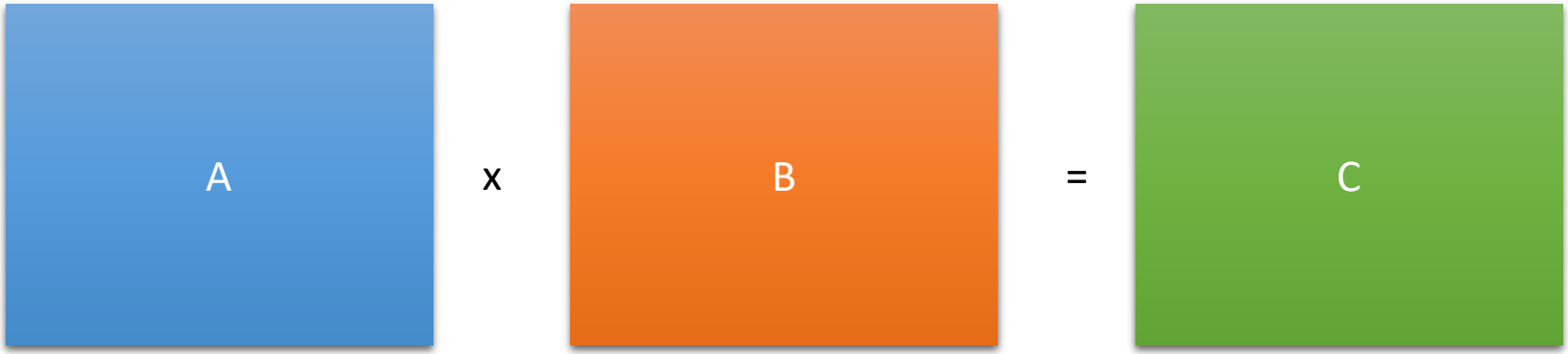
Programming Assignment #2 -- Multi-Process Matrix Multiplication using Shared Memory

Overview

- Matrix multiplication using multiple processes
  - Basic parallel processing
  - Will be faster with multicore machines
- Input: the dimension of two square matrices A & B
  - E.g., 100 → A, B, and C are 100x100 square matrices
- Output: an execution time and a checksum



Task Partition

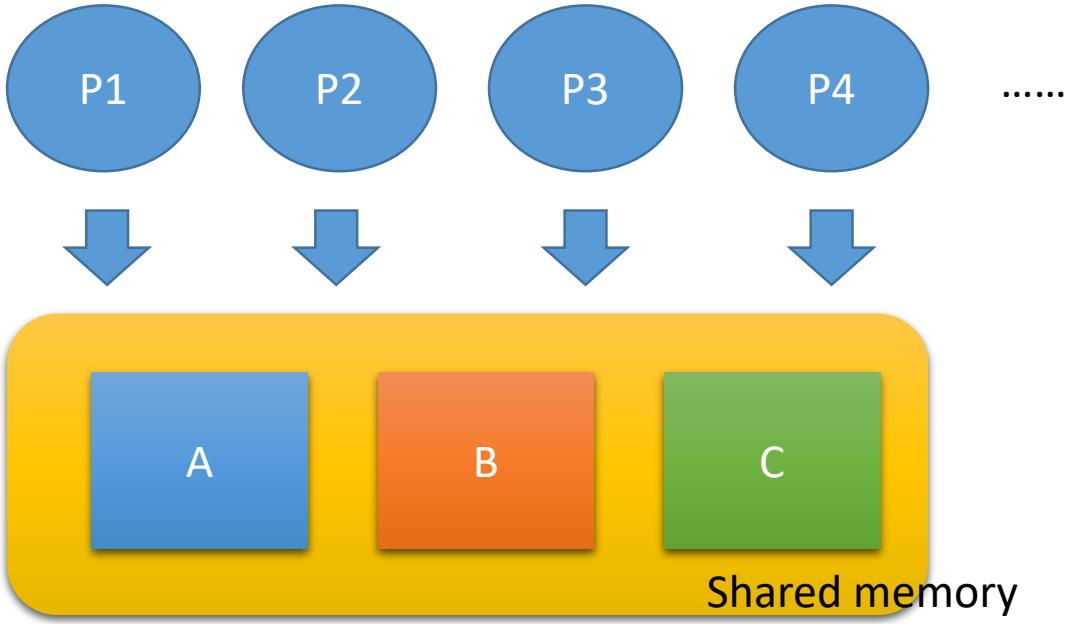
- 1-process matrix multiplication

- 2-process matrix multiplication

- 16-process matrix multiplication

Shared Memory

- Matrices A, B, and C are stored in a shared memory
- No locking/synchronization is required since multiplication on sub-metrics are mutually independent



Header Files

- unistd.h
- sys/ipc.h
- sys/shm.h
- sys/wait.h

- sys/time.h

APIs

- shmget() – create a block of shared memory
- shmat() – attach shared memory to the current process's address space
- shmdt() – detach shared memory from the current process's address space
- shmctl() – control shared memory

- gettimeofday()

shmget()

- **`int shmget(key_t key, size_t size, int shmflg);`**

- create a block of shared memory
- Return the id of the request shm of size equals to the value of *`size`*
- *`key`* : 0/IPC_PRIVATE for new allocate shm
- *`size`* : size in bytes
- *`shmflg`* : IPC_CREAT | mode_flags(9 bits)

  e.g. IPC_CREAT | 0600 for read only shm

shmat()

- **`void *shmat(int`** *`shmid`*`, `**`const void *`**`shmaddr`**`, int`** *`shmflg`*`);`

- Attach shared memory to the current process's address space
- Return the address of the attached shared memory segment identified by *`shmid`*
- *`shmaddr`* : NULL for system to choose suitable address

- *`shmflg`* : 0 for read/write, **`SHM_RDONLY`** for read only

shmdt()

- **`int shmdt(const void *`*`shmaddr`*`);`**

- Detach the shared memory segment located at the address *`shmaddr`* from the address space of the calling process
- *`shmaddr`* must equal to the value returned by **`shmat()`**

shmctl()

- **`int shmctl(int shmid, int cmd, struct shmid_ds *buf);`**

- control shared memory
- Perform control operation
  - **`IPC_STAT`**
  - **`IPC_SET`**
  - **`IPC_RMID`**
  - **`…`**

- **`IPC_RMID: Marking a shared memory to be deleted. The share memory will be destroyed on when the last process detach the memory from its address space. Must be called by the creator of the shared memory.`**

gettimeofday()

```
struct timeval start, end;
gettimeofday(&start, 0);
//do something
gettimeofday(&end, 0);
int sec = end.tv_sec – start.tv_sec;
int usec = end.tv_usec – start.tv_usec;

printf(“elapsed %f ms”, sec*1000+(usec/1000.0));
```

Matrix Initial Values

- Matrix elements in A and B are initialized as follows (for example, an 8x8 matrix)

0	1	2	3	4	5	6	7
8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31
32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63

Checksum of this matrix: 2016

Requirements

- Create worker processes using fork()
  - Wait until all works exit()
- Put all the metrics in the shared memory
- Print the elapsed time and matrix checksum
  - 16 cases, process parallelism from 1 to 16
  - The final checksum must be correct
  - Matrix elements and the checksum are 32-bit unsigned integers
  - Do not care about integer overflows
- TAs will test your program using any matrix dimension between 100*100 and 800*800
- TAs will test your program on a multicore machine (VM)
  - Your 2-process and 3-process versions must be noticeably faster than your 1-process version
- Violating any one of the requirements will receive a score penalty

Output

Input the matrix dimension: 800↵

Multiplying matrices using 1 process
Elapsed time: 5.814723 sec, Checksum: 561324032
Multiplying matrices using 2 processes
Elapsed time: 3.10231 sec, Checksum: 561324032
Multiplying matrices using 3 processes
Elapsed time: 2.927338 sec, Checksum: 561324032
……
Multiplying matrices using 16 processes
Elapsed time: x.xxxxx sec, Checksum: 561324032

API Reference

- http://blog.csdn.net/guoping16/article/details/6584058
- http://man7.org/linux/man-pages/man2/shmget.2.html
- http://man7.org/linux/man-pages/man2/shmat.2.html

Testing OS Environment

- Ubuntu 16.04, Ubuntu 14.04 or CS linux work station
  - Your code should compile successfully in one of the above environments