

Comp 311

Functional Programming

Nick Vrvilo, Two Sigma Investments
Robert “Corky” Cartwright, Rice University

About the Course

Course Overview

- An Introduction to Functional Programming
- Lectures: Tuesdays and Thursdays 4pm–5:15pm
- Office hours:
 - Corky (Duncan Hall 3104):
 - Monday–Friday, 8:30am–9:30am
 - Monday/Wednesday/Friday, 11:00am–12:00pm
 - Nick: Tuesdays & Thursdays, immediately after class

Course Mechanics

- Course website: <https://comp311.rice.edu>
 - Syllabus and lectures posted here
 - Lecture topics are subject to change
- Piazza: <https://piazza.com/rice/fall2019/comp311/home>
 - Course announcements and Q&A forum
 - Homework assignments and practice exams posted here

Course Overview

- No required textbook
 - We will draw from a variety of sources
- Coursework consists primarily of biweekly homework assignments
 - Make sure you do these!
 - Missing even one assignment will significantly impact your grade

Homework Assignments

- Think of the assignments in this class as short essays
- Focus as much on style as you would for an essay
- 50% of a homework grade is based on clarity and style
- 50% on correctness

Homework Assignments

- Projects are due two weeks after being assigned.
- There will be no “slip days” or other late policy. The assignments are due when they are due.
- If you have a serious conflict with the course schedule, please contact the instructors *before* the assignment due date to make arrangements.
- Aiming for roughly 10 hours of coursework per week.
- Block this time off now. Make a priority of respecting it.

Homework Assignments

- Assignments are published on Thursdays.
- Start on assignments early so that you have time to ask questions in class, on Piazza, and at office hours.

Homework Assignments

- Assignments will be programming exercises in Scala.
- We will cover the parts of Scala needed for the assignments in class.

Homework Assignments

- You have the option of DrScala and IntelliJ IDEA for assignments. DrScala is less professional but better supported.
 - Installed on all Rice systems and available for download from the course website.
- We will use SVN (turnin on CLEAR) for all assignments.
 - Instructions on the course website:
<https://wiki.rice.edu/confluence/display/FPSCALA/Homework+Submission+Guide>

What is Functional Programming?

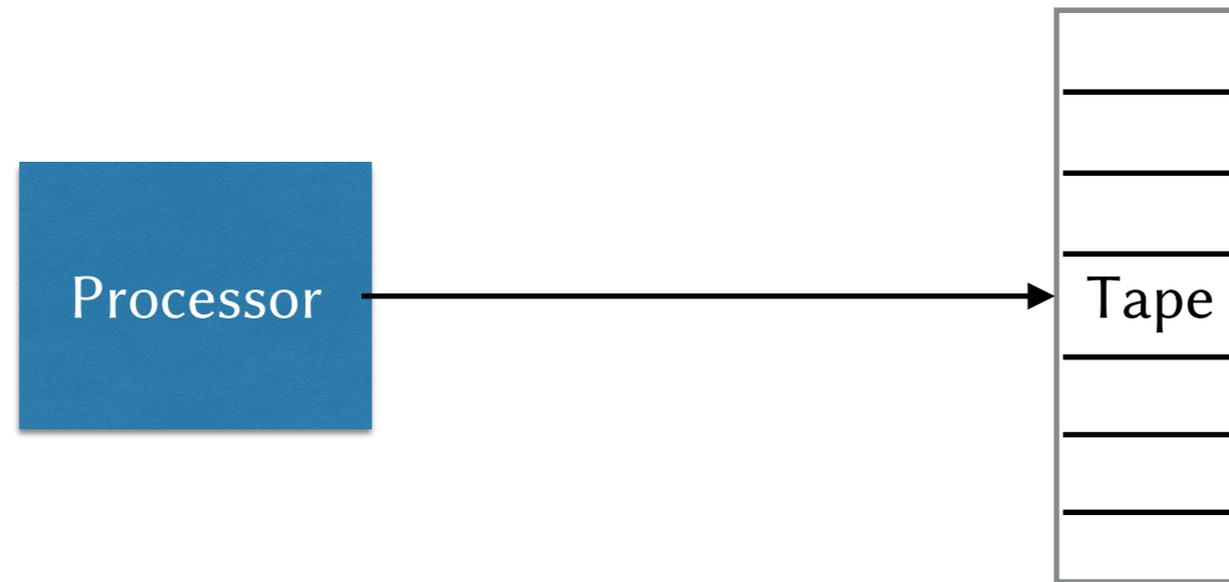
Early Models of Computation

- Turing Machines (Turing)
- Type-0 Grammars (Chomsky)
- The Lambda Calculus (Church)
- ... *and many others*

Early Models of Computation

- Turing Machines (Turing)
- Type-0 Grammars (Chomsky)
- The Lambda Calculus (Church)
- ... *and many others*
- To the surprise of their inventors, all of these systems turned out to be equivalent in expressive power.
- Suggests there is a deeper structure to the nature of computation.

Turing Machines



- Processor is a finite state machine that loads and stores *memory cells*.
- Turing coined the term “compute” and introduced the notion of storage.
- Many programs, languages, and computer architectures are heavily influenced by this model (and its derivatives: Von Neumann, etc.) .

Early Models of Computation

- Turing Machines (Turing)
- Type-0 Grammars (Chomsky)
- **The Lambda Calculus (Church)**
- *... and many others*
- To the surprise of their inventors, all of these systems turned out to be equivalent in expressive power.
- Suggests there is a deeper structure to the nature of computation.

The Lambda Calculus

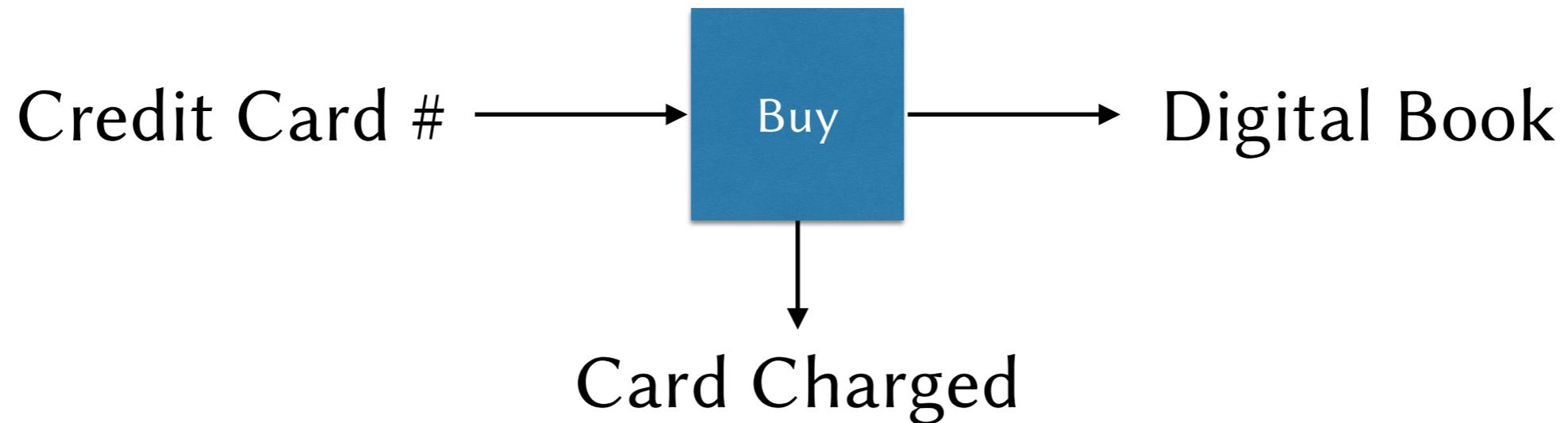
- *A calculus* consists of a set of rules for rewriting symbols
- An attempt to rebuild all of mathematics on the notion of *functions* and *applications*
- There is no mutation in the lambda calculus
- Every program consists solely of applications of functions to arguments (which are also functions)
- Applications of functions return values (which are also functions)

What is Functional Programming?

A style of programming inspired by the Lambda Calculus as a foundational model of computation.

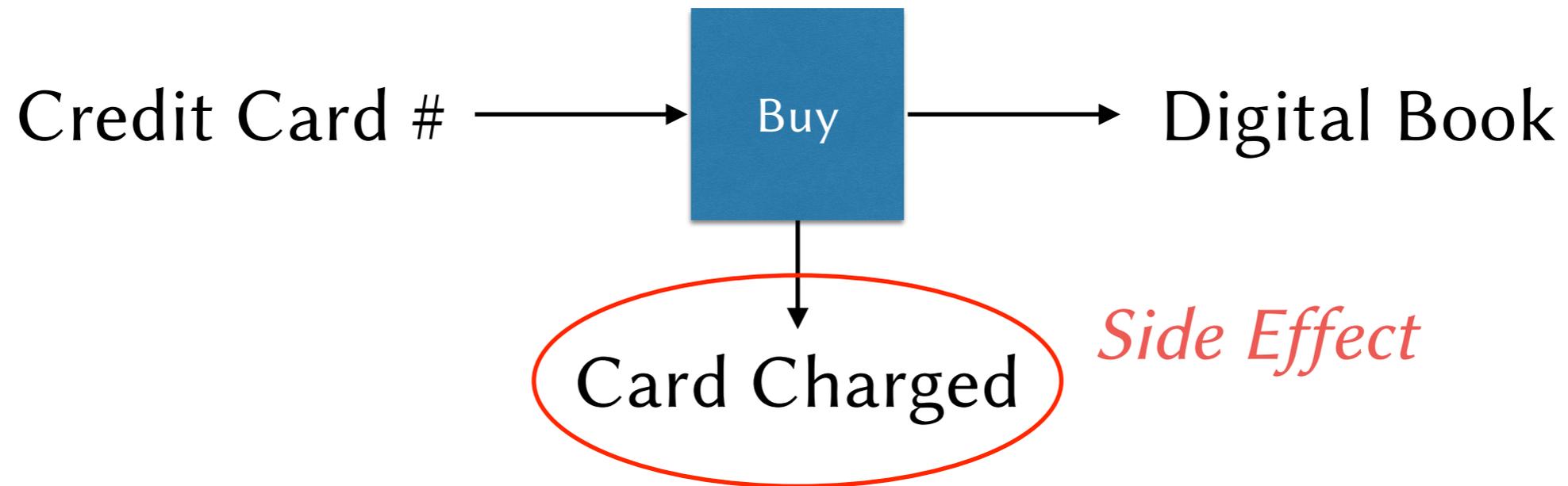
What is Functional Programming?

- A style of programming that avoids side effects



What is Functional Programming?

- A style of programming that avoids side effects



What is Functional Programming?

- A style of programming that avoids side effects



- All results of a computation are sent as output

Why Avoid Side Effects?

- **Programs are easier to write:** There are fewer interactions between program components, enabling multiple programmers (or a single programmer on multiple days) to work together more easily
- **Programs are easier to read:** Pieces of a program can be read and understood in isolation
- **Programs are easier to test:** Less context needs to be built up before calling a function to test it
- **Programs are easier to debug:** Problems can be isolated more easily, and behavior is inherently deterministic
- **Programs are easier to reason about:** The model of computation needed to understand a program without mutation is much simpler

Why Avoid Side Effects?

- **Programs are easier to execute in parallel:** Because separate pieces of a computation do not interact, it is easy to compute them on separate processors
- This is an increasingly important consideration in the era of multicore chips, big data, and distributing computing
 - *This advantage undermines an often cited argument for mutation (efficiency)*

What is Functional Programming?

- A style of programming that emphasizes functions as the basis of computation
 - Functions are applied to arguments
 - Functions are passed as arguments to other functions
 - Functions are returned as values of applications

Why Emphasize Functions?

- Functions allow us to factor out common code
 - DRY: Don't Repeat Yourself
 - Why is this important?
 - Passing functions as arguments is often the most straightforward way to abide by DRY
 - Returning functions as values is also important for DRY

Why Emphasize Functions?

- Functions allow us to concisely package computations and move them from one control point to another
- Aids us with implementing and reasoning about parallel and distributed programming (yet again)

A Word on Object-Oriented Programming

- There is no tension between functional and object-oriented programming. In fact, OOP can be cast as an enrichment of FP.

<https://www.cs.rice.edu/~javaplt/papers/OOPEnrichesFP.pdf>

- In many ways, they complement one another
- Scala was designed to integrate both styles of programming