POIR 613: Computational Social Science

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Parallel computing

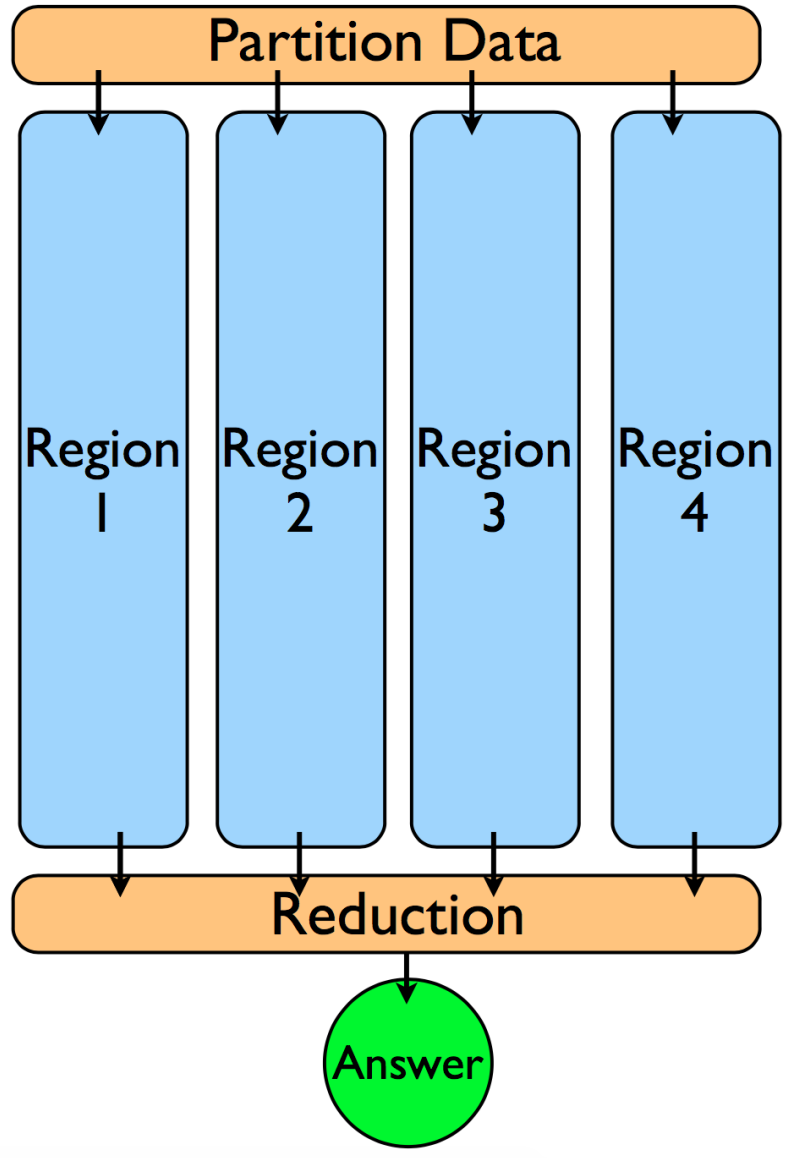
Some hardware terms:

- Node: a single motherboard, with possibly multiple processors
- Processor: silicon containing one or more cores
- Core: unit of computation
- Most modern CPUs (processors) have multiple cores

Logic of parallel computing

Split-apply-combine framework (Hadley Wickham and others):

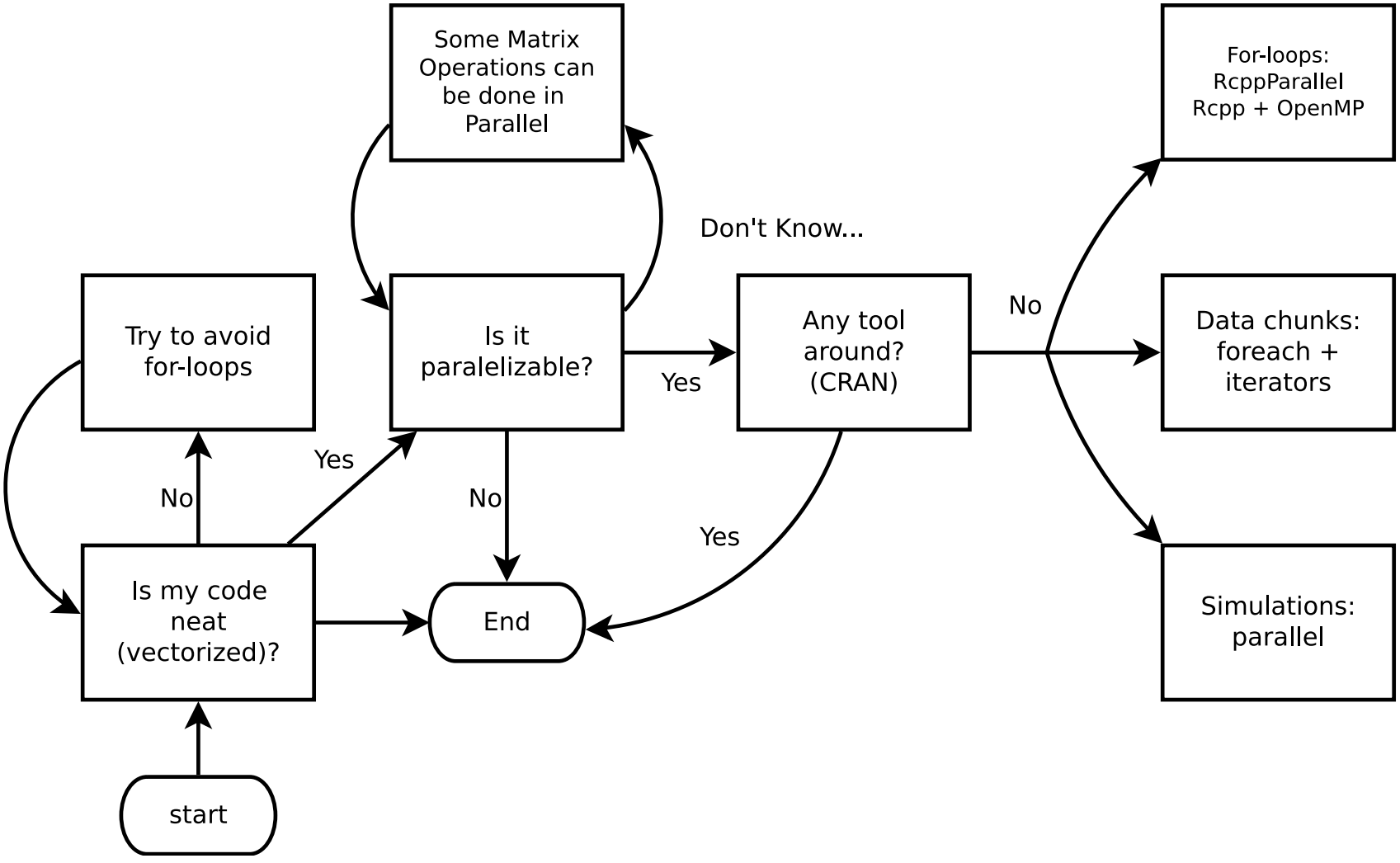
- Split your code and data across multiple nodes/processors/cores
- Apply computation in each region
- Combine the individual results into an aggregate answer



Logic of parallel computing

- BUT: overhead (e.g. splitting and combining data also take some time, no free lunch!)
- Works best with embarrassingly parallel problems:
  - Statistical simulation using multiple seeds
  - Word counts in documents
  - Cross-validation or ensemble learning
  - Rule-of-thumb: can you change the order of the iterations without altering the result?
- Sometimes problematic: applying on subsets of data, or when full dataset is needed in each node
- Not parallelizable: Markov-Chain Monte-Carlo methods, cumulative sums, etc.

Parallel computing



Source: Vega Yon and Garrett Weaver, 2017

Parallel computing in R

Two main approaches:

1. R packages
   - `parallel`: built-in package with support for parallel computation, including random-number generation (good for statistical simulation)
   - `foreach`: new type of loops that supports parallel execution (good for data analysis)
   - `iterators`: tools for iterating over various R data structures (more advanced)
2. Running C++ code in R:
   - `RcppArmadillo`: interact with C++ linear algebra library
   - `OpenMP`: utility to improve multiprocessing using shared memory; works across all platforms

And many others (e.g. Spark, Hadoop, RcppParallel...) we will not cover in this course. See the High-Performance and Parallel Computing Task View

For more: see slides+code by Vega Yon and Garrett Weaver