Introduction to Software Engineering

CMPT 276 - D300

Today’s Agenda

- What is software engineering?
  - Software engineering vs programming

- Why is it difficult?
  - How Committees Invent
  - Programming as Theory-Building

- Why is it worth studying?
  - To build a career
  - To learn how to solve problems in any domain
  - To help the world

Software Engineering

Software Engineering

- Programming?

Software Engineering

- Programming?
  - The act of writing a computer program

Software Engineering

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  - The act of writing a computer program

NO

Software Engineering

⬆

Software Engineering

- The application of mathematics or systematic knowledge beyond the routine skills of practise, for the design of any complex system which performs useful functions
  - GNU version of the Collaborative International Dictionary of English

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complex **software** systems

Software Engineering

- Software engineering encompasses the
  - design
  - implementation
  - deployment
  - and maintenance

  of software, in order to achieve tangible outcomes

Software Engineering

- “I want to schedule waiters in my restaurant”

Software Engineering

- “I want to schedule waiters in my restaurant”
  - Determine requirements:
    - how many waiters?
    - what kind of coverage do you need?
    - what happens if someone is sick?
    - how many hours per day/week can each waiter work?
    - does seniority matter?
    - how often will the scheduler need to run?
    - where will the code execute?
    - what kind of interface do you need?
    - how secure does this thing need to be?

Software Engineering

- “I want to schedule waiters in my restaurant”
  - Make design decisions:
    - what programming language?
    - what execution environment?
    - what architecture/data structures?
    - what scheduling algorithm?
    - how will the user interface look and behave?

Software Engineering

- “I want to schedule waiters in my restaurant”
    - Actually implement the thing

Software Engineering

- “I want to schedule waiters in my restaurant”
  - Actually implement the thing
  - Fix inevitable bugs

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  - Address miscommunication of requirements

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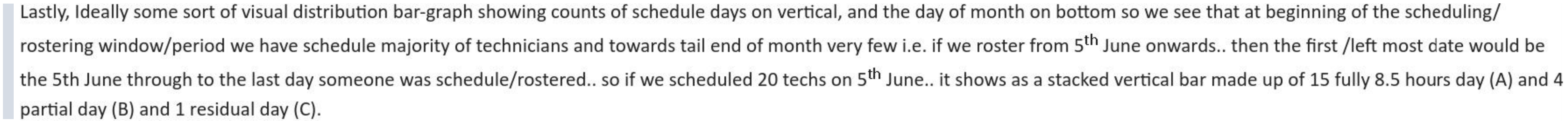
Software Engineering



> Lastly, Ideally some sort of visual distribution bar-graph showing counts of schedule days on vertical, and the day of month on bottom so we see that at beginning of the scheduling/ rostering window/period we have schedule majority of technicians and towards tail end of month very few i.e. if we roster from 5th June onwards.. then the first /left most date would be the 5th June through to the last day someone was schedule/rostered.. so if we scheduled 20 techs on 5th June.. it shows as a stacked vertical bar made up of 15 fully 8.5 hours day (A) and 4 partial day (B) and 1 residual day (C).

Software Engineering

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    - Actually implement the thing
    - Fix inevitable bugs
    - Address miscommunication of requirements
    - Address new requirements
    - Deploy the thing

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- Software engineering encompasses the
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  - and maintenance → ownership

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Why is software engineering difficult?

Software Engineering

- COMPLEXITY

Software Engineering

- **COMPLEXITY**
  - Where does it come from?

Software Engineering

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- Tons of theories on how complexity is introduced, why, and methods to prevent it

Software Engineering

- **COMPLEXITY**
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- Tons of theories on how complexity is introduced, why, and methods to prevent it

- But complexity is inevitable

Software Engineering

- **COMPLEXITY**
  - Where does it come from?

Essential

Complexities of the domain and requirements

E.g., business logic for scheduling waiters is complicated, with many dependencies, rules, and exceptions to rules

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Accidental

Complexities arising from translating requirements into software

E.g., interfaces of objects in your system and in other libraries you use are complicated

Software Engineering

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Essential

Complexities of the domain and requirements

E.g., busine
sched
complica
depe
exceptio

Bounds on human cognition

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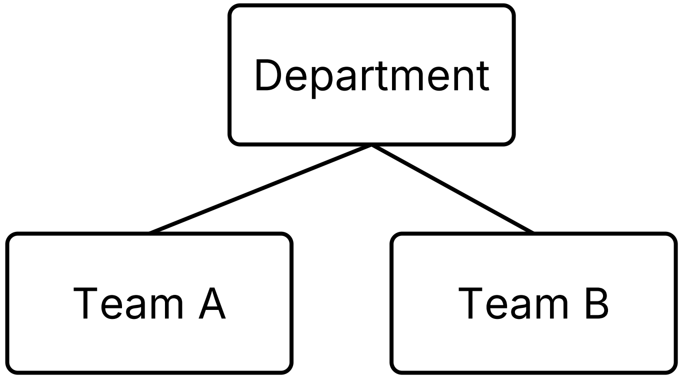

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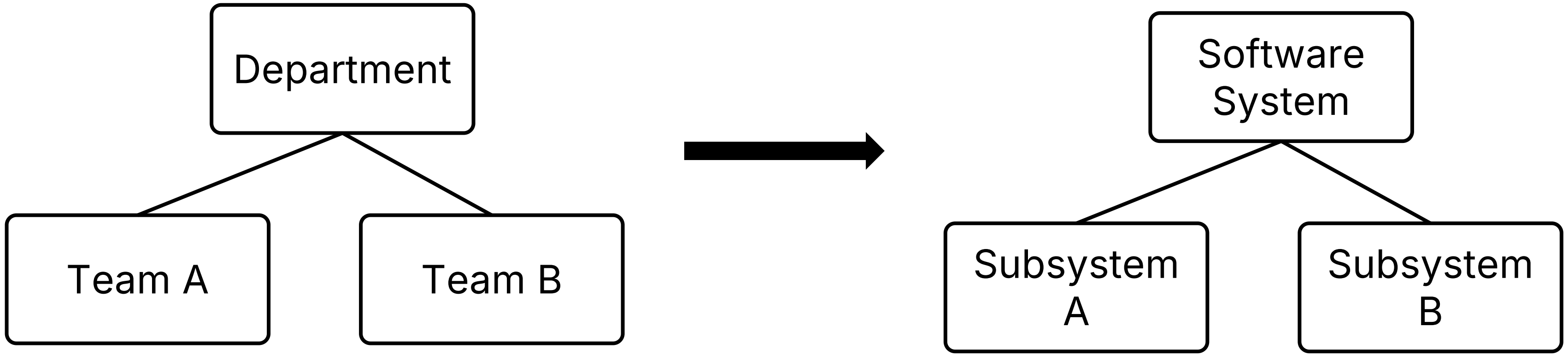

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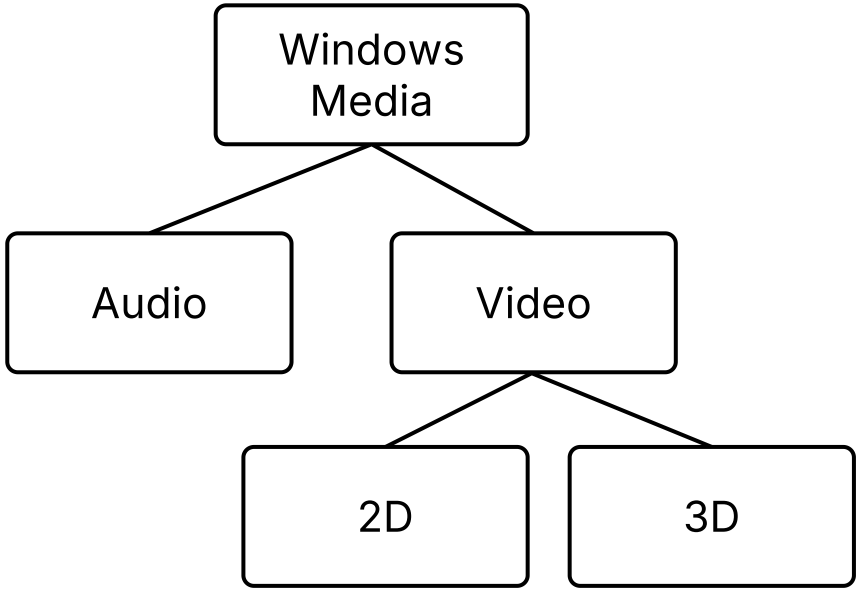

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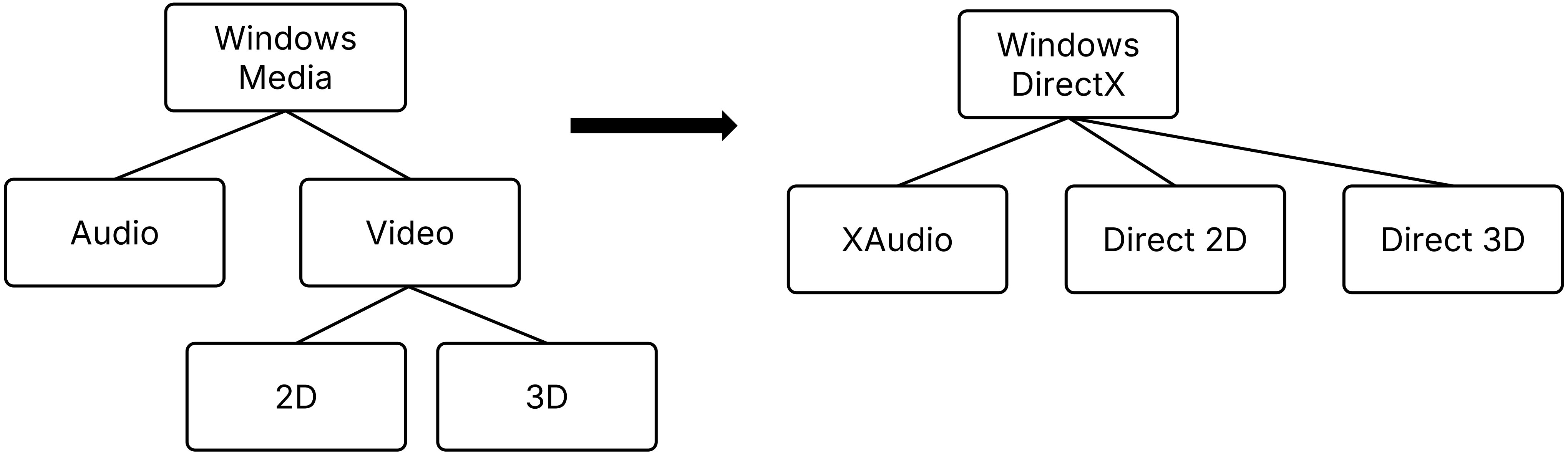

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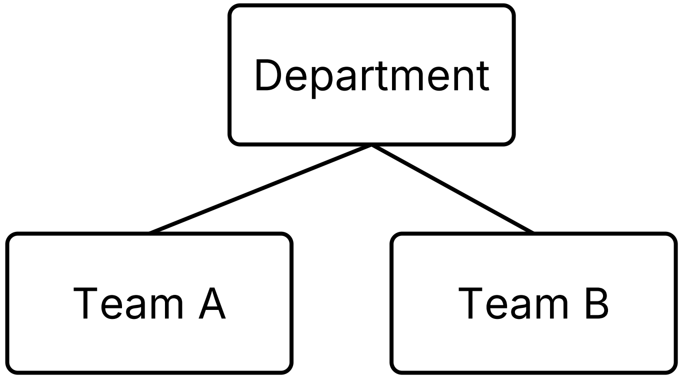

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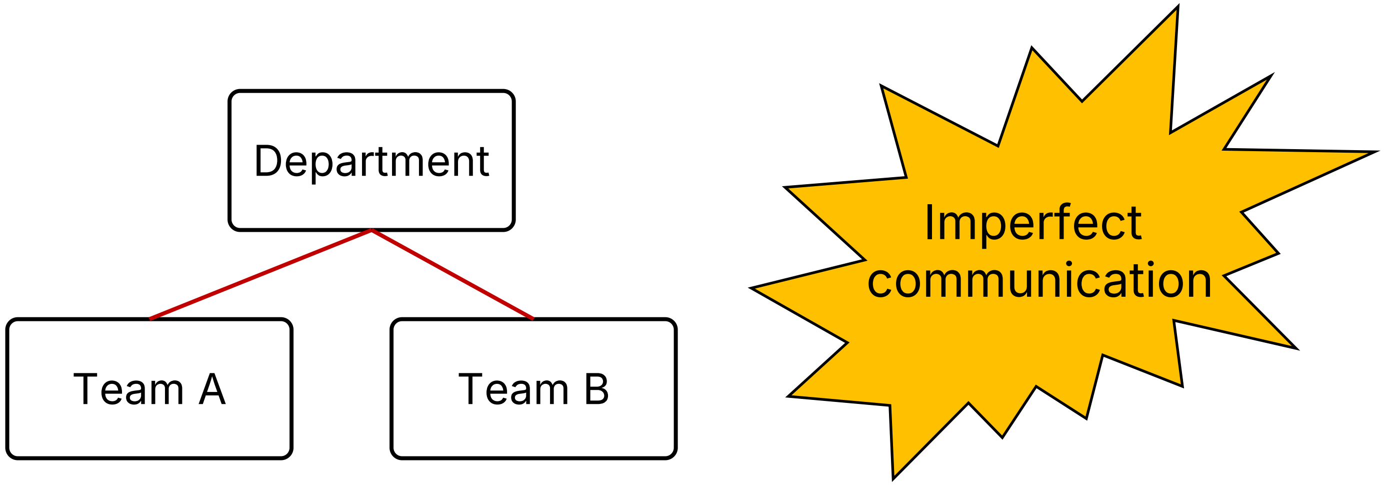

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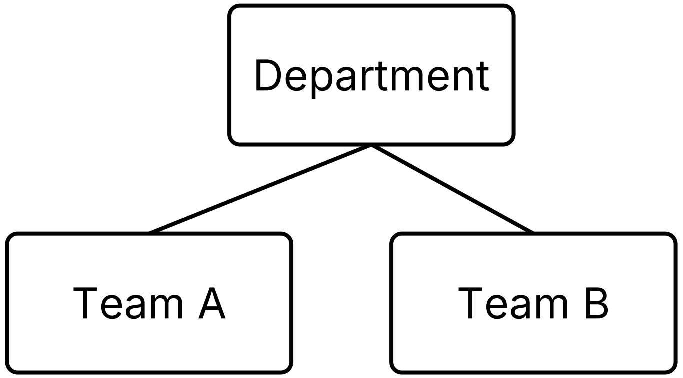

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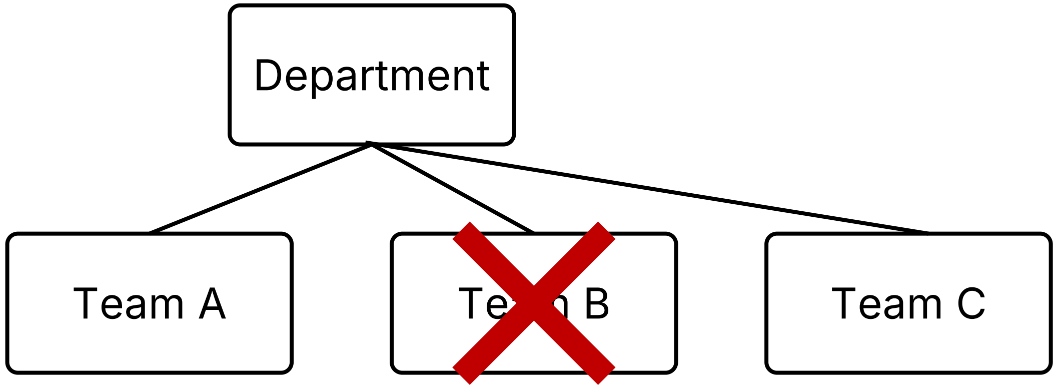

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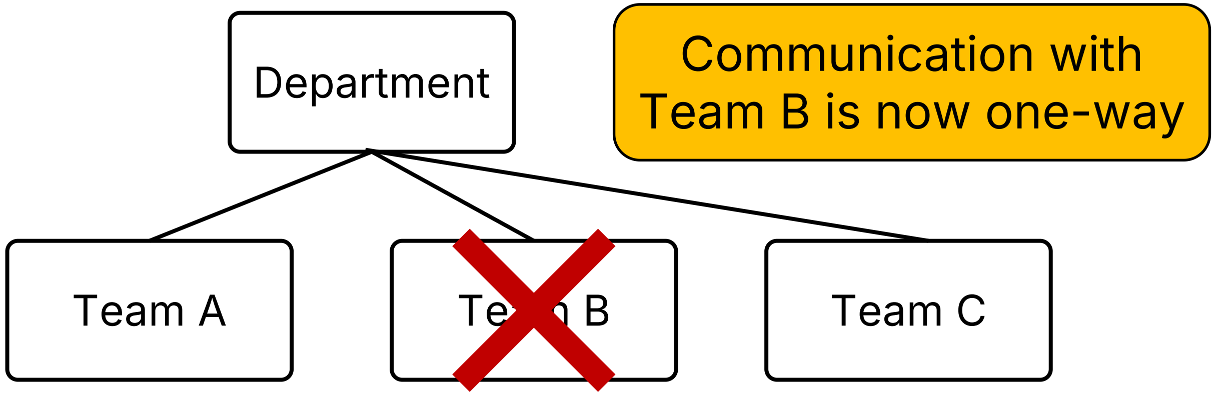

Communication with Team B is now one-way

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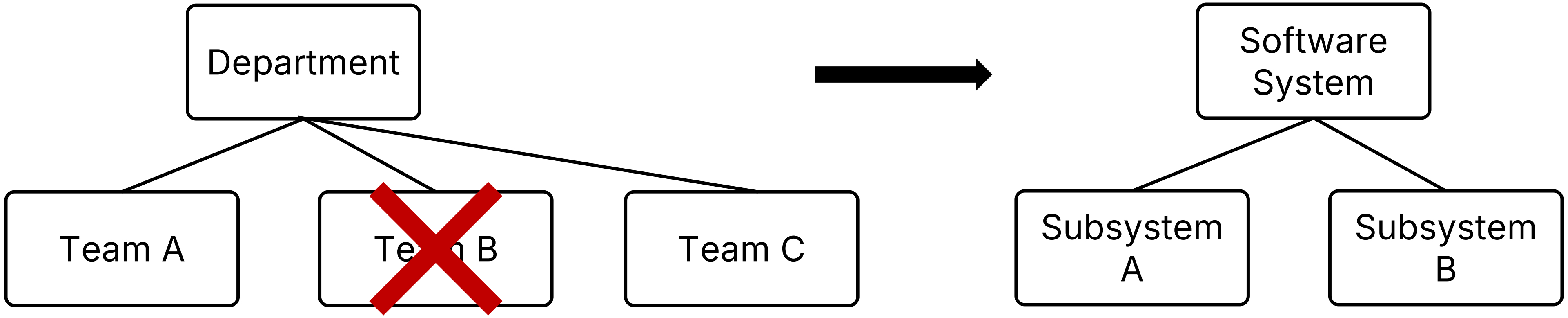

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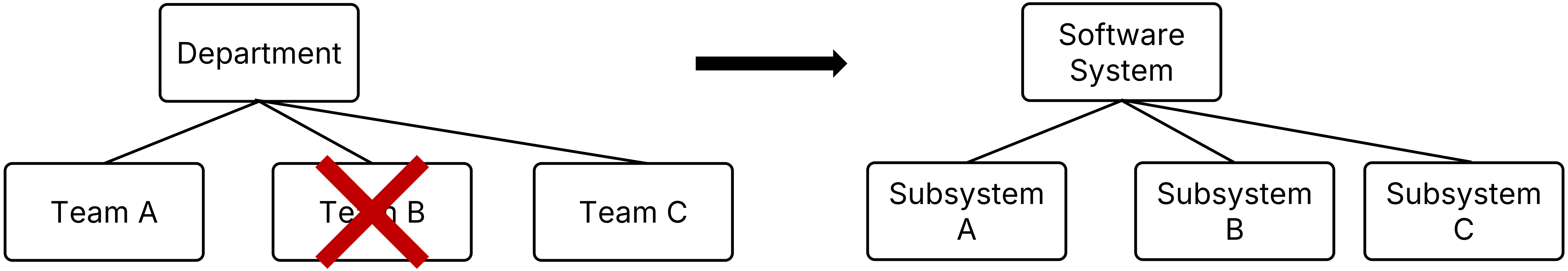

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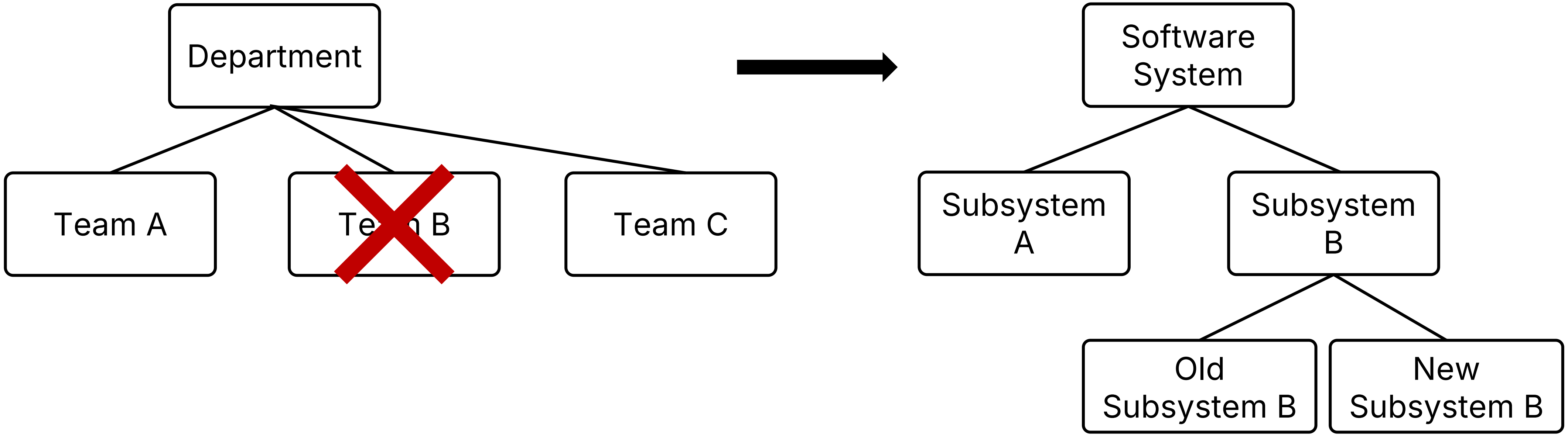

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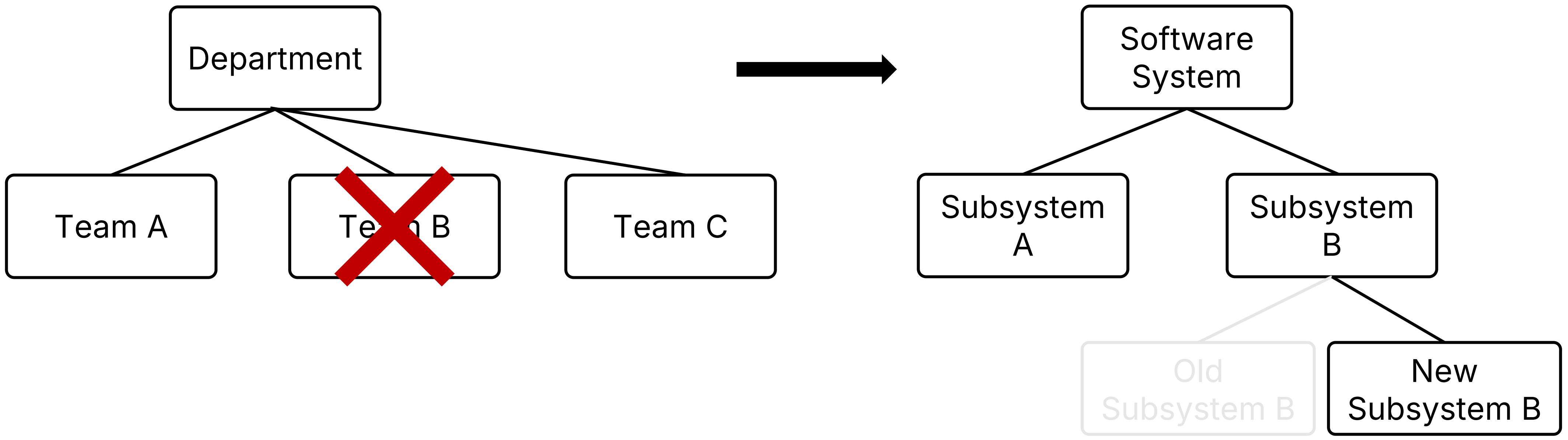

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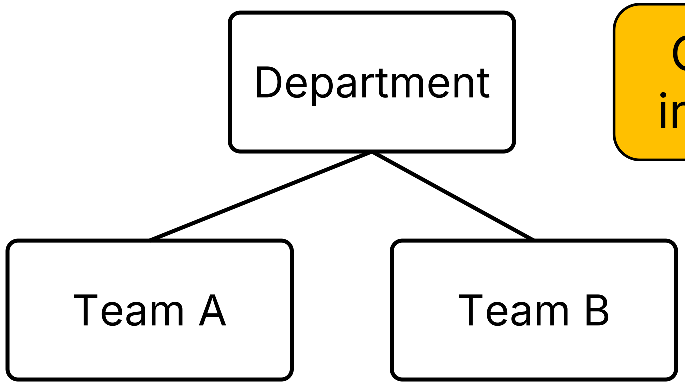

Change in personnel: increase in complexity

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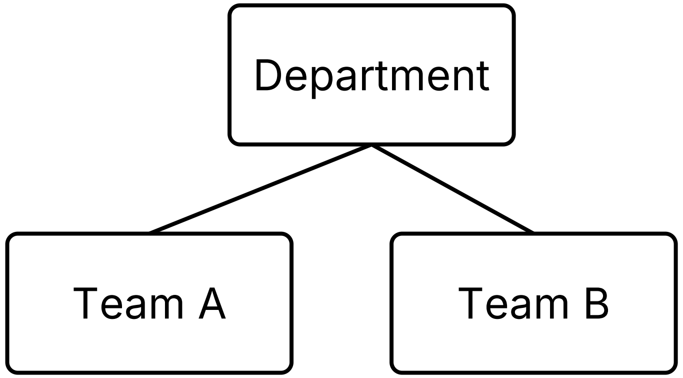

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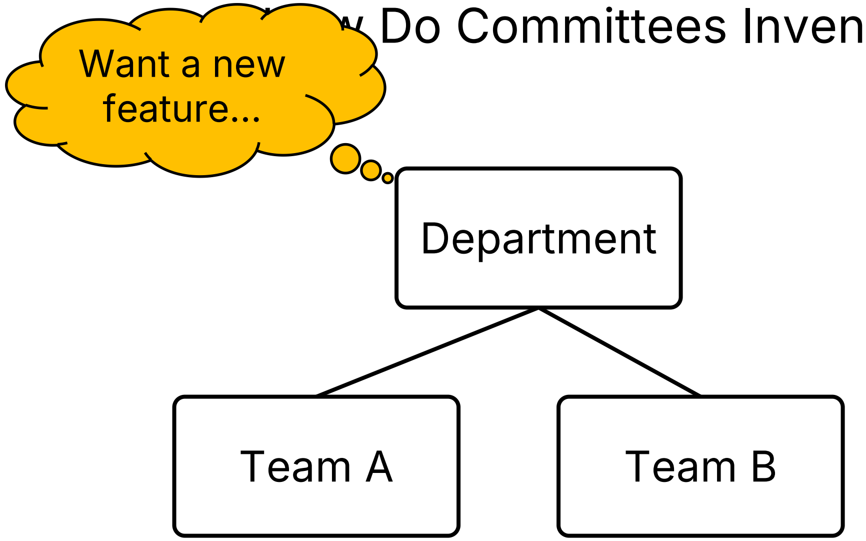

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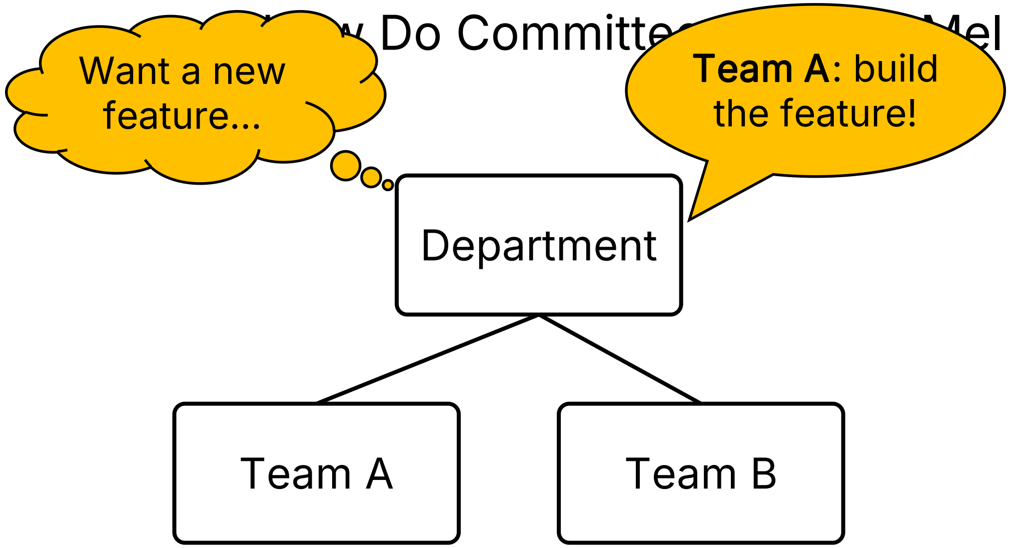

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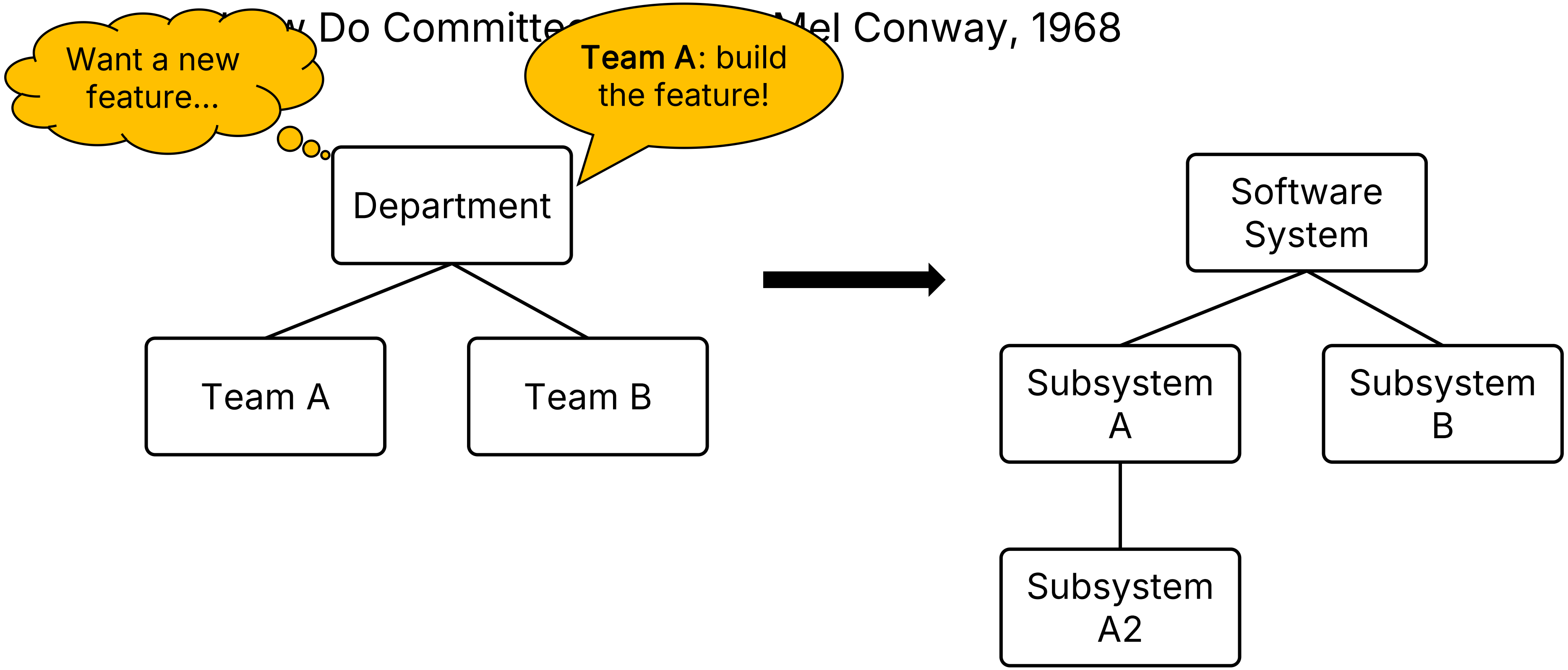

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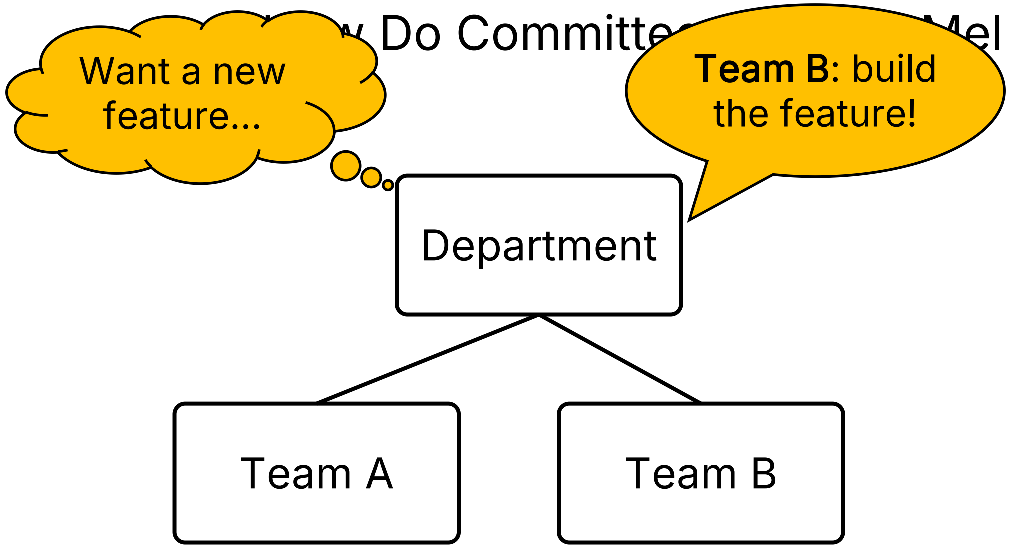

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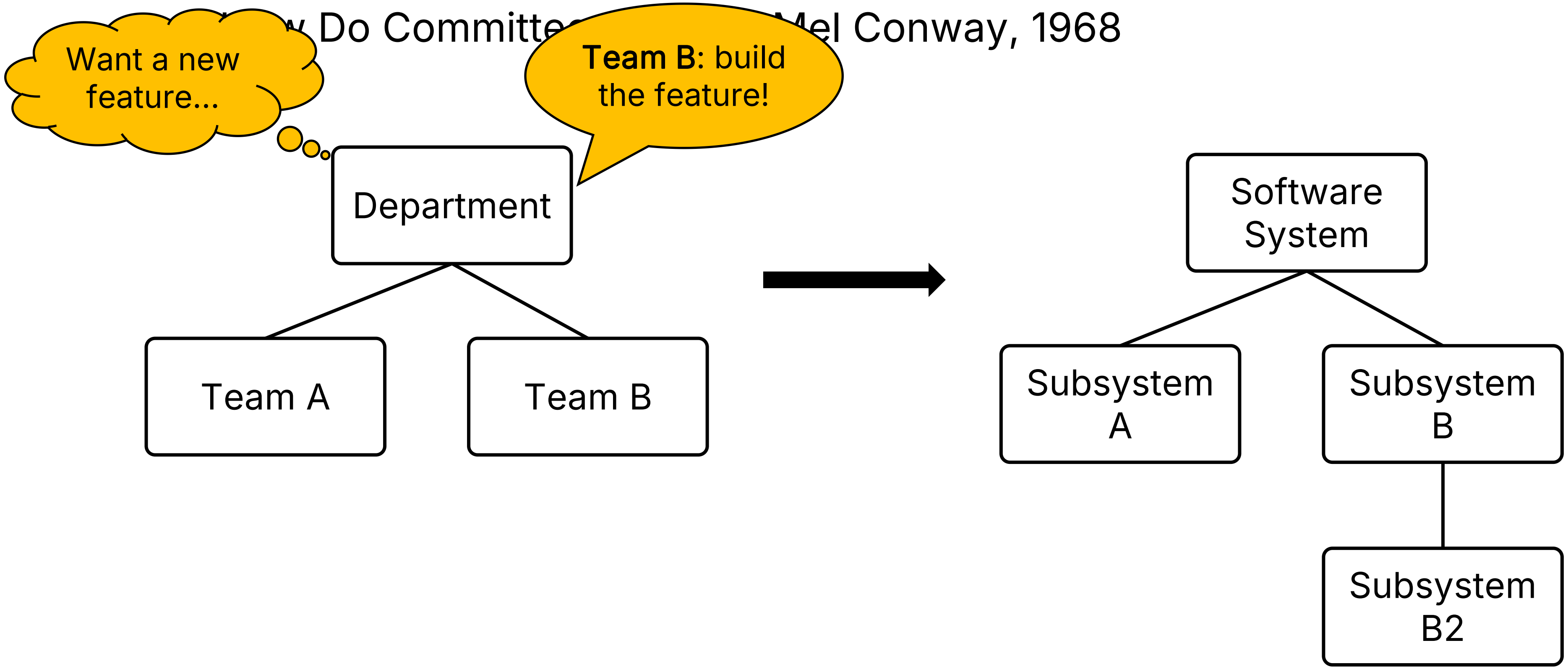

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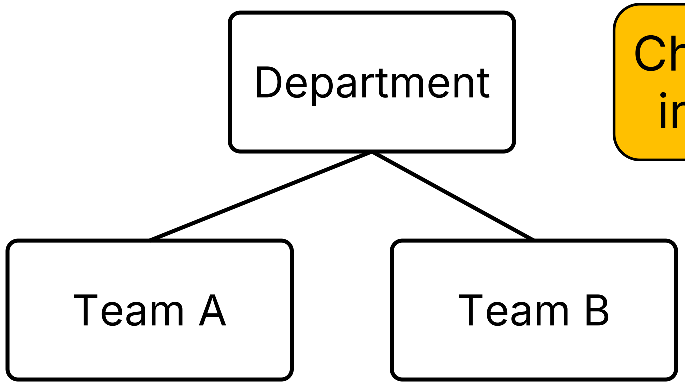

Change in requirements: increase in complexity

Software Engineering

- Maintenance is forever

Software Engineering

- Maintenance is forever
    - Requirements will grow

Software Engineering

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  - “Owners” of the codebase change

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Increase in complexity

Quick Break

Programming as Theory-Building

- “…programming properly should be regarded as an activity by which the programmers form or achieve a certain kind of insight, a theory, of the matters at hand. This suggestion is in contrast to what appears to be a more common notion, that programming should be regarded as a production of a program and certain other texts.”
    - Programming as Theory-Building, Peter Naur (of Backus-Naur fame), 1985

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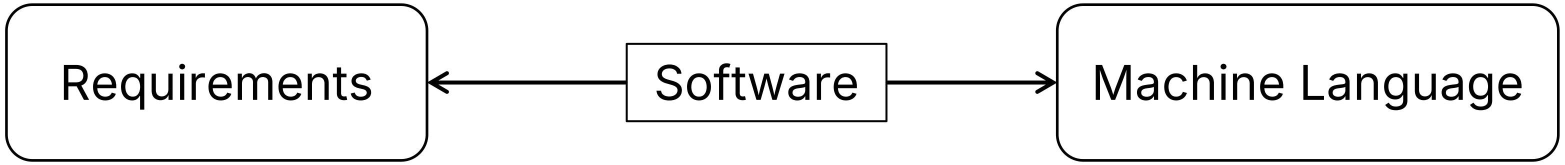
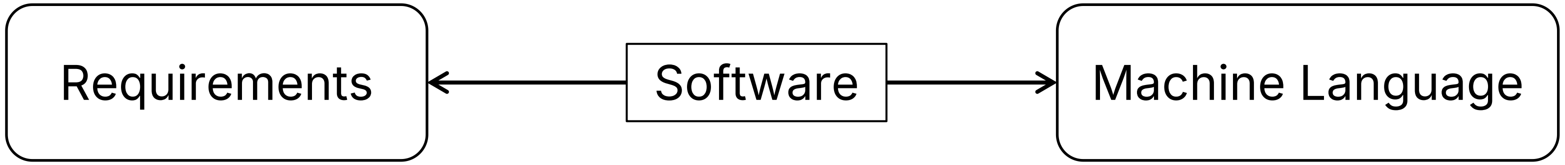
- Code communicates your understanding of the mapping between requirements and the programming constructs available to you

Programming as Theory-Building

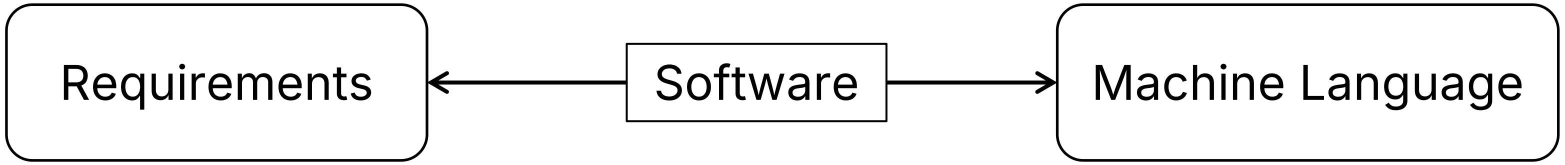


Programming as Theory-Building



“Find students
who share classes”

Programming as Theory-Building



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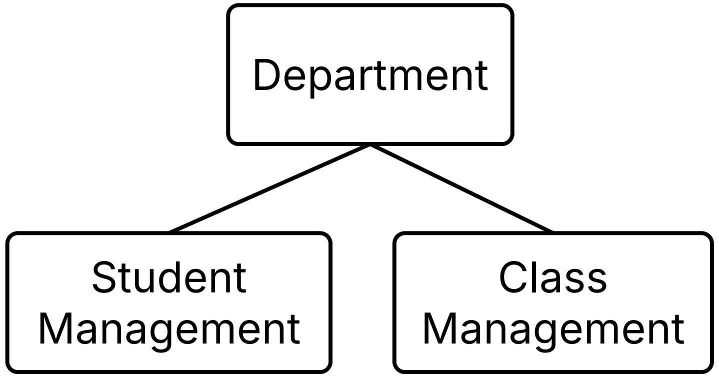

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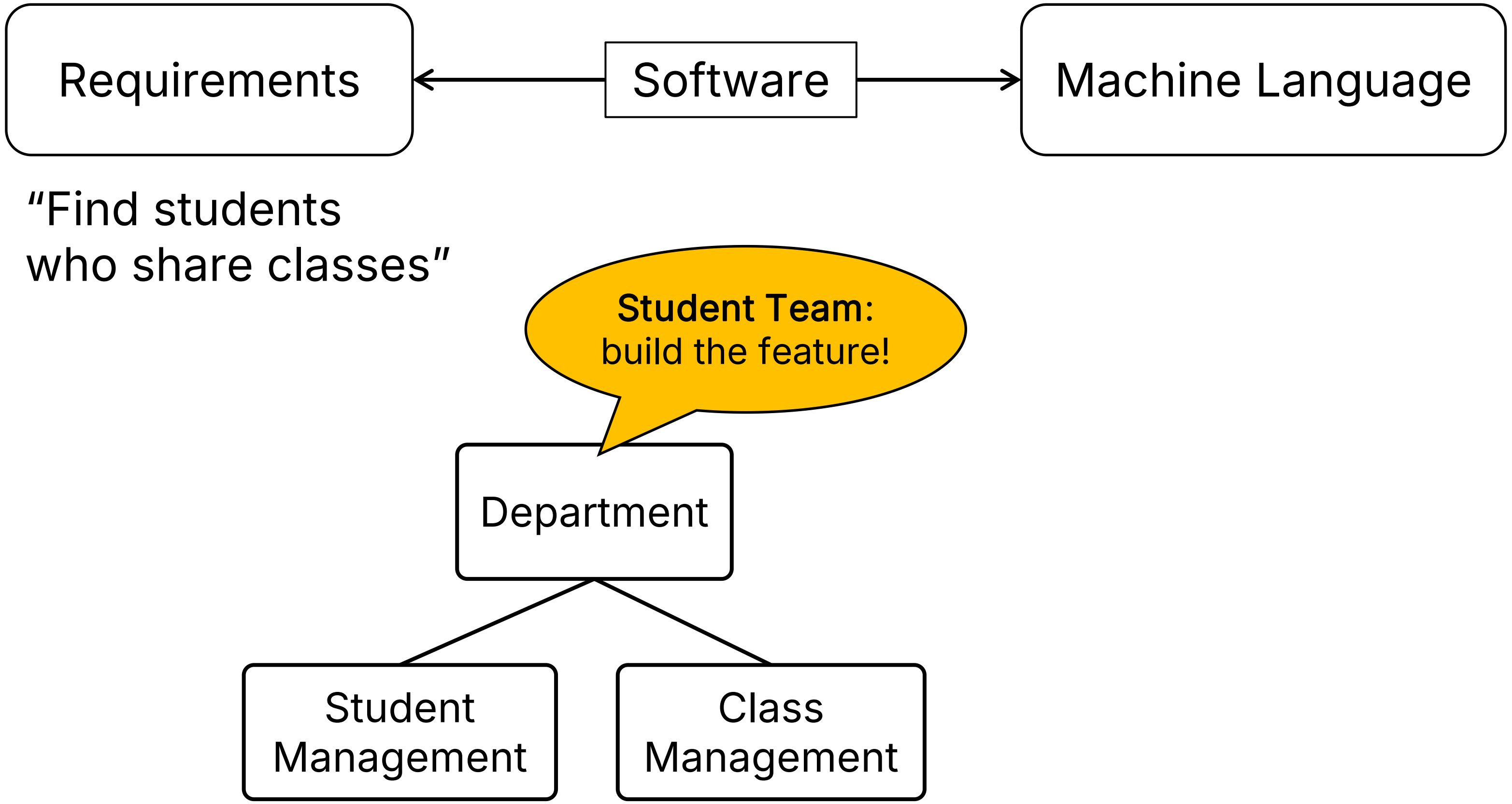


Requirements ← Software → Machine Language

“Find students
who share classes”

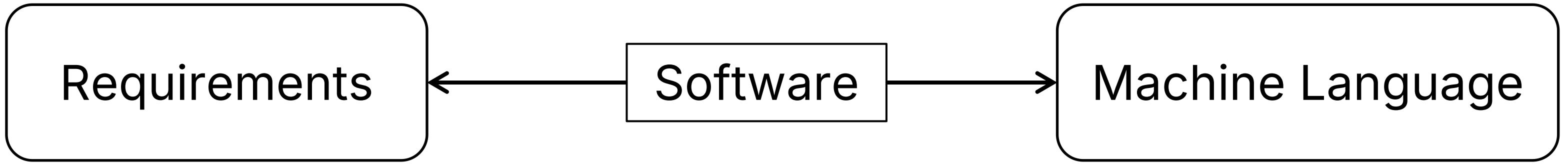
Student Team:
build the feature!

Department

Student Management

Class Management

Programming as Theory-Building



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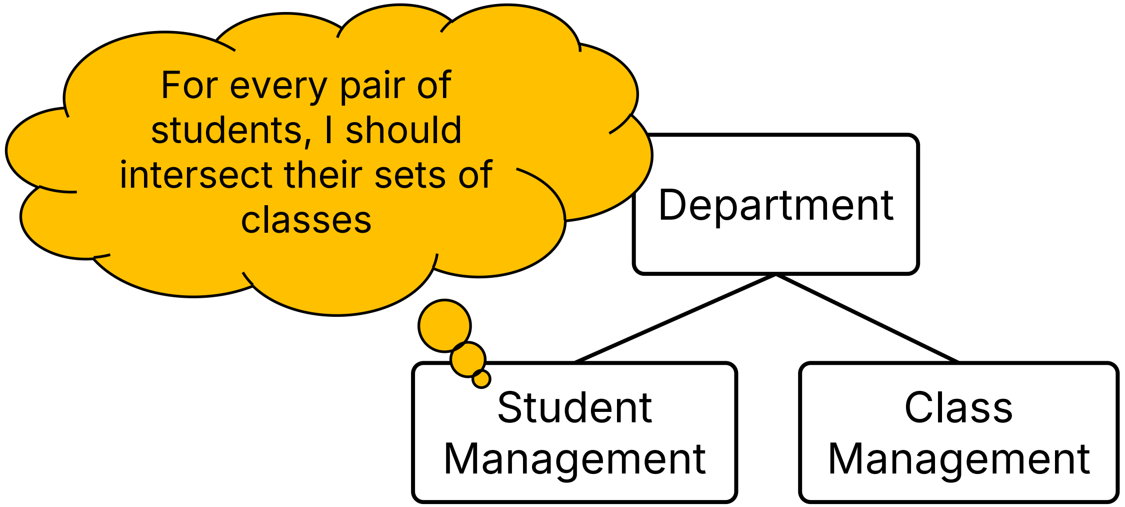


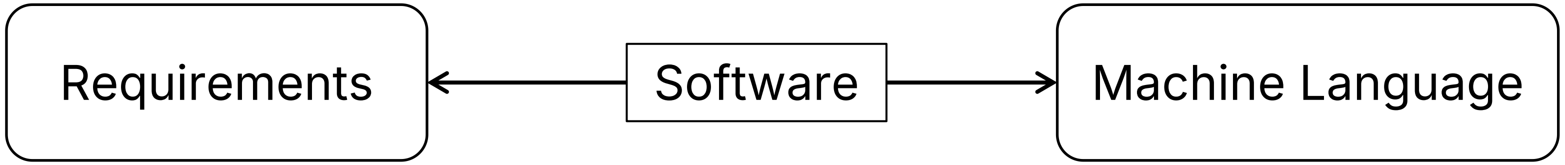
For every pair of students, I should intersect their sets of classes

Department

Student Management

Class Management

Programming as Theory-Building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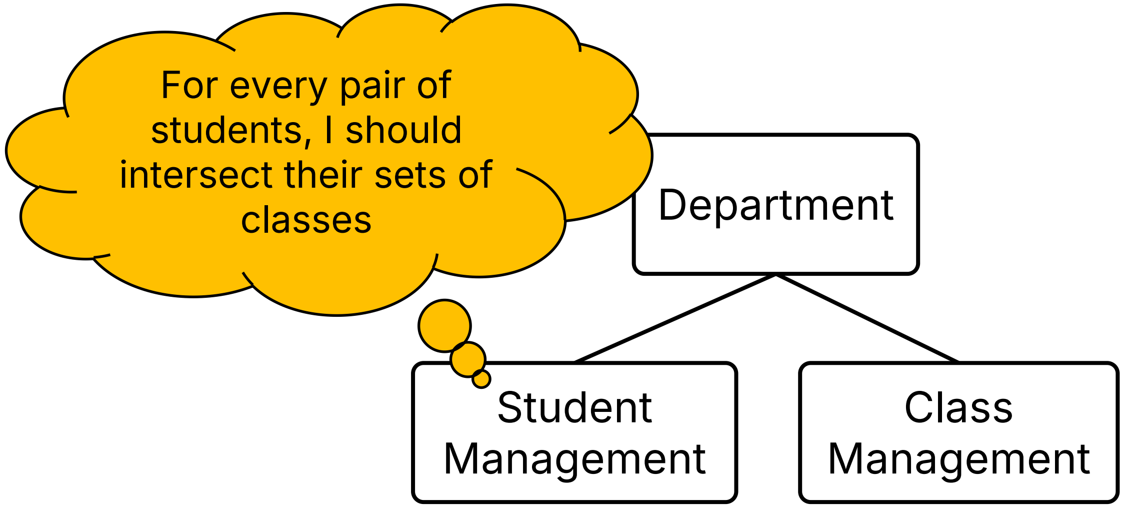
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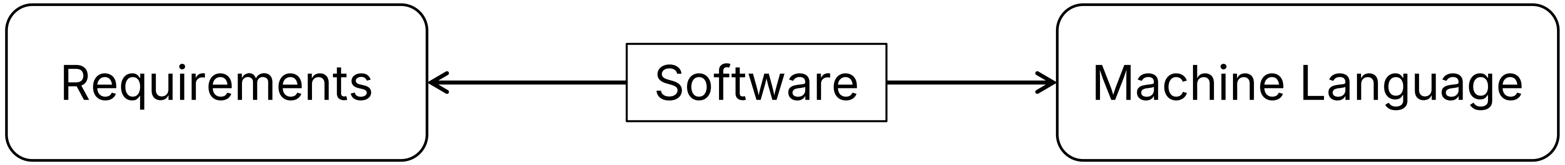
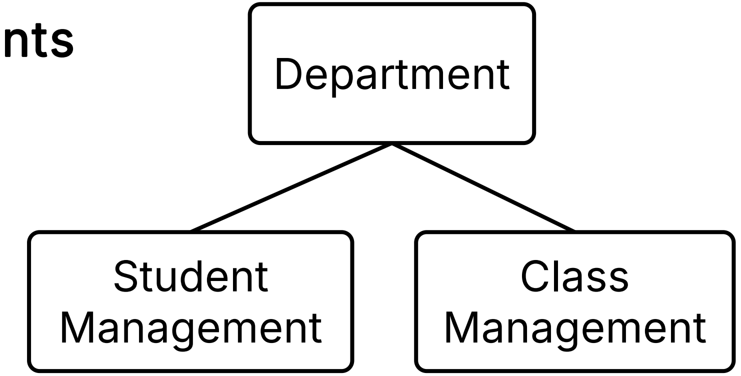
```
def findClassmatePairs(students):
  classMates = []
  for s1 in students:
    c1 = s1.classes
    for s2 in students:
      c2 = s2.classes
      if intersect(c1, c2):
         classMates.append([s1, s2])
  return classMates
```

Programming as Theory-Building



“Find students
who share classes”

“I also want to list all classes that have students enrolled”



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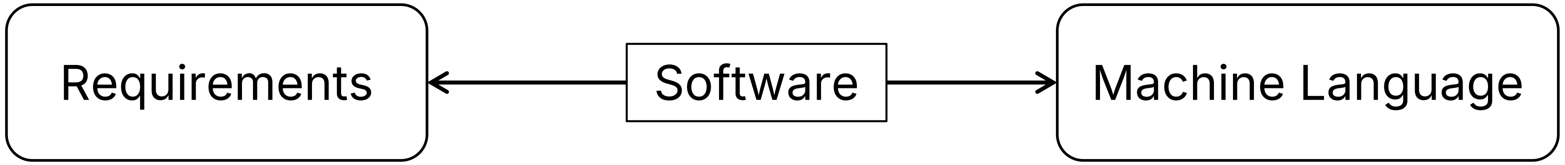

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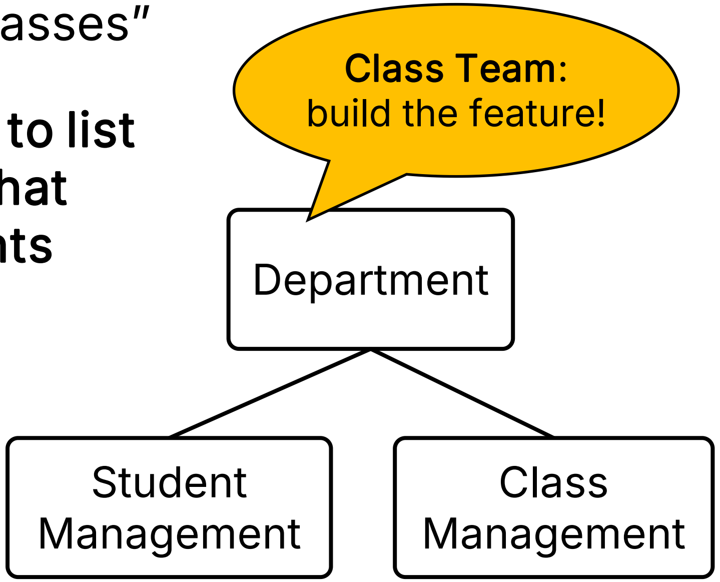

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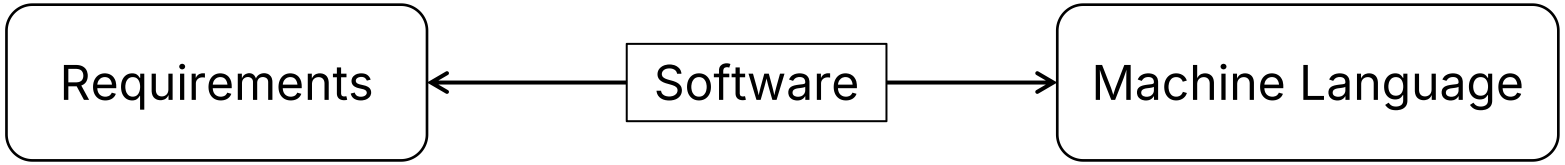

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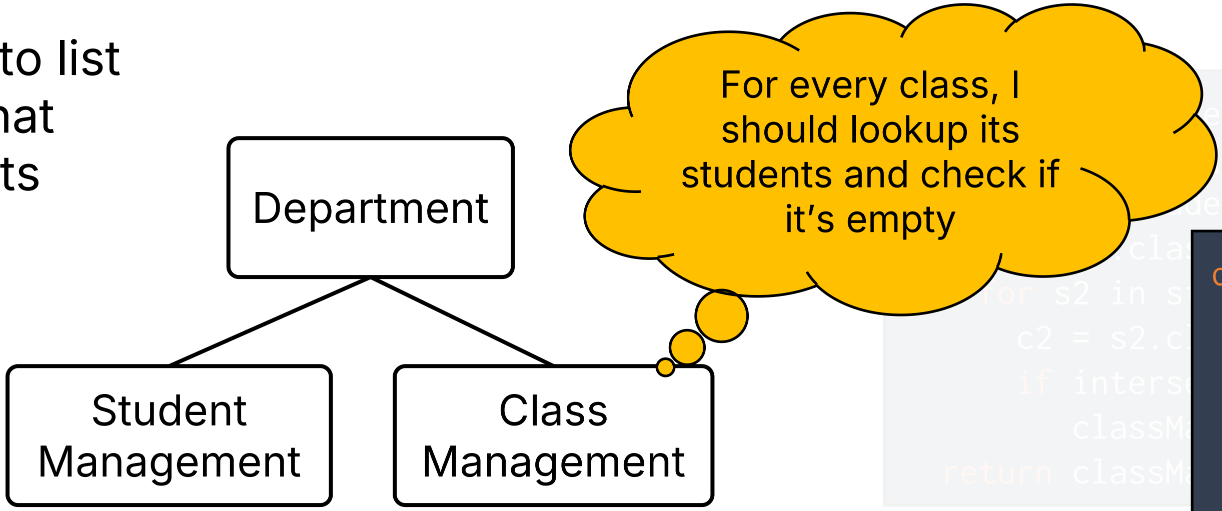


Department

Student Management

Class Management

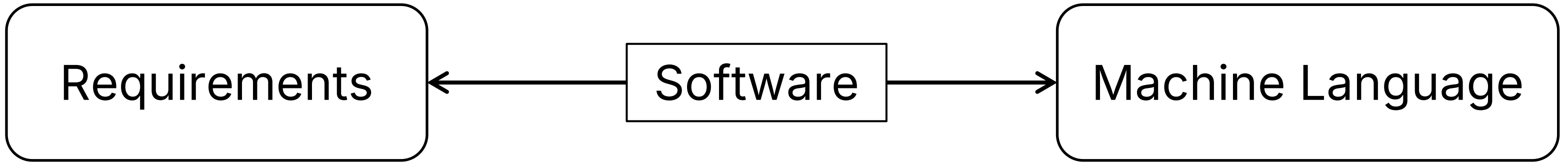
For every class, I should lookup its students and check if it’s empty

```
ePairs(students):

ents:
 cla
or s2 in s
 c2 = s2.c
 if inters
   classM
return classM
```

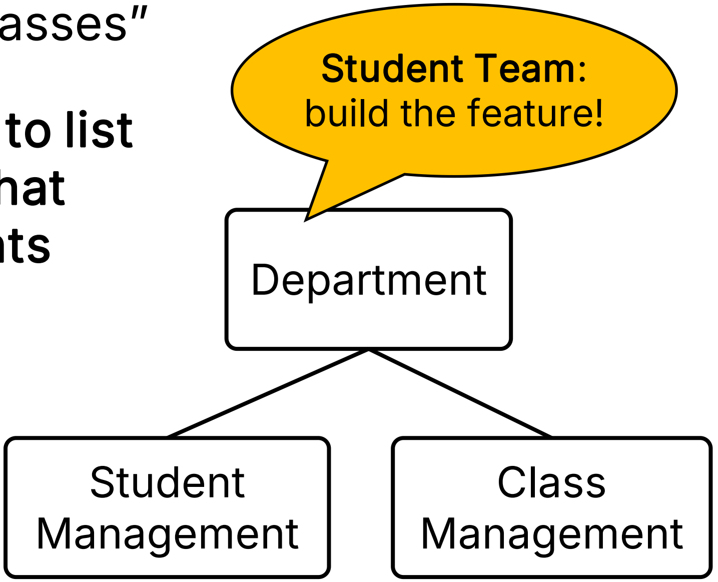
```
def findNonEmptyClasses(classes):
  activeClasses = []
  for c1 in classes:
    if len(c1.students) > 0:
      classes.append(c1)
  return classes
```

Programming as Theory-Building



"Find students who share classes"

"I also want to list all classes that have students enrolled"



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def findClassmatePairs(students):
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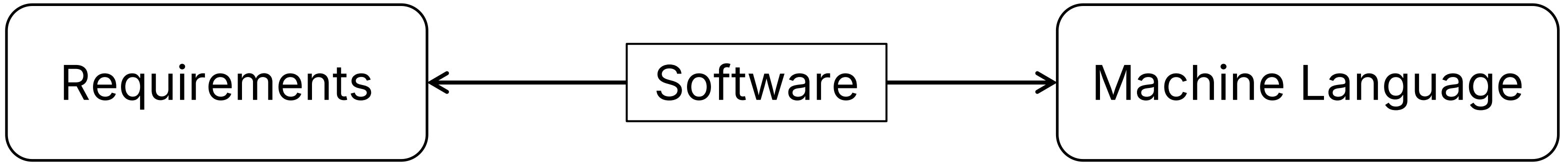
Programming as Theory-Building



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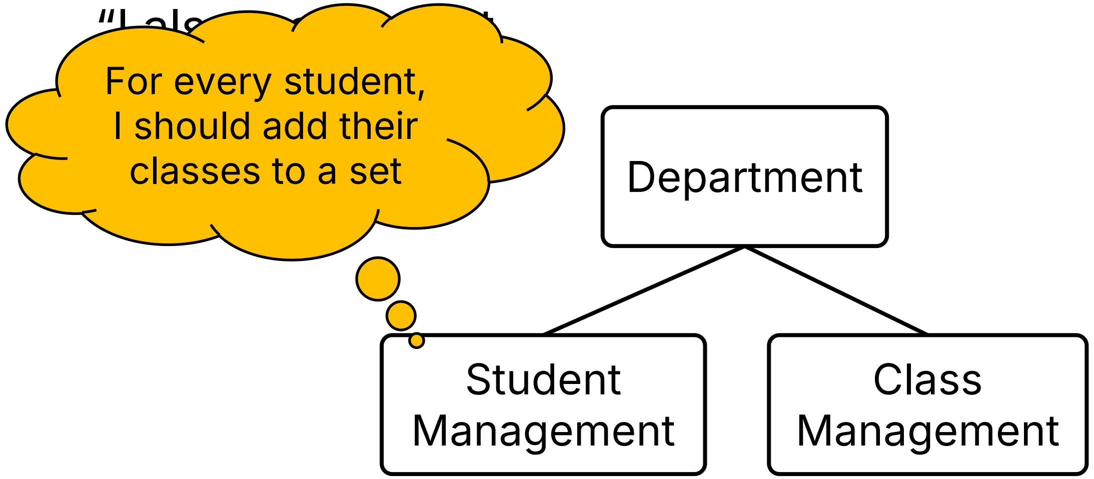

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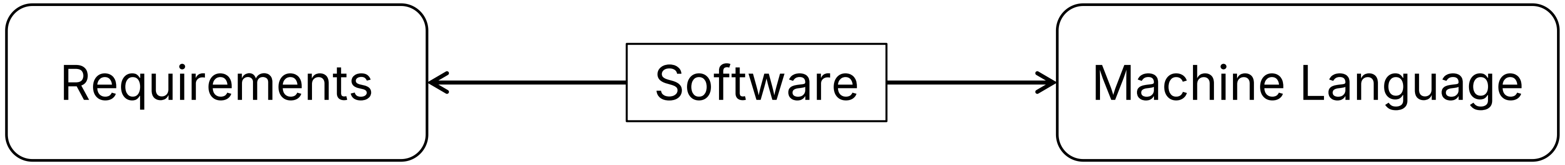

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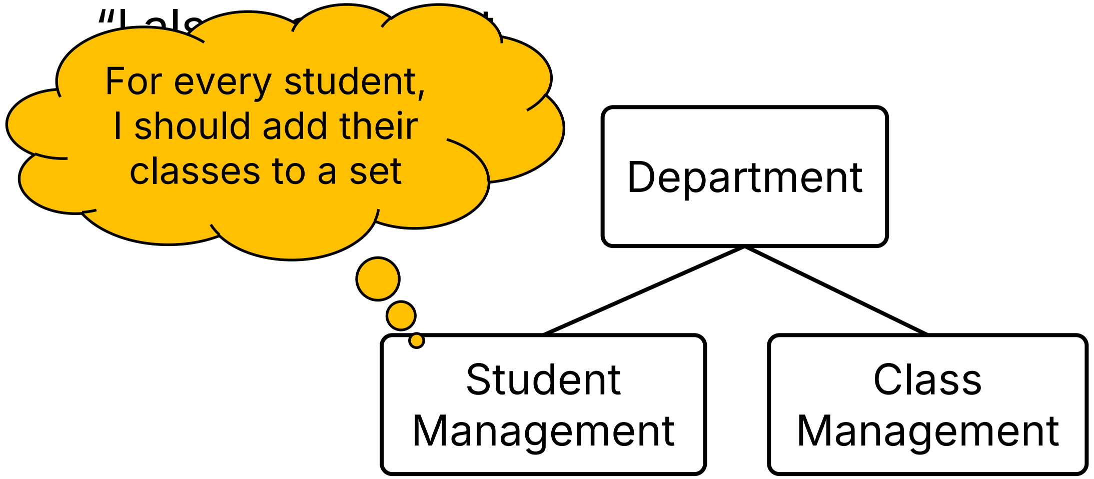

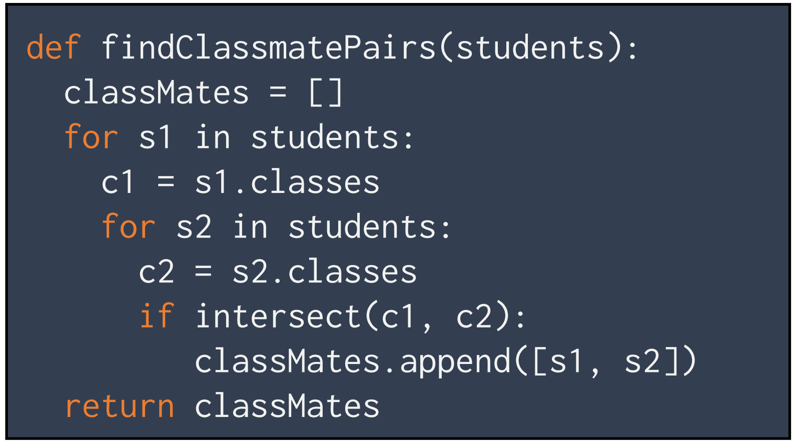

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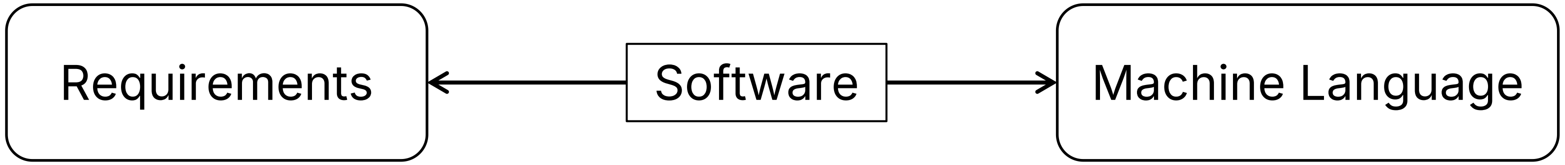

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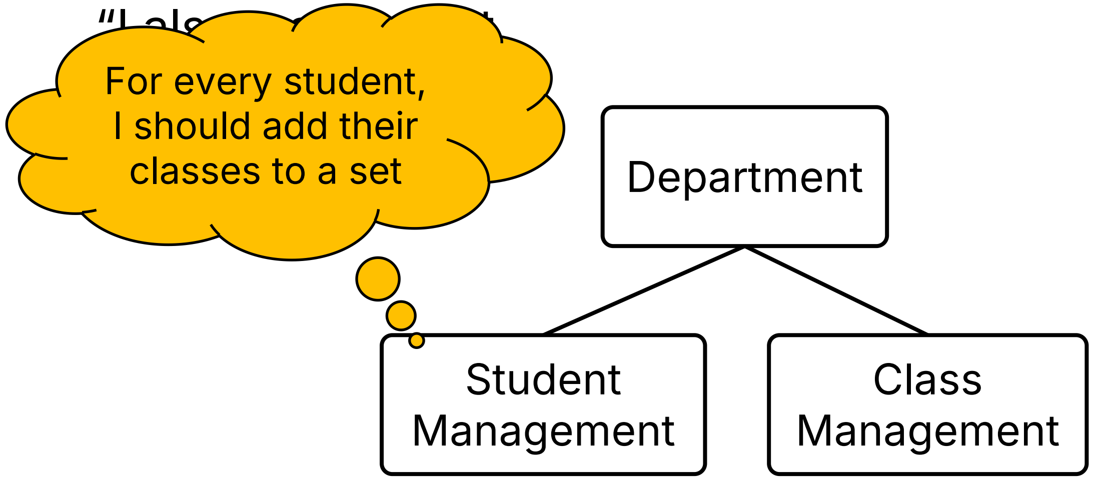

```
activeClasses = set()
classMates = set()
def buildIndex(students):
  for s1 in students:
    c1 = s1.classes
    activeClasses.add(c1)
    for s2 in students:
      c2 = s2.classes
      if intersect(c1, c2):
         classMates.add([s1, s2])

def findClassmatePairs(students):
  return classMates

def findNonEmptyClasses(students):
  return activeClasses
```

Programming as Theory-Building

- For software to retain its quality as it undergoes changes, it is mandatory that each modification is grounded in the theory of the software

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Theory is lost when programmers leave

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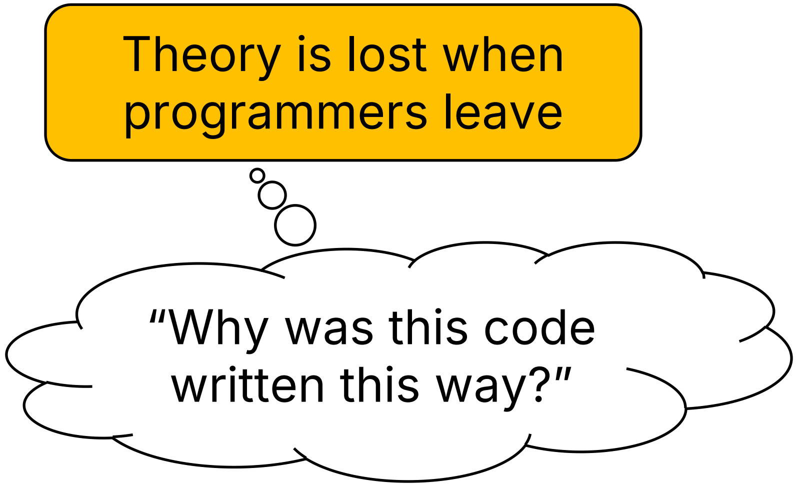

Theory is lost when programmers leave

“Why was this code written this way?”

Programming as Theory-Building

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Theory changes alongside requirements

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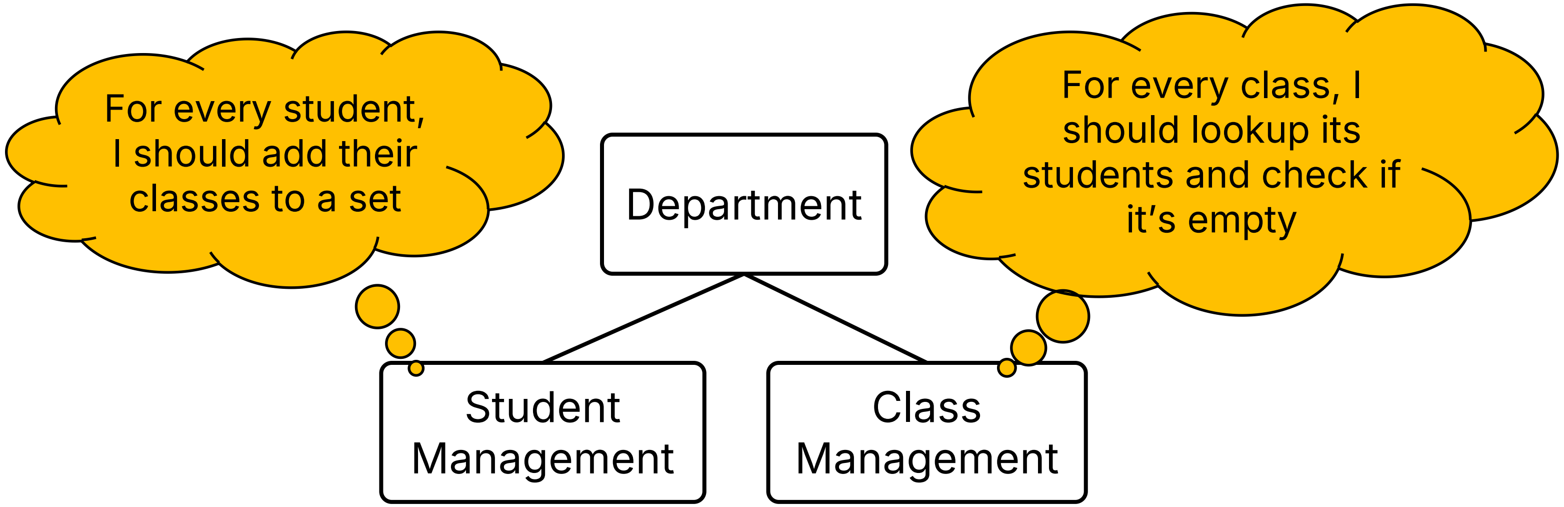
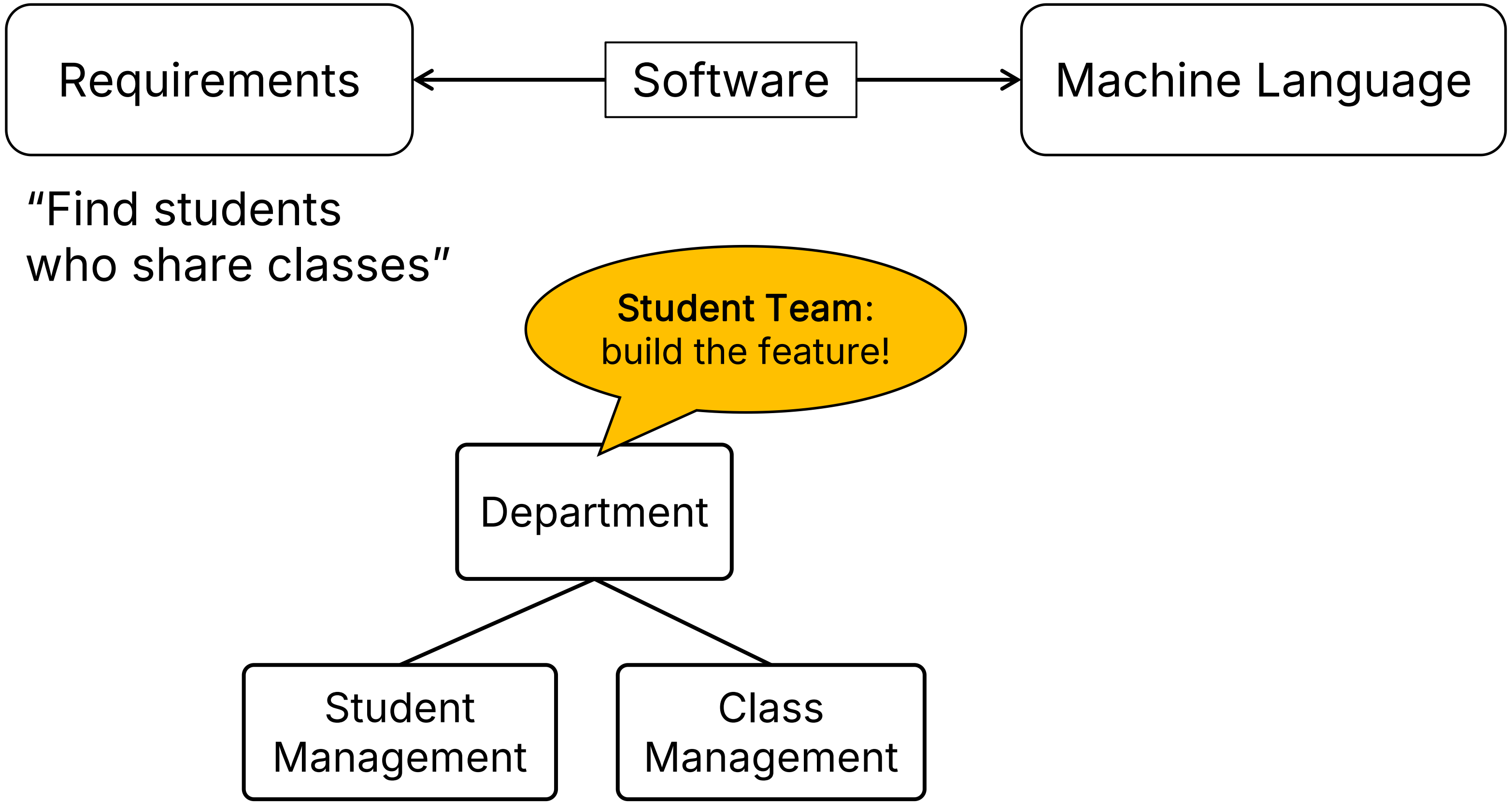

For every student, I should add their classes to a set
Department
For every class, I should lookup its students and check if it's empty
Student Management
Class Management

Programming as Theory-Building



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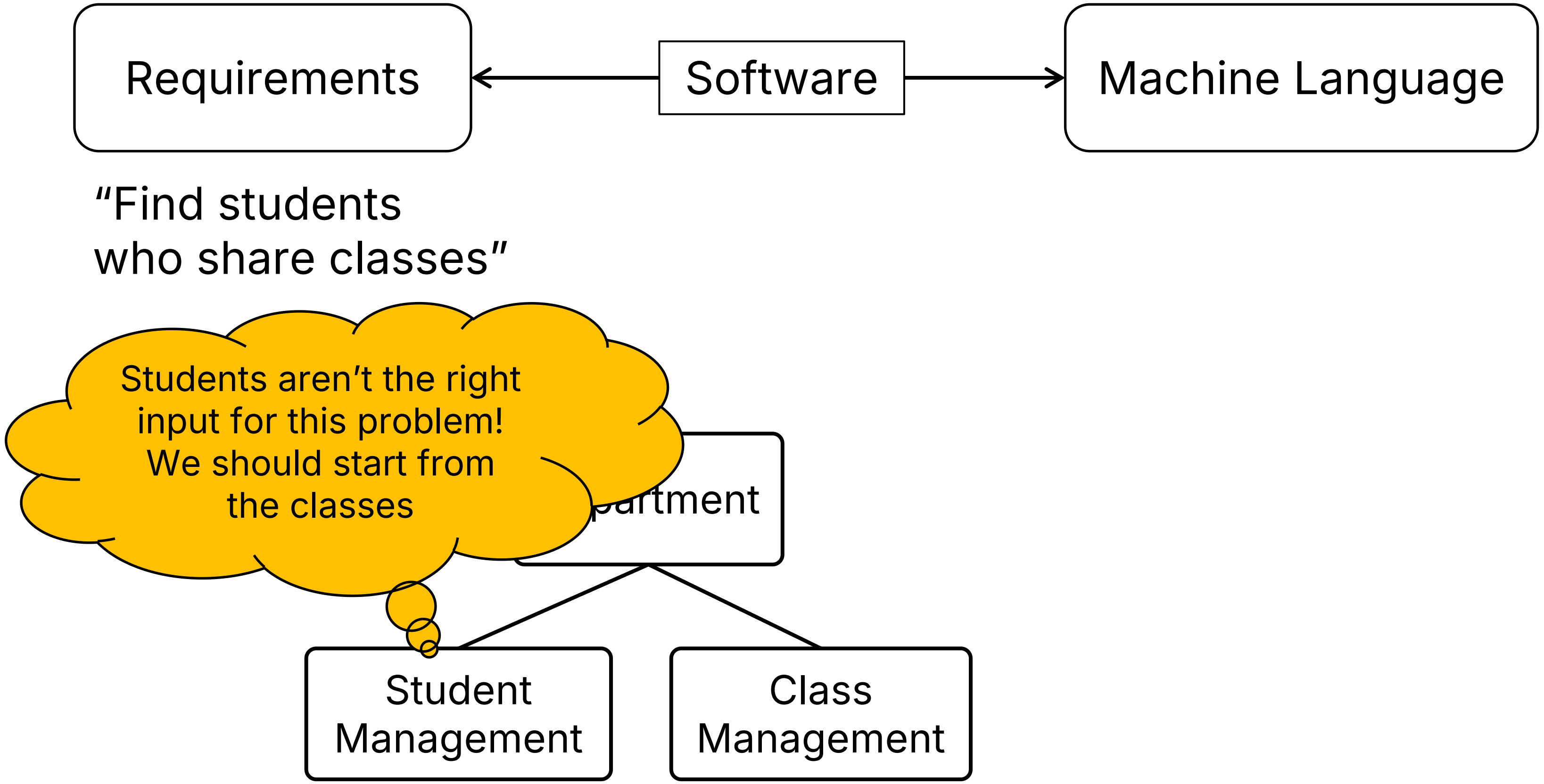
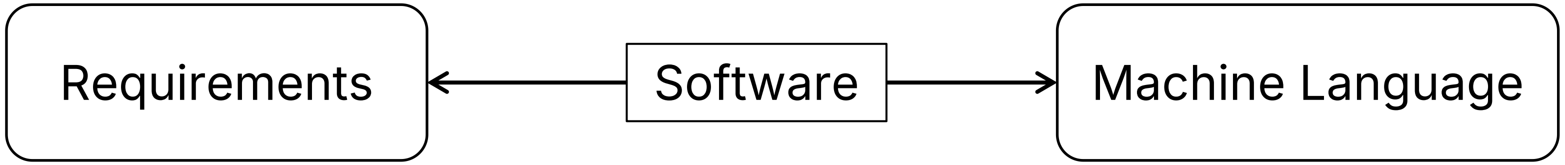


"Find students who share classes"

Students aren't the right input for this problem! We should start from the classes

Programming as Theory-Building

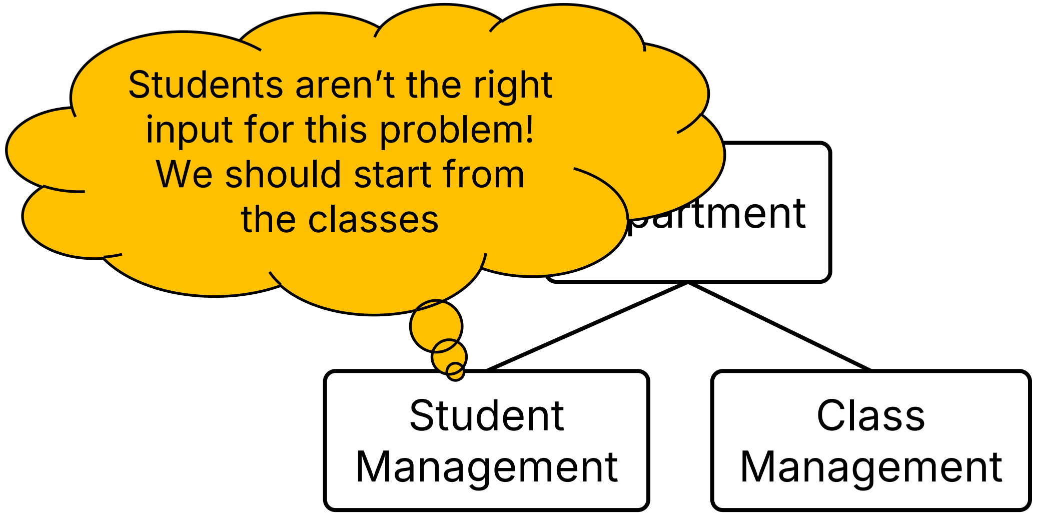


Requirements

Software

Machine Language

“Find students
who share classes”



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We should start from
the classes

partment

Student
Management

Class
Management

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def findClassmatePairs(classes):
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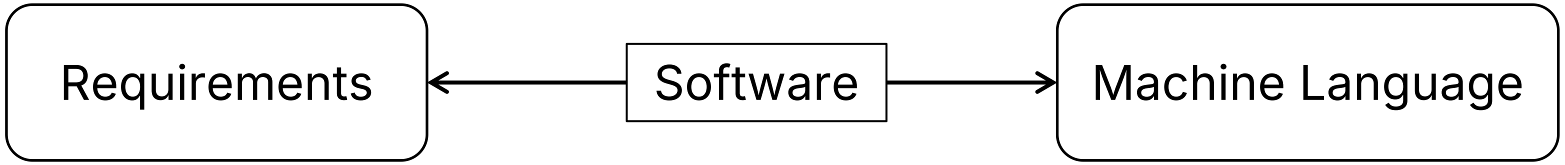
```

Programming as Theory-Building



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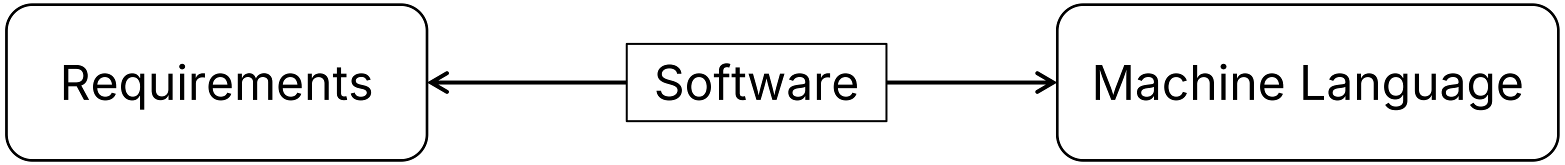

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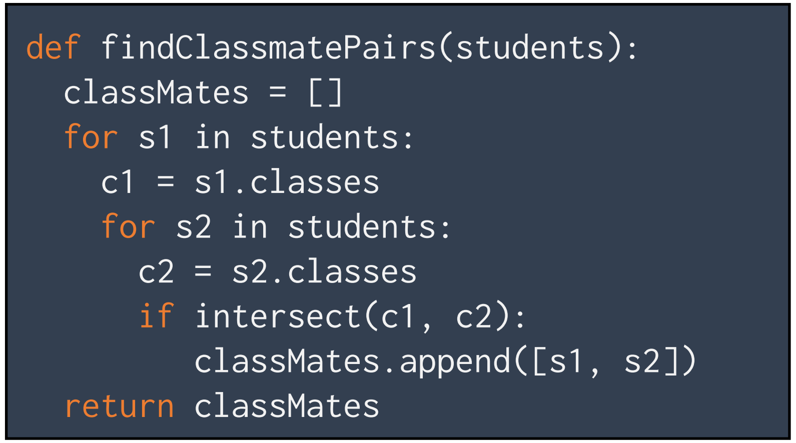

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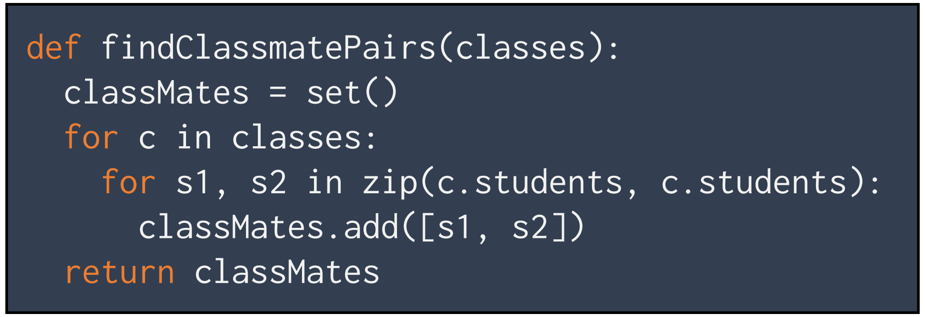
$|students|^2 \cdot 2|classes|$



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- The larger the codebase, the harder to have an accurate theory
- In order to make good changes, you need access to other people’s theories

Software Engineering

- Why is it difficult?

Software Engineering

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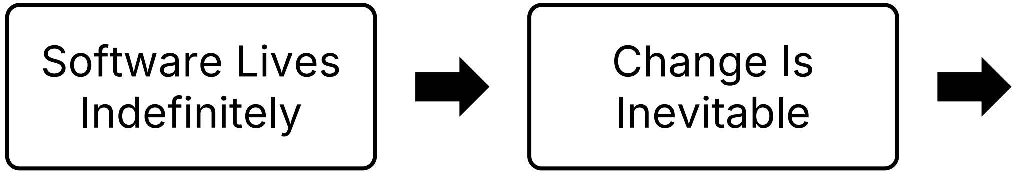
Software Lives Indefinitely

Software Engineering

- Why is it difficult?



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Change Is Inevitable

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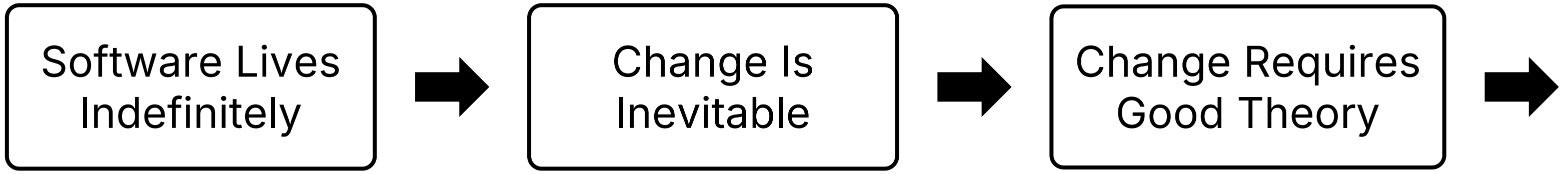

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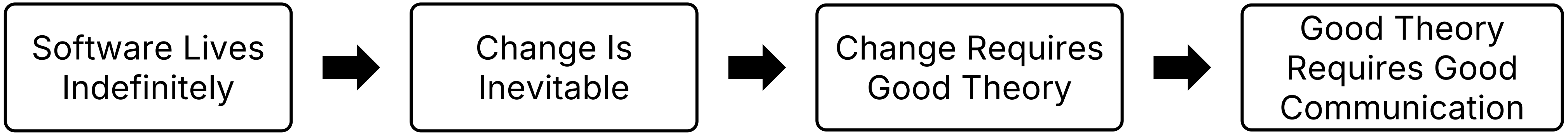

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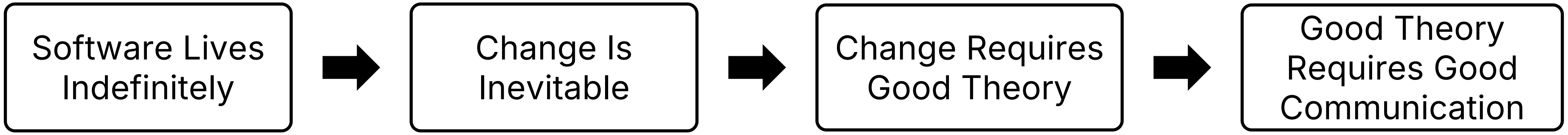

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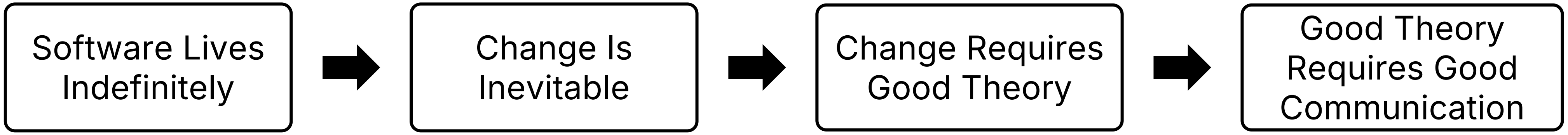

Software Lives Indefinitely ➡ Change Is Inevitable ➡ Change Requires Good Theory ➡ Good Theory Requires Good Communication

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People Leave

Software Engineering

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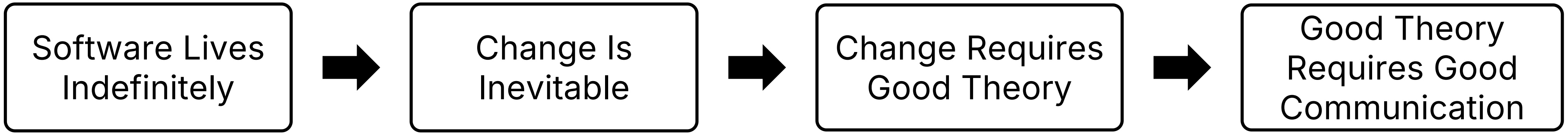

Software Lives Indefinitely → Change Is Inevitable → Change Requires Good Theory → Good Theory Requires Good Communication

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Code Remains After Requirements Change

Software Engineering

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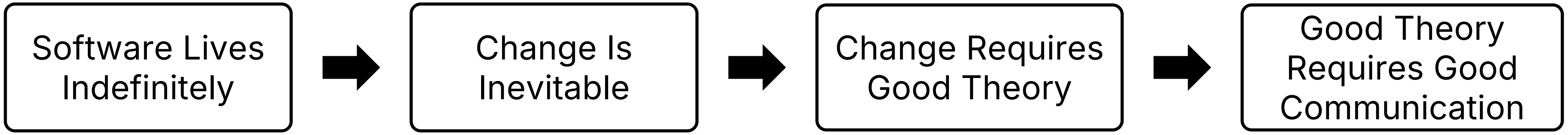
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Doesn’t Match

Why Study Software Engineering?

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- To make the world a better place
  - Software has transformative power in our society, for good or ill
  - If you don’t chase money, there are lots of opportunities for good