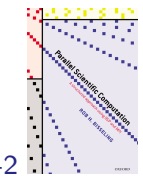
Message Passing Interface (MPI-2)

(PSC Appendix C, §C.2.5–C.4)

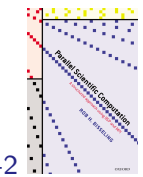


One-sided communications in MPI-2

```
bsp_hpput(pid, src, dst, dst_offsetbytes, nbytes);

MPI_Put(src, src_n, src_type,
        pid, dst_offset, dst_n, dst_type, dst_win);
```

- The standard put operation in MPI-2 is the unbuffered put, equivalent to the high-performance put in BSPlib.
- Data sizes and offsets are measured in units of the basic data type, `src_type` for the source array and `dst_type` for the destination array. Both could e.g. be `MPI_DOUBLE`.
- The destination memory area is not given by a pointer to memory space such as an array, but by a pointer to a window object.



Windows for one-sided communications

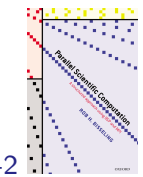
```
bsp_push_reg(variable, nbytes);

MPI_Win_create(variable, nbytes, unit, info, comm, win);

bsp_pop_reg(variable);

MPI_Win_free(win);
```

- A window is a preregistered and distributed memory area, consisting of local memory on every processor of a communicator.
- A window is created by `MPI_Win_create`, equivalent to `bsp_push_reg`.
- `win` is the window of type `MPI_Win` corresponding to the array `variable`.
- The integer `unit` is the unit for expressing offsets; `comm` is the communicator of the window.



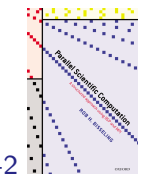
Creating a window

```
MPI_Win_create(variable, nbytes, unit, info,
               comm, win); //syntax
```

```
MPI_Win v_win;

MPI_Win_create(v,nv*SZDBL,SZDBL,MPI_INFO_NULL,
               MPI_COMM_WORLD,&v_win);
MPI_Win_fence(0, v_win);
```

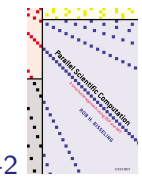
- A window can be used after a call to `MPI_Win_fence`, which can be thought of as a synchronisation of the processors that own the window.



Fanout in mpimv

```
for(j=0; j<ncols; j++)
    MPI_Get(&vloc[j],  1,MPI_DOUBLE,srcprocv[j],
            srcindv[j],1,MPI_DOUBLE,v_win);
MPI_Win_fence(0, v_win);
```

- Communications initiated before a fence are guaranteed to have been completed after the fence.
- The fence acts as a synchronisation at the end of a superstep.

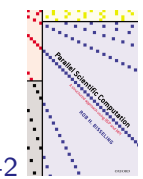


Fanin using accumulate

```
for(i=0; i<nrows; i++){
    /* compute psum =  local partial sum of row i */
    ...

    MPI_Accumulate(psum,1,MPI_DOUBLE,
                   destprocu[i], destindu[i],
                   1,MPI_DOUBLE,MPI_SUM,u_win);
}
MPI_Win_fence(0, u_win);
```

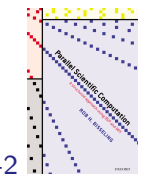
- Accumulate is a one-sided communication.
- Instead of putting a value into the destination location, accumulate adds a value into the location, or takes a maximum, or performs another binary operation.



Comparison of BSPlib and MPI for inner product

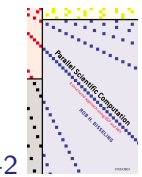
Program	n	p	BSPlib	MPI
Inner product	100 000	1	4.3	4.3
		2	4.2	2.2
		4	5.9	1.1
		8	9.1	0.6
		16	26.8	0.3

- Time $T_p(n)$ (in ms) of parallel program from BSPedupack and MPIedupack on p processors of a Silicon Graphics Origin 3800.
- BSPlib implementation was designed for earlier machine.
- The vendor's version of MPI is clearly well-optimised, leading to good scalability.



Comparison of BSPlib and MPI for LU and FFT

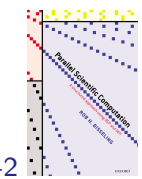
Program	n	p	BSPlib	MPI
LU decomposition	1000	1	5408	6341
		2	2713	2744
		4	1590	1407
		8	1093	863
		16	1172	555
FFT	262 144	1	154	189
		2	111	107
		4	87	50
		8	41	26
		16	27	19



Comparison of BSPlib and MPI for matrix–vector

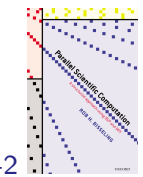
Program	n	p	BSPlib	MPI
Matrix–vector	20 000	1	3.8	3.9
		2	11.4	2.7
		4	14.7	6.9
		8	20.8	8.4
		16	18.7	11.0

- Test problem `amorph20k` too small to obtain speedup.



How to use BSP in an MPI world?

- The first, purist approach is to write our programs in BSPlib and install BSPlib ourselves if needed.
- Main advantages: ease of use; automatic enforcement of the BSP style; no deadlock.
- For shared-memory architectures, efficient implementation is available through Albert-Jan Yzelman's MulticoreBSP for C.
- Always possible to use BSPonMPI by Wijnand Suijlen.
- BSPonMPI is a library. Linking it with your BSPlib program turns it into an MPI program. Then use `mpirun` ...

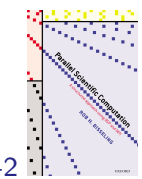


Second approach: the hybrid program

- The hybrid approach is to write a single program in BSP style, but express all communication both in MPI and BSPlib.
- The resulting single-source program can then be compiled conditionally (with or without a flag `-DMPITARGET`), e.g. for the FFT:

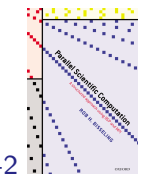
```
#ifdef MPITARGET
    mpiredistr(x,n,p,s,c0,c,rev,rho_p);
#else
    bspredistr(x,n,p,s,c0,c,rev,rho_p);
#endif
```

- Main advantages: single-source program; choice of BSP or MPI, whichever is fastest; encourages programming in BSP style also in the MPI part of programs.
- Disadvantage: longer program texts.



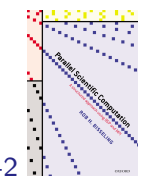
Third approach: write in BSPlib, then convert to MPI

- Main advantages: saves human time when developing the program; single-source program.
- Disadvantage: some extra effort needed at the end of the development stage.
- This approach was taken for BSPedupack, which was converted into MPIedupack within a week.



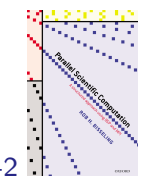
Fourth approach: write in MPI-2

- Use collective communications where possible, and keep the lessons learned from the BSP model in mind.
- This probably works best after having obtained some experience with BSPlib.



Differences between BSPlib and MPI

- BSPlib: system optimises. MPI: user optimises.
- BSPlib: small. MPI: large.
- BSPlib is easier for the novice. MPI gives experts more power.
- BSPlib: paternalistic library which steers programming efforts in the right direction. MPI allows many different styles of programming.



Summary: where BSP meets MPI

- Use BSPlib when learning to program in parallel.
- Use MPI later in life.
- Use BSPonMPI if you prefer BSPlib but want the portability of MPI.
- MPI-2 provides one-sided communications.
- Our experimental comparisons were unfair to BSPlib. More testing is needed, also using BSPonMPI.
- The third approach may be the best: write in BSPlib, but be prepared to convert to MPI. You may never need to!