Agenda

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9:00-9:30	Experience reports ▶ Flash
9:30-12:00	Score-P instrumentation & measurements
10:00-11:00	MPI Tracing
11:00-12:00	Case studies of parallel performance analyses with CUBE & Vampir
13:00-15:00	Workshop
13:00-14:00	MPI programming refresher (optional)

Experience report: Flash

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Before we start: non-verbal feedback

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- I can't see (most of) you, but I'd appreciate non-verbal feedback
- Open `http://dev.atlas-tool.eu/room?username=username&creator=atlas&room=Performance+Analysis+Workshop03763003231`
- Press button (mouse, keyboard) in Windows *if something is not clear*
  (you can still scratch your head)
- Feel free to continue to press until things become clearer again
- We will distribute a questionnaire after the session to gather some feedback (pilot)

More info: `http://dev.atlas-tool.eu/tool`

Three types of message exchange

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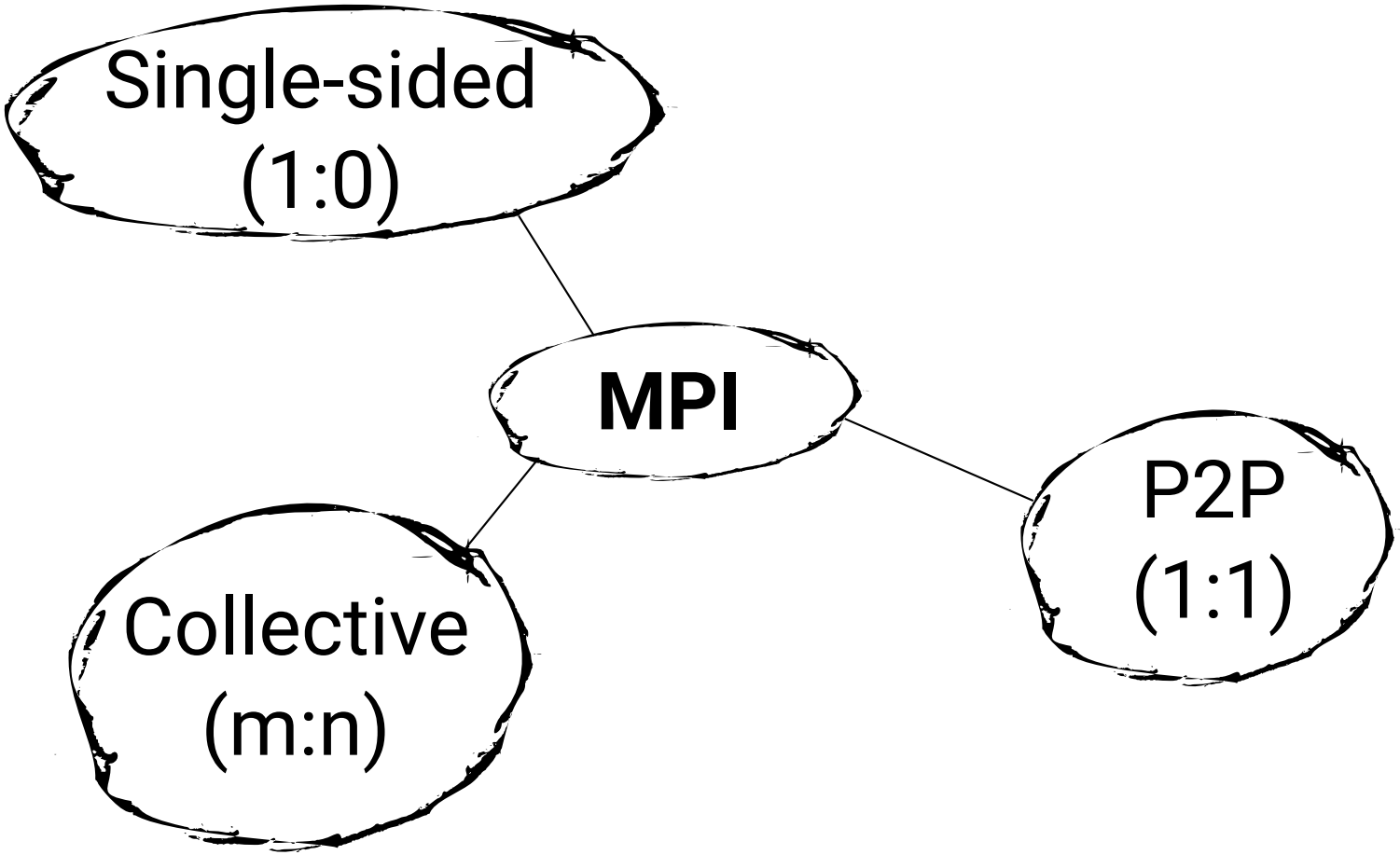

We ignore single-sided today.

Point-to-point: send plus receive

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```
int MPI_Send(
  const void *buffer, int count, MPI_Datatype datatype,
  int dest, int tag, MPI_Comm comm
)
```

```
int MPI_Recv(
  void *buffer, int count, MPI_Datatype datatype,
  int source, int tag, MPI_Comm comm,
  MPI_Status *status
)
```

- `buffer` is a pointer to the piece of data you want to send away or into which you want to receive.
- Every send has to be matched by receive.
- Messages are transferred in-order.
- `tag` allows you to distinguish (and receive out-of-order).

Collectives for n:m

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Collective operation: A collective (MPI) operation is an operation involving many/all nodes/ranks.

Type of collective	One-to-all	All-to-one	All-to-all
Synchronisation			
Communication			
Computation			

Insert the following MPI operations into the table (MPI prefix neglected):

- Barrier
- Broadcast
- Reduce
- Allgather
- Scatter
- Gather
- Allreduce

The notion of blocking

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> Blocking: MPI_Send is called `blocking` as it terminates as soon as you can reuse the buffer, i.e. assign a new value to it, without an impact on MPI.

> Blocking: MPI_Recv is called `blocking` as it terminates as soon as you can read the buffer, i.e. MPI has written the whole message into this variable.

- If a blocking send returns, it does **not** mean that the corresponding message has been received on the other side.
- Blocking and asynchronous or synchronous execution have **nothing** to do with each other. However blocking receives do make receiver side lag behind sender.
- With blocking sends, you never have a guarantee that the data has been received, i.e. blocking sends are not *synchronised*.
- The term blocking just refers to the safety of the local variable. If a blocking send returns, the data might have been copied to the local network chip, e.g.

$\Rightarrow$ Both P2P ops and collectives are by default blocking.

Where messages roam

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Where is the message buffered?

> Eager protocol: Destination rank has some memory buffer available or receive has been posted already.

> Rendezvous protocol: No spare buffer available. Sender thus waits until destination rank signals ok.

- Protocol choice depends on MPI configuration, number of messages in the system, message sizes, ...
- Eager reduces algorithmic latency, but
  - requires additional memory copies
  - searching through unexpected message queue is expensive
- Rendezvous reduces memory movement overhead, but
  - synchronises ranks

$\Rightarrow$ Deadlock #1: MPI falls back to rendezvous protocol but no buffer becomes available as receiver side in return waits for a buffer on another rank

$\Rightarrow$ Deadlock #2: MPI can't even get the envelope of rendezvous through

- You can tweak your MPI protocol thresholds (rarely do this; rather understand algorithm's behaviour)

Flavours of message exchange

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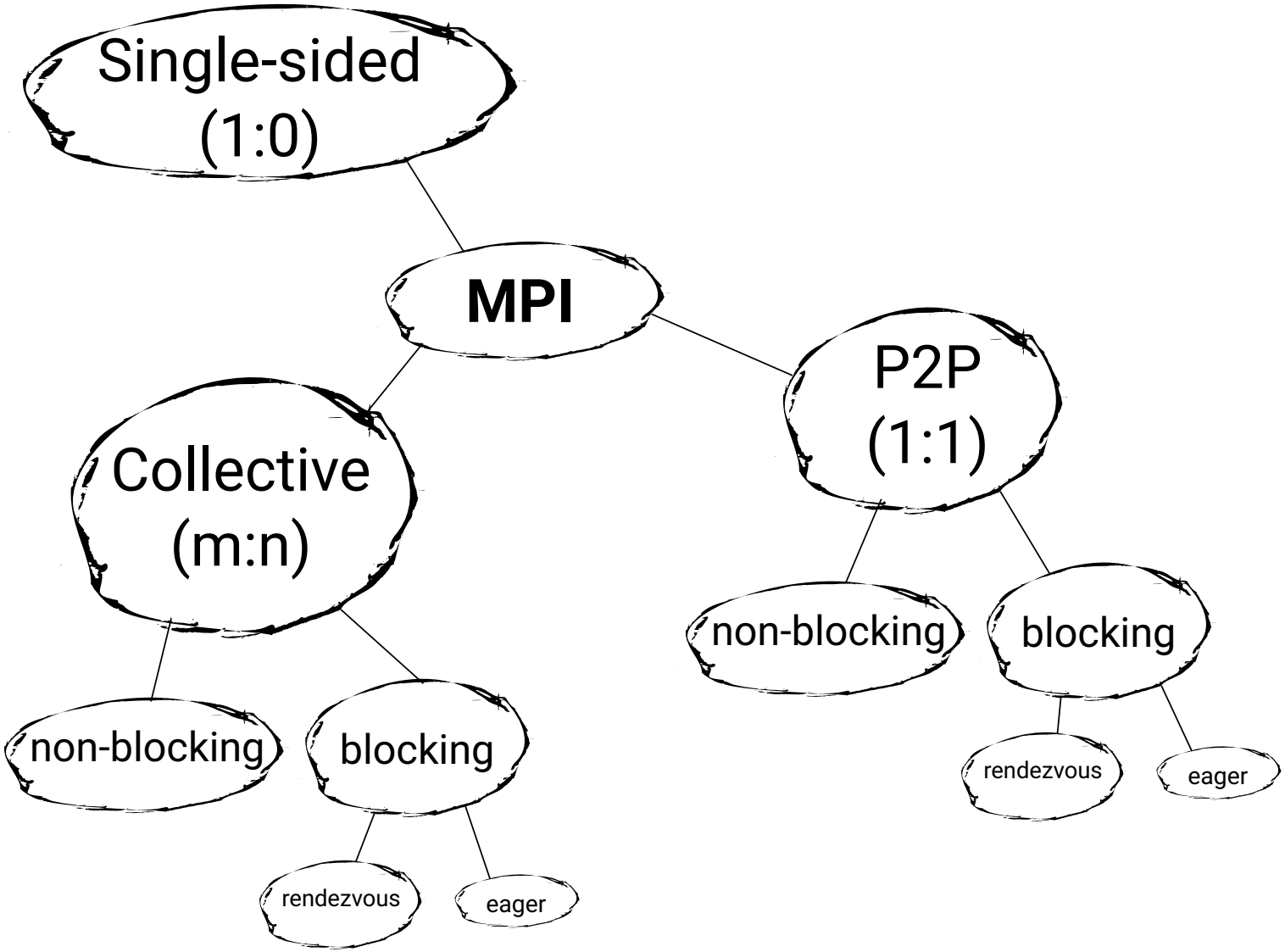

Nonblocking P2P communication

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- Non-blocking commands start with I (immediate return)
- Non-blocking means that operation returns immediately though MPI might not have transferred data yet
- Buffer (variable) thus is still in use and we may not overwrite it
- We explicitly have to validate whether message transfer has completed before we reuse or delete the buffer

```
Create helper variable (handle)
int a = 1;
trigger the send
do some work
check whether communication has completed
a = 2;
...
```

- We now can overlap communication and computation, as we eliminate synchronisation.
- Works for P2P and collectives.
- Wannabe MPI experts will sell you this one as solution to all problems.

Isend and Irecv


```
int MPI_Send(
  const void *buffer, int count, MPI_Datatype datatype,
  int dest, int tag, MPI_Comm comm
)
```

```
int MPI_Isend(
  const void *buf, int count, MPI_Datatype datatype,
  int dest, int tag, MPI_Comm comm,
  MPI_Request *request
)

int MPI_Test(MPI_Request *request, int *flag, MPI_Status *status)
int MPI_Wait(MPI_Request *request, MPI_Status *status)
```

- Pass additional pointer to object of type `MPI_Request`.
- Non-blocking, i.e. operation returns immediately.
- Check for send completition with `MPI_Wait` or `MPI_Test`.
- `MPI_Irecv` analogous.
- The status object is not required for the receive process, as we have to hand it over to wait or test later.

Progression

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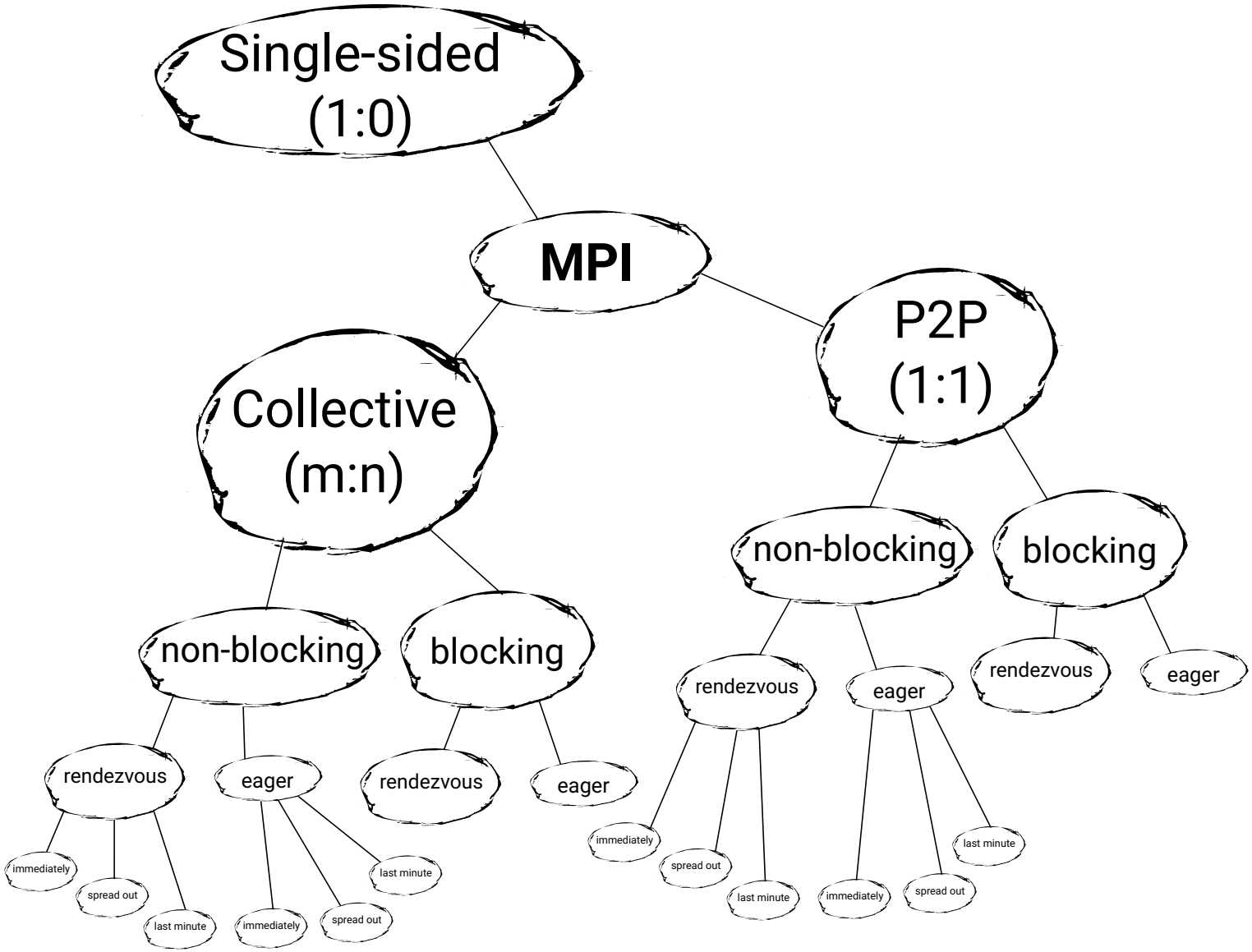
MPI Progression: Machine still needs CPU cycles to transfer message

- Rely on separate (progression) thread (Intel MPI)
- Rely on hardware
- Rely on MPI to plug into other MPI calls

If MPI does the job (predominant pattern):

- Immediately: Send immediately returns, i.e. logically no difference to blocking exchange.
- Spread out: Some `MPI_xxx` call in your code makes MPI interrupt your execution and transfer data.
- Last minute: The final `MPI_Wait` or `MPI_Test` makes MPI realise message transfer.

Summary


Single-sided
(1:0)
MPI
Collective
(m:n)
P2P
(1:1)
non-blocking
blocking
non-blocking
blocking
rendezvous
eager
rendezvous
eager
rendezvous
eager
rendezvous
eager
immediately
spread out
last minute
immediately
spread out
last minute
immediately
spread out
last minute
immediately
spread out
last minute