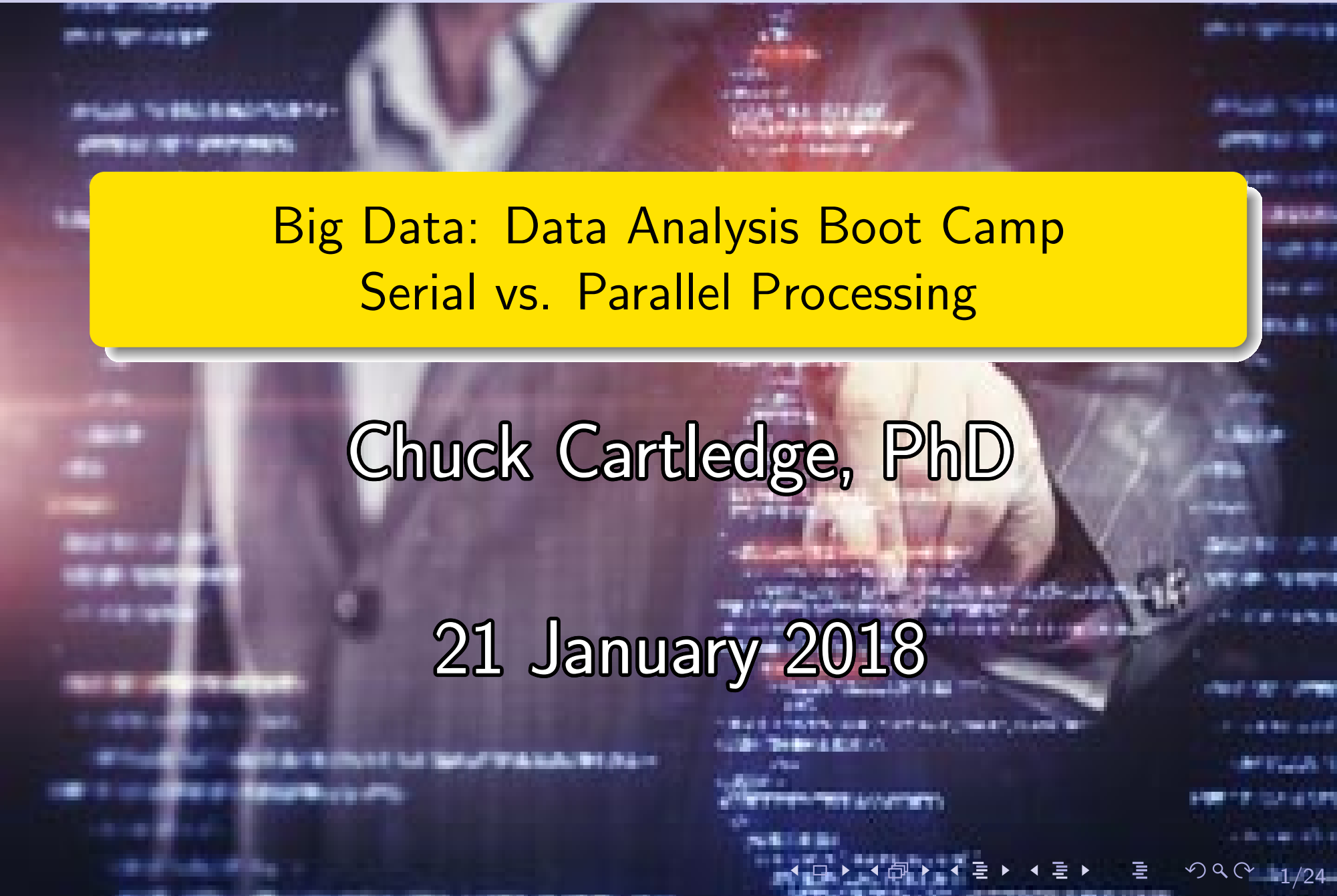

Big Data: Data Analysis Boot Camp
Serial vs. Parallel Processing

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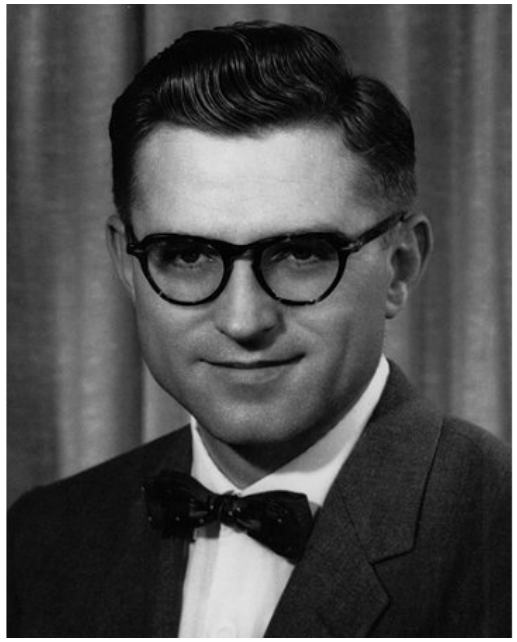
What are we going to cover?

We're going to talk about:

- Why it is important to understand your problem
- What are single and multithreaded programs
- What are different tools, and frameworks to support BD processing
- What languages and programming paradigms fit the BD world

Amdahl's Law [2]

- Time for serial execution $\stackrel{\text{def.}}{=} T(1)$
- Portion that can NOT be paralyzed $\stackrel{\text{def.}}{=} B \in [0, 1]$
- Number of parallel resources $\stackrel{\text{def.}}{=} n$
- $T(n) = T(1) * (B + \frac{1}{n}(1 - B))$
- Speed up $\stackrel{\text{def.}}{=} S(n)$
  $S(n) = \frac{T(1)}{T(n)} = \frac{1}{B + \frac{1}{n}(1 - B)}$

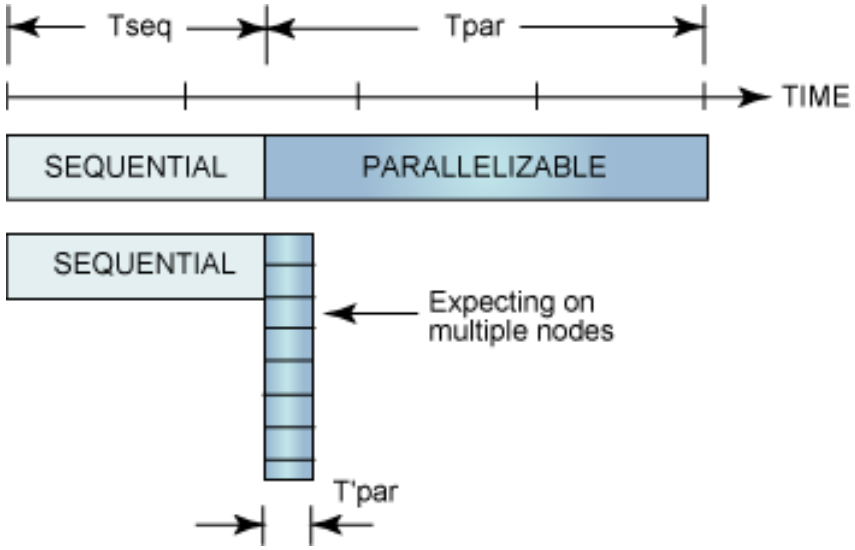


Dr. Gene Amdahl (circa 1960)

Amdahl's Law (A summary)

Division and measurement of serial and parallel operations appears time and again. (Shades of Mandelbrot.)

- "Make the common fast."
- "Make the fast common."
- Understand what parts have to be done serially
- Understand what parts can be done in parallel

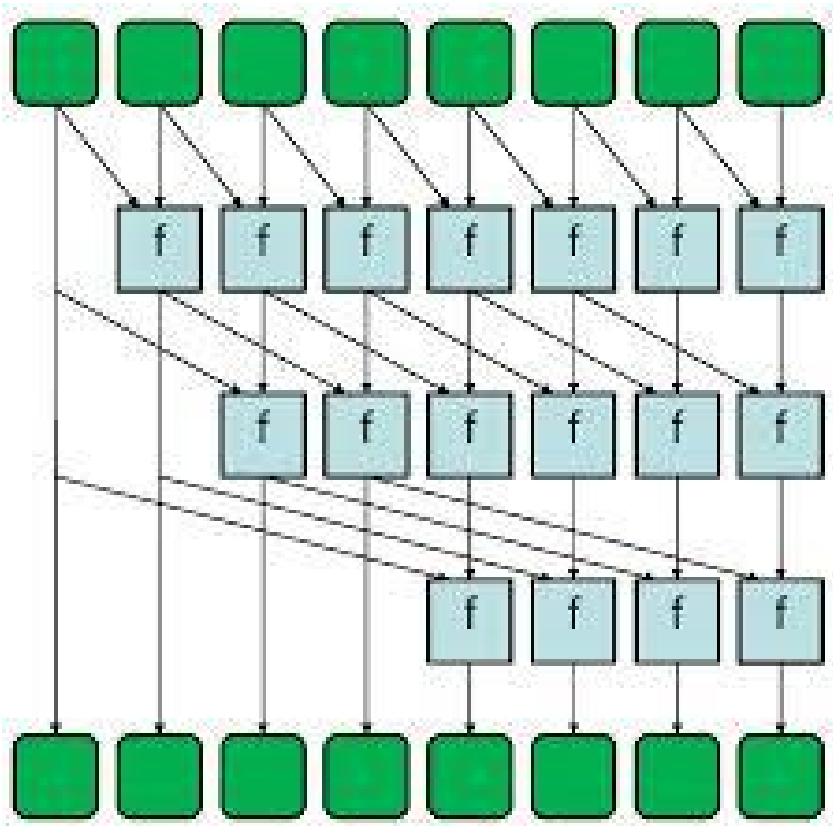


Need to factor in "overhead" costs when computing speed up.

Some questions are easily stated, . . .

Which of these are paralizable (and why)?

1. $a[i] = b[i] + c[i]$
2. $a[i] = f(b)$
3. $a[i] = a[i-1] + b[i-1]$
4. $a = b + c$



Single thread vs. multithreads

- Single-threaded process – has full access to CPU and RAM
- Multithreaded process – shares access to CPU and RAM
- Multithreaded makes sense with independent tasks
- Multithreaded may share the same memory space (language dependent)

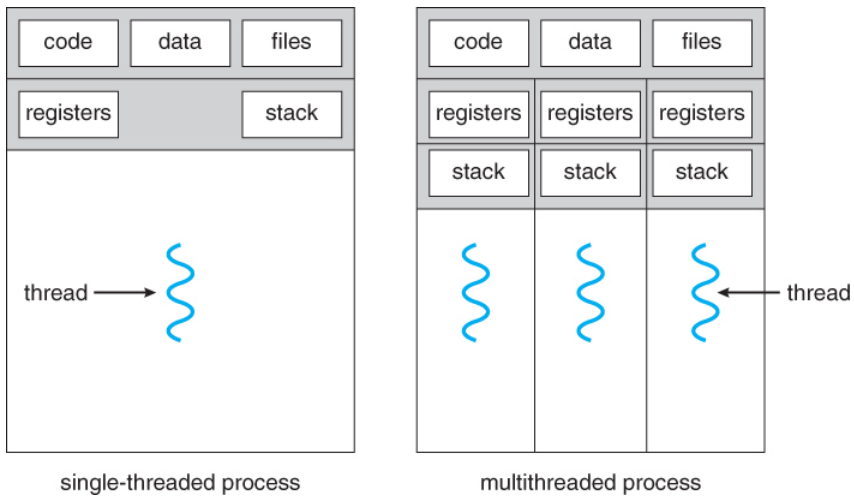


Image from [3].

Coordination across multiple threads can be tricky.

Hadoop multithreading hidden from view.

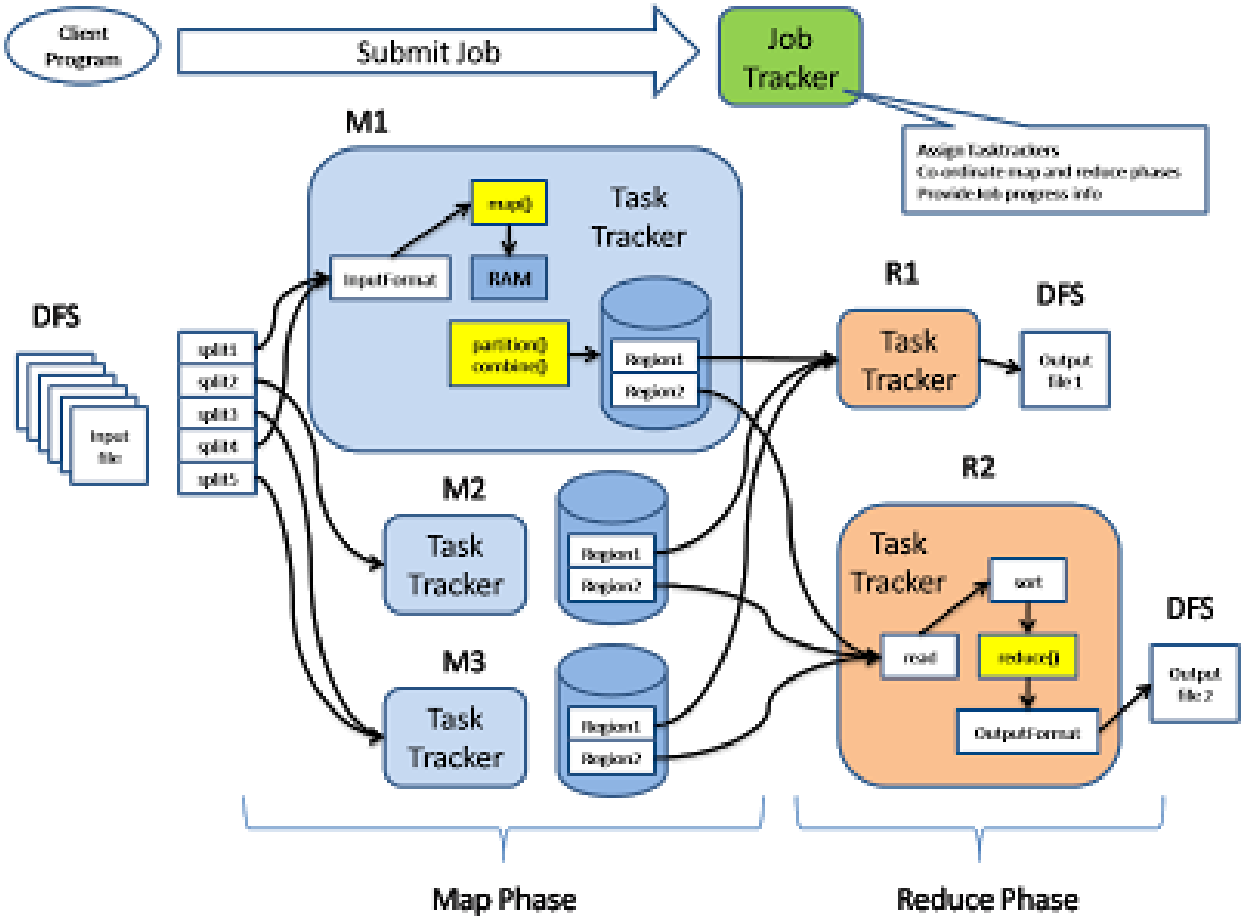


Image from [4].

Vocabulary

- Data Sources – where data comes from
- Ingestion – how data is pre-processed for acceptance
- Data Sea/Lake – where data lives
- Processing – how data is processed prior to storage
- Data warehouse – transition from SQL to NoSQL
- Analysis – extracting information from data
- User interface – how the user interacts with the information

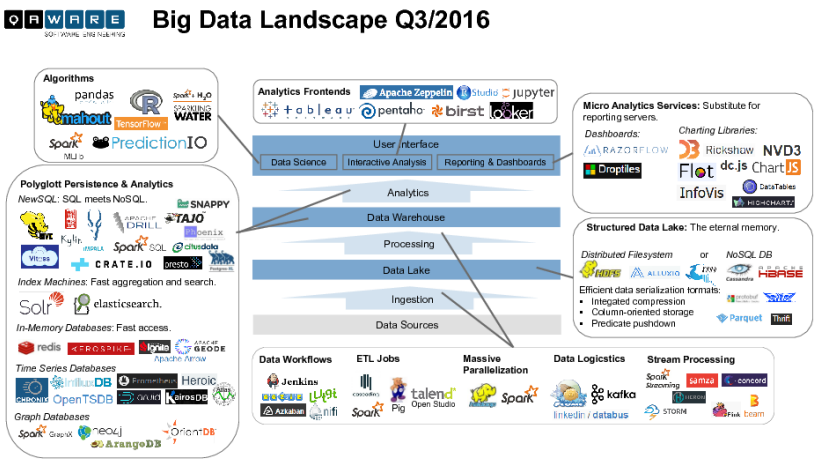


Image from [1].

Same image.

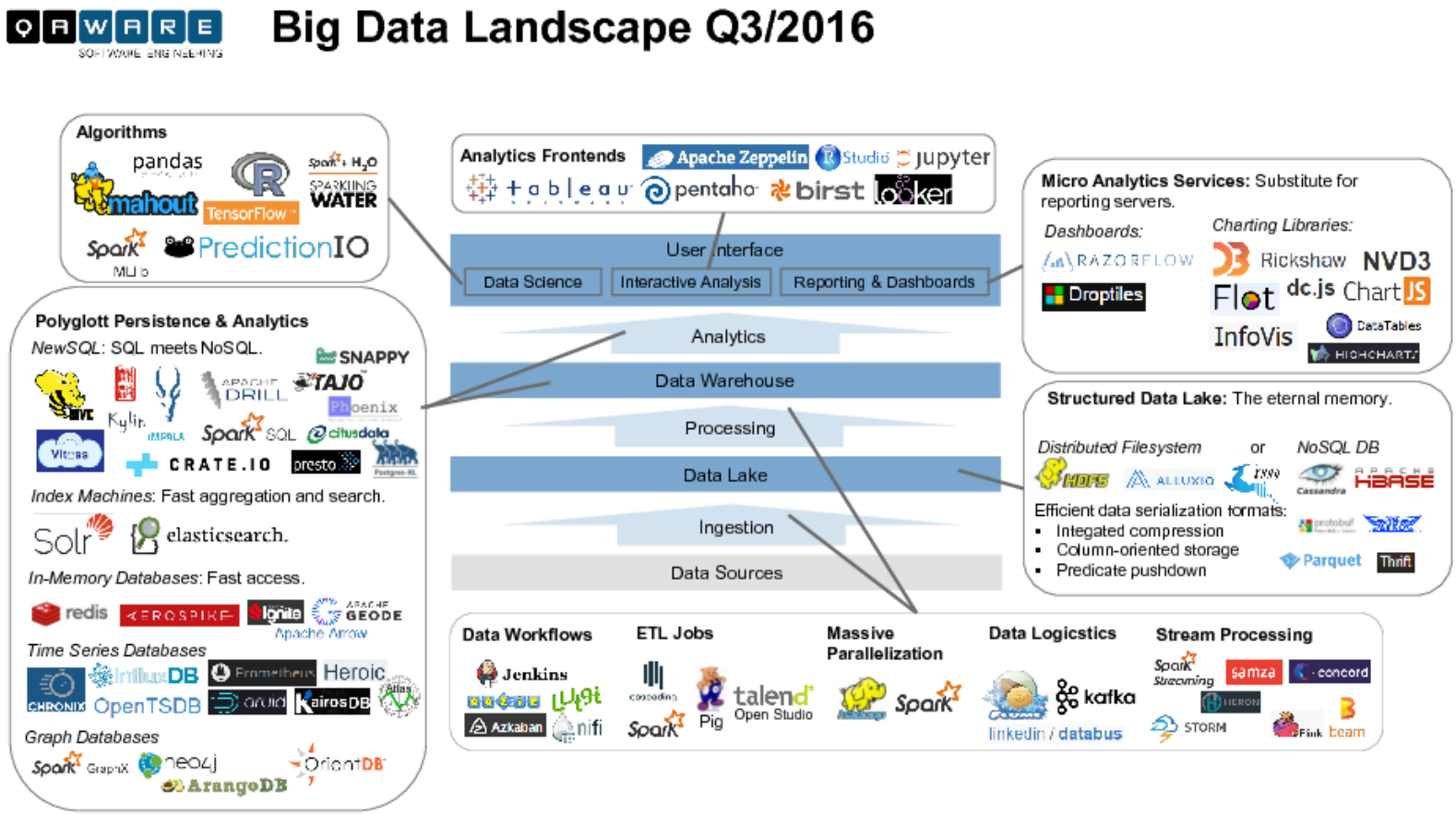


Image from [1].

Another collection of Open Source BD tools

Tools partitioned differently:

- Big Data search
- Business Intelligence
- Data aggregation
- Data Analysis & Platforms
- Databases / Data warehousing
- Data aggregation
- Data Mining
- Document Store
- Graph databases
- Grid Solutions
- In-Memory Computing
- KeyValue
- Multidimensional
- Multimodel
- Multivalue database
- Object databases
- Operational
- Programming
- Social
- XML Databases

Image from [7].

Image from [7].

The reference has links to each piece of software.

Hammer and nails . . .

". . . it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail."

Abraham H. Maslow [6]

Image from [8].

A simple comparison of some languages

Languages are created by people to solve certain types of problems.

- C# – declarative, functional, generic, imperative, object-oriented (class-based)
- Java – client side, compiled, concurrent, curly-bracket, impure, imperative, object-oriented (class-based), procedural, reflective
- Python – compiled, extension, functional, imperative, impure, interactive mode, interpreted, iterative, metaprogramming, object-oriented (class-based), reflective, scripting
- R – array, impure, interpreted, interactive mode, list-based, object-oriented prototype-based, scripting

Categorizations from [9].

Vocabulary (1 of 2)[9].

- array – generalize operations on scalars to apply transparently to vectors, matrices, and higher-dimensional arrays.
- client side – languages are limited by the abilities of the browser or intended client.
- compiled – languages typically processed by compilers, though theoretically any language can be compiled or interpreted.
- concurrent – languages provide language constructs for concurrency.
- curly-bracket – languages have a syntax that defines statement blocks using the curly bracket or brace characters
- declarative – languages describe a problem rather than defining a solution.
- extension – languages embedded into another program and used to harness its features in extension scripts.
- functional – languages define programs and subroutines as mathematical functions.
- generic – language is applicable to many domains.
- imperative – languages may be multi-paradigm and appear in other classifications.
- impure – languages containing imperative features.
- interactive mode – languages act as a kind of shell

Vocabulary (2 of 2)[9].

- interpreted – languages are programming languages in which programs may be executed from source code form, by an interpreter.
- iterative – languages are built around or offering generators.
- list-based – languages are a type of data-structured language that are based upon the list data structure.
- metaprogramming – that write or manipulate other programs (or themselves) as their data or that do part of the work that is otherwise done at run time during compile time.
- object-oriented (class-based) – support objects defined by their class.
- object-oriented prototype-based – languages are object-oriented languages where the distinction between classes and instances has been removed
- procedural – languages are based on the concept of the unit and scope
- reflective – languages let programs examine and possibly modify their high level structure at runtime.
- scripting – another term for interpreted

Each reflects/supports a programming paradigm

A plethora of programming paradigms:

- Action
- Agent-oriented
- Automata-based
- Concurrent
- Data-driven
- Declarative
- Functional
- Dynamic
- Event-driven
- Generic
- Imperative
- Language-oriented
- Parallel
- Semantic
- Structured

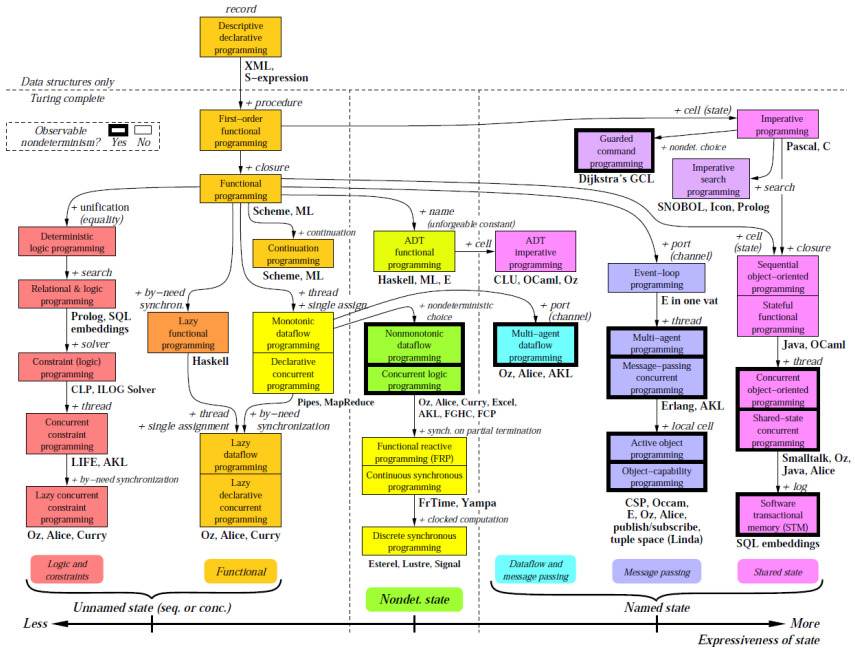


Image from [10].

Each paradigm is a result of a problem domain.

Each is different for a reason

Same image.

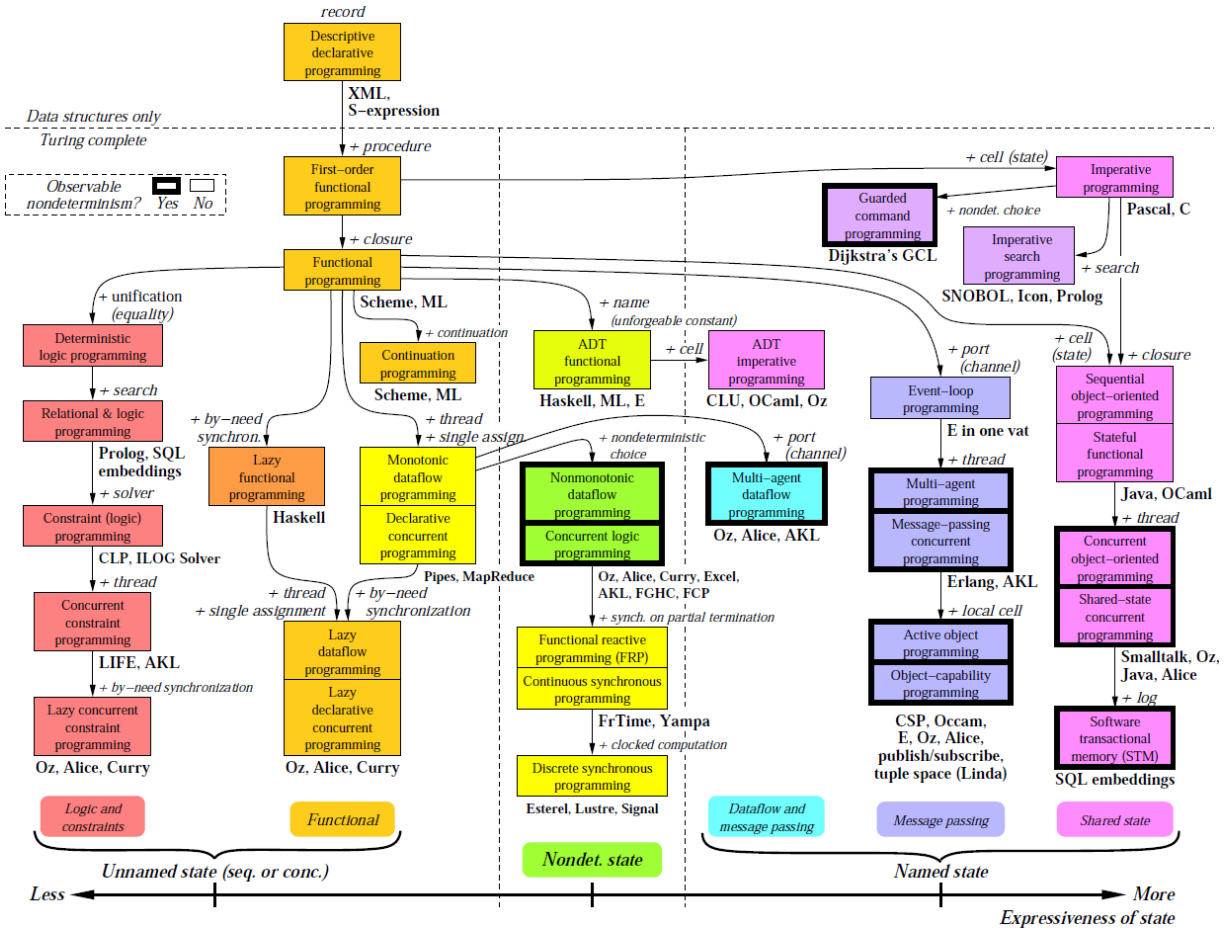


Image from [10].

What does the future hold?

> *"If languages are not defined by taxonomies, how are they constructed? They are aggregations of features. Rather than study extant languages as a whole, which conflates the essential with the accidental, it is more instructive to decompose them into constituent features, which in turn can be studied individually. The student then has a toolkit of features that they can re-compose per their needs."*
>
> *S. Krishnamurthi [5]*

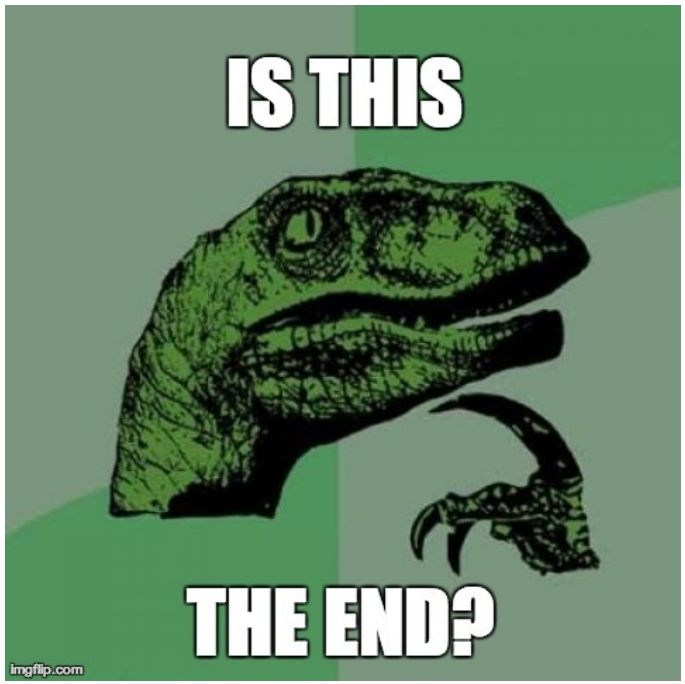
New languages will be created all the time to fit needs.

Q & A time.

"Never attempt to teach a pig to sing; it wastes your time and annoys the pig."
Robert A. Heinlein, Time Enough for Love

What have we covered?

- The importance of understanding your problem
- The importance of knowing the limitations of your tools
- The importance of understanding marketing hype



Next: BDAR Chapter 3, unleashing R

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