2.2 Why processes

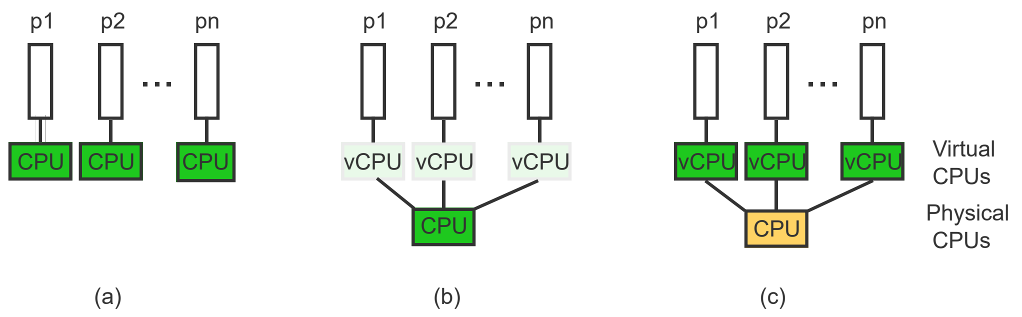
Virtual CPUs

Structuring an application as processes allows independence from the:

- Number of CPUs: A ***physical CPU*** is a real hardware instance of a CPU. Multiple processes may run on one physical CPU using a technique known as ***time sharing***. Each process is given a ***virtual CPU***: A CPU that the process assumes is available only to itself.
- Type of CPU: A virtual CPU can be just an abstraction of the physical CPU or it can be software that emulates the behavior of a different CPU.

PARTICIPATION ACTIVITY | 2.2.1: Multiple processes can run on different hardware configurations but in all cases each process can assume having the same private physical CPU. ✓

Start ☐ 2x speed



Captions

1. Each process can have a separate physical CPU.
2. All processes can time-share the same CPU, which is repeatedly switched among the processes.
3. The time-sharing of the CPU is transparent to the processes, which creates the illusion for each process to have a separate CPU: a virtual CPU.
4. A different physical CPU with a different instruction set may be substituted without changing or recompiling the code of the processes.
5. With a different physical CPU, the virtual CPUs are not just illusions but are implemented in software and emulate the behavior of the original CPU. The processes remain unchanged.

Feedback?

PARTICIPATION ACTIVITY | 2.2.2: Changing CPUs. ✓

1) In parts (b) and (c) of the animation, ________.

[✓ the physical CPUs have different instruction sets]

the virtual CPUs have different instruction sets

both the physical and the virtual CPUs have different instruction sets

Correct

The processes can run on different physical CPUs using virtual CPUs.

✓

Feedback?

PARTICIPATION ACTIVITY | 2.2.3: Number of virtual vs physical CPUs.

1) What is the maximum number of physical CPUs an application consisting of 3 processes can utilize?

3

Check Show answer

Correct

3

Each of the 3 processes can run on a separate CPU.

2) What is the minimum number of physical CPUs an application consisting of 3 processes can utilize?

1

Check Show answer

Correct

1

Each of the 3 processes can be time-shared on 1 physical CPU.

3) On how many virtual CPUs will the 3 processes run?

3

Check Show answer

Correct

3

Each process can assume having a (virtual) CPU for itself.

Feedback?

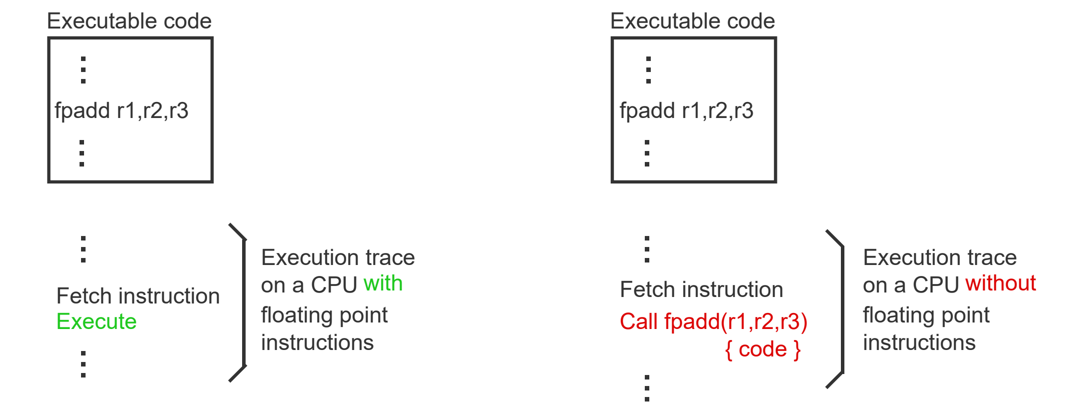
Benefits of virtual CPUs

Independence from the number and type of CPUs provides several crucial benefits:

- Multi-user support: Multiple users, each represented by one or more separate processes, can share the same machine without being aware of each other.
- Multi-CPU transparency: An application written to utilize multiple CPUs will run correctly, although perhaps more slowly, if only one CPU is available.
- Portability: An application compiled for one type of CPU can run on a different CPU without being modified or even recompiled.

PARTICIPATION ACTIVITY | 2.2.4: Code portability between different types of CPU.

Start ☐ 2x speed



Captions

1. A program containing a floating point add instruction (fpadd) is to be executed.
2. The CPU fetches and decodes the instruction.
3. If the CPU supports floating point instructions, then the fpadd instruction is simply executed directly in hardware by adding the contents of the registers r1 + r2 and storing the sum in r3 .
4. The same program can be executed without any changes on a CPU without floating point operations. The floating point operations are implemented by the virtual CPU in software.
5. The virtual CPU software fetches the instruction and, transparently to the program, executes the fpadd instruction using a corresponding software function.

Feedback?

PARTICIPATION ACTIVITY | 2.2.5: Using a simpler CPU. ✓

1) When the CPU with floating operations is replaced with a CPU without floating point operations, then ________.

- ○ the correctness of the operations may change
- [✓ speed of execution may change]

Correct
The virtual CPU software will implement the same operations as the hardware but the hardware implementation is likely to be faster.

✓

Feedback?

PARTICIPATION ACTIVITY | 2.2.6: Changing the number of CPUs. ✓

3 independent processes are executing on 2 physical CPUs.

1) Decreasing the number of CPUs from 2 to 1 will ________ speed of execution.

- [✓ decrease]
- ○ increase
- ○ not affect

Correct
All 3 processes will have to time-share the single CPU.

✓

2) Increasing the number of CPUs from 2 to 3 will ________ speed of execution.

- ○ decrease
- [✓ increase]
- ○ not affect

Correct
Each of the 3 processes can now have a separate physical CPU.

✓

3) Increasing the number of CPUs further from 3 to 4 will ________ speed of execution.

- ○ decrease
- ○ increase
- [✓ not affect]

Correct
Each process can only use one CPU and thus only 3 CPUs can be utilized.

✓

Feedback?

PARTICIPATION ACTIVITY | 2.2.7: Physical vs virtual CPUs.

1) An application running on multiple physical CPUs must be modified in order to run correctly on a single CPU.

○ True
[✓ False]

Correct

A process can run on a dedicated CPU or with interruptions on a shared CPU. The context switches are transparent to the process, and the results are unaffected.

2) The main purpose of virtual CPUs is to improve the performance of a system.

○ True
[✓ False]

Correct

Virtual CPUs allow processes to transparently share a physical CPU, generally at the cost of reduced speed. Virtual CPUs also allow processes to run different physical CPUs without code modification or recompilation.

Feedback?

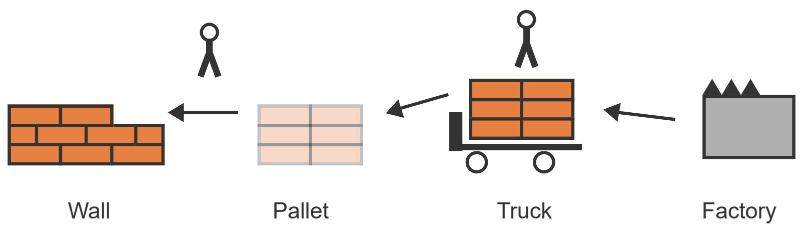
A modular structuring concept

An application can generally be divided into multiple tasks, each implemented as a process. Using multiple cooperating processes instead of one has several important advantages:

1. The interfaces between the processes are simple and easy to understand.
2. Each process can be designed and studied in isolation.
3. The implementation reduces idle time by overlapping the execution of multiple processes.
4. Different processes can utilize separate CPUs, if available, thus speeding up the execution.

PARTICIPATION ACTIVITY | 2.2.8: Two cooperating processes yield a better design than one: A wall-building analogy.

Start ☐ 2x speed



Captions

1. A mason is building a wall by taking bricks one at a time from a pallet and placing them on the wall.
2. The bricks are driven from a factory to the construction site in bulk, one pallet at a time.
3. The mason has a dilemma: when to get the next pallet. Approach 1: wait until the current pallet is empty. Drawback: the mason is delayed at the factory until bricks are loaded.
4. Approach 2: Mason goes to the factory ahead of time to request bricks but returns empty if no bricks are available. Drawback: the mason may be wasting time doing so multiple times.
5. 2-worker approach: Mason keeps laying bricks and only needs to stop when pallet is empty.

6. A separate driver waits at the factory, takes pallet to construction, and only waits until the current pallet is empty.

Feedback?

PARTICIPATION ACTIVITY | 2.2.9: Benefits of the 2-process design. ✓

Refer to the above wall-building analogy.

1) The 2-process design reduces the number of context switches necessary for the periodic checking of brick availability at the factory.

[✓ True] False

Correct ✓

The mason can keep working as long as the pallet is not empty. The supply is handled by the separate truck driver, which is blocked except when moving bricks from the factory or unloading bricks.

2) The 2-process design permits the mason and the driver to operate in parallel.

[✓ True] False

Correct ✓

When 2 workers are available, the process of laying bricks and the process of driving bricks can be done at the same time.

Feedback?

PARTICIPATION ACTIVITY | 2.2.10: Extending the wall-building analogy. ✓

Under which condition would each extension of the 2-process solution be beneficial?

Select the definition that matches each term

1) Increasing the space at the construction site to hold 2 pallets.

[✓ Beneficial if moving a pallet from the truck to the work space takes a long time.]

Correct

Having 2 pallets would eliminate the mason's delay between finishing one pallet and starting the next.

2) Increasing the space at the construction site to hold more than 2 pallets.

[✓ Beneficial if the supply of bricks from the factory is irregular, that is, long delays interspersed with bursts of production are common.]

Correct

Having multiple spaces for pallets would serve as a larger buffer for periods of slow production.

3) Employing more than one truck.

[✓ Beneficial if the round trip between the factory and the construction site is very long.]

Correct

If the round trip is longer than the time to use up one pallet, then having multiple trucks would create a pipeline able to supply the pallets at the needed frequency.

Reset

Feedback?

How was this section?

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