COMP 322: Parallel and Concurrent Programming

Lecture 37: Concurrent and Parallel Languages and Frameworks

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What have we learned in this course?

- Functional programming for parallelism
- Lazy computation, streams
- Futures and promises
- Data-driven programming approach
- Computation graphs and their properties
- Map/Reduce programming model
- Data-parallel programming model
- Loop parallelism
- Locality control
- Handling concurrency while avoiding deadlock/livelock/starvation
- Barrier and point-to-point synchronization
- Actor programming model

Habanero

- Habanero-Java and Habanero-C
- Async/finish, futures/promises, loop parallelism, phasers, locality control, actors, isolation
- HJlib is a library implementation of these features
- Still developed and improved
- Python, Scala, Rust, X10, OpenMP, Chapel, Java, C/C++
- There's also PCDP-Java
  - Coursera equivalent of COMP 322
- No streams

https://habanero.cc.gatech.edu/

X10

- Designed and developed at IBM
- One of the original “Next-generation” Asynchronous Partitioned Global Address Space projects
- Ancestor of Habanero Java
- Originally based on Java, later switched to Scala
- Async, finish, loop parallelism, clocks (phasers), locality control
- No abstract metrics, data-driven execution, actors, streams

http://x10-lang.org/

Chapel

- Designed, implemented and maintained by Cray
- Partitioned Global Address Space
- Loop parallelism, task parallelism
- Locality control
- Distributed system execution
- Tasks, futures, promises
- No phasers, actors, abstract metrics, data-driven execution

https://chapel-lang.org/

Kotlin

- From the creators of IntelliJ
- Based on Java
- Multi-paradigm programming language
  - Functional, object-oriented
- Lots of support for functional programing
- More compact than Java
- Fully interoperable with Java
- Support for coroutines: very similar to asyncs and future tasks
- Low-level synchronization between tasks
- Channels
- No loop parallelism, phasers, abstract metrics, streams, locality control, actors

https://kotlinlang.org/

Go

- Multi-paradigm, object-oriented, concurrent language
- Goroutines (asyncs)
- Channels
- Concurrency control structures
  - Sending messages between coroutines
- No phasers, loop parallelism, futures/promises, abstract metrics, actors, locality control

https://go.dev/

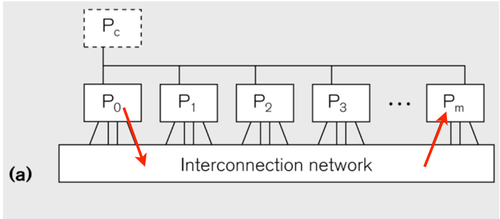
Python/Ray

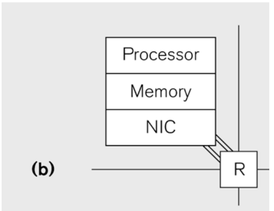
- Library based approach
- Aimed at data science, machine learning, data processing
- Futures and actors
- No task-level parallelism on shared memory
- No abstract metrics, phasers, loop parallelism

https://www.ray.io/

MPI

- Library framework
- Message-passing programming model
- Designed for distributed systems
- Implementations on top of several programming languages
  - C/C++
  - Java
  - Fortran
  - Julia, MATLAB, OCaml, Python, R
- Implementations for most modern supercomputers
- No tasking, futures/promises, abstract metrics, streams, phasers





Summary

- Concurrent and parallel programming is becoming pervasive
- Many languages and frameworks support some aspects
- Most of them do not support all aspects of concurrent and parallel programming
- It's possible to build additional features on top of a few basic ones
- You have learned most of the basic concepts in COMP 322