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| **Parallel programming** | Fall 2019  Group Name: Quinary  Members: Ivana Lanzani, Dominick DiLeo, Meet Patel, Akiva Ochoa, Chowdhury Mobin. |

1. Raspberry Pi has various components on a single board.

* ARM CPU/RAM,
* Ethernet Port
* Ethernet controller
* Wireless LAN, Bluetooth BLE
* HDMI port
* Display connector
* Camera connector
* 3.5mm Audio Jack
* 4 USB port
* LED’s
* Micro USB Power Port
* SD card slot

2. The Raspberry Pi’s B+ is a single board computer, it has a quad-core CPU. Which means there are four cores in the CPU.

3. Three main differences between X86 (CISC) and ARM Raspberry (RISC):

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| X86 (CISC) | ARM Raspberry (RISC) |
| It has a large instruction set which allows various complex instructions to access the memory. | It has a much smaller instruction set than the X86, |
| X86 has the Load/Store logic is already built inside more complex inside complex instructions. | ARM uses Load/Store memory model for accessing memory which means only way to access the memory is by using Load/Store instructions. |
| Complex instructions of X86 takes multiple clock cycles per instruction to be executed. | The instructions of ARM can be executed faster, which is approximately one clock cycle per instruction. |

4. The differences between sequential and parallel computation:

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| Sequential Computing | Parallel Computing |
| Problems are broken into discrete series of instructions which are solved in sequence. | Problems are broken into discrete pieces of work and which can be solved simultaneously. |
| Instructions are executed one after another on a single processor. | Instructions are executed at the same time on multiple processors. |
| Limited compute resources make problem solving slower. | Multiple compute resources such as multiple processor or core make problem solving quicker. |

5. Data parallelism and task parallelism are two general forms of parallelism at the algorithmic level. Data parallelism is a king of parallelism in which same computation is applied to multiple data items. Here, the available parallelism is proportional to the input size. Which leads to massive amount of potential parallelism. Global sum is considered to be a data parallel operation.

Task parallelism applies to solutions, where parallelism is organized around the functions to be performed rather than the data. Functional programs exhibit huge amount of task parallelism.

6. A process is the abstraction of a running program. Thread is a lightweight process that allows a single executable to be a decomposed to smaller, independent parts. Processes don’t share memory, but all threads share the common memory of the process they belong to. Single core CPU can only handle one process at a time, to execute more processes at once we need more cores. Threads are scheduled by operating system on separate cores as available.

7. OpenMP or Open Multi Processing is an application programming interface (API). OpenMP is comprised of three components. Which are environment variables, compiler directives and runtime library routines. This API supports Fortran, C and C++ on most platforms, instruction set architectures and operating systems such as Windows, Linus and macOS.

OpenMP pragmas are compiler directives which enables the compiler to generate threaded code. Open MP pragmas are one of the two primary patterns used as program structure implementation strategies which almost every shared memory parallel program have.

8. There are a lot of applications which benefits from multi-core CPU. Here are the four among those applications:

* Multimedia applications (Houdini, Final Cut Pro, Adobe Illustrator etc.)
* Scientific applications (SciLab, MATLAB etc.)
* Compilers (Clang, GCC, javac etc.)
* Web servers (Apache Tomcat, NGINX etc.)

9. Multi-core contains multiple core processing units or cores in a single physical processor. Multi-core is supported by most major operating systems like Windows, Linux and MacOS. The reasons to choose multi-core instead of single-core are the followings:

* Multi-core is much faster than single-core, it can also do multitasking.
* Heat problem is an issue in single-core, which decreases CPU performance, sometimes it causes applications to crash.
* Many new applications are multithreaded which runs faster in multi-core CPU’s.
* Single-core has higher power consumption than multi-core due to its high clock rates.