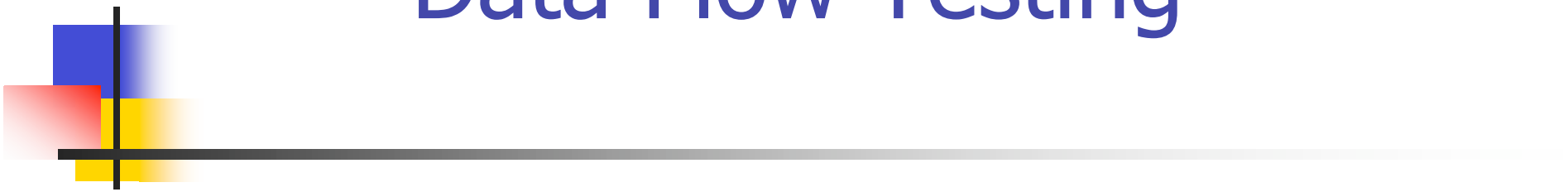
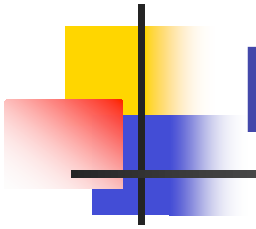


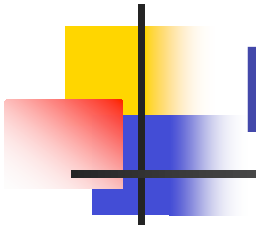
Data Flow Testing

Chapter 10



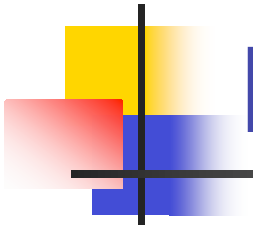
Data Flow Testing

- Testing All-Nodes and All-Edges in a control flow graph may miss significant test cases
- Testing All-Paths in a control flow graph is often too time-consuming
- Can we select a subset of these paths that will reveal the most faults?
- Data Flow Testing focuses on the points at which variables receive values and the points at which these values are used



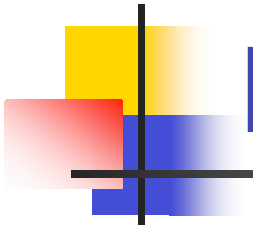
Data Flow Analysis

- Can reveal interesting bugs
  - A variable that is defined but never used
  - A variable that is used but never defined
  - A variable that is defined twice before it is used
- Paths from the definition of a variable to its use are more likely to contain bugs



Definitions

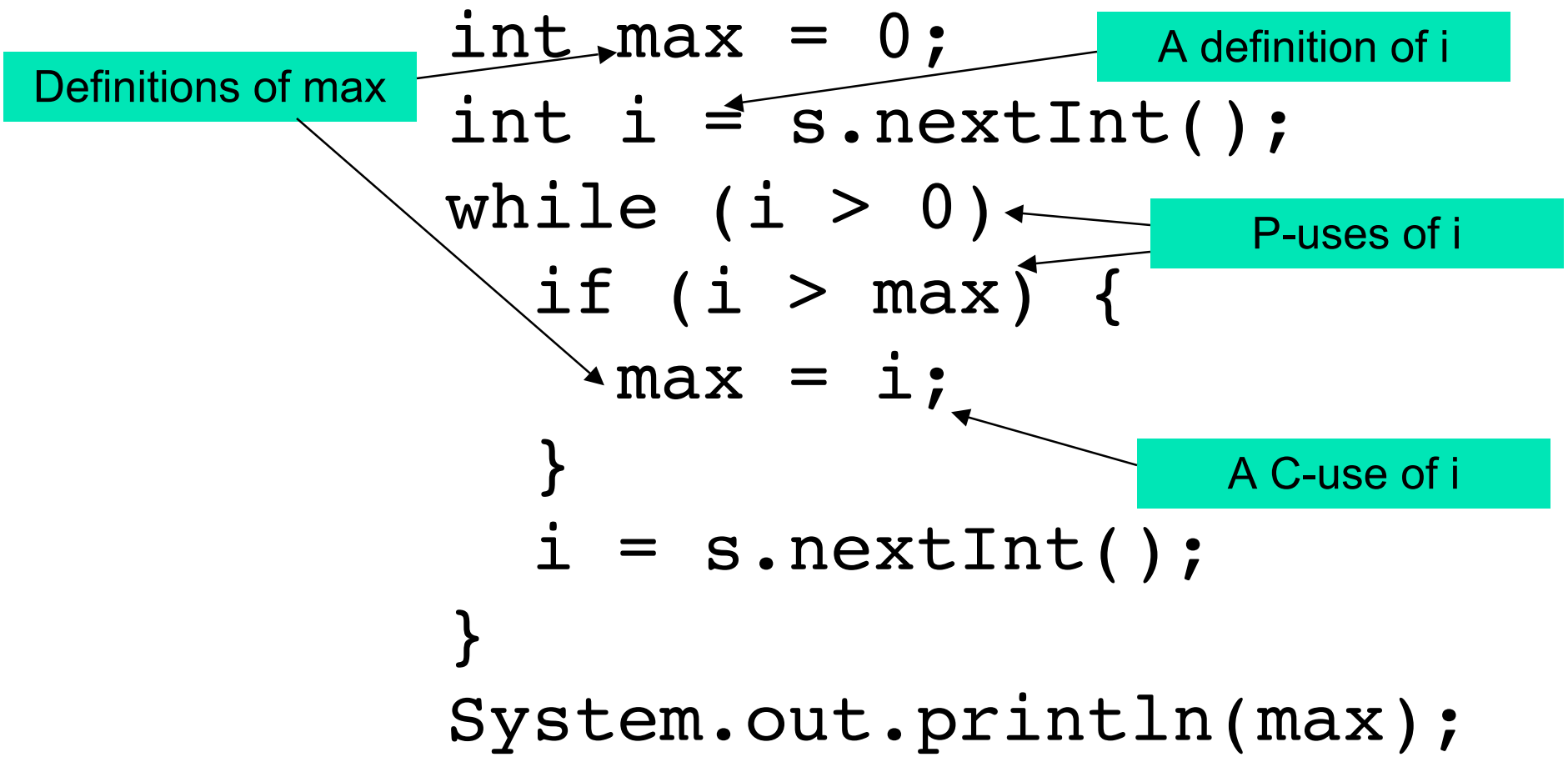
- A node in the program graph is a **defining** node for variable v if the value of v is defined at the statement fragment in that node
  - Input, assignment, procedure calls
- A node in the program graph is a **usage** node for variable v if the value of v is used at the statement fragment in that node
  - Output, assignment, conditionals

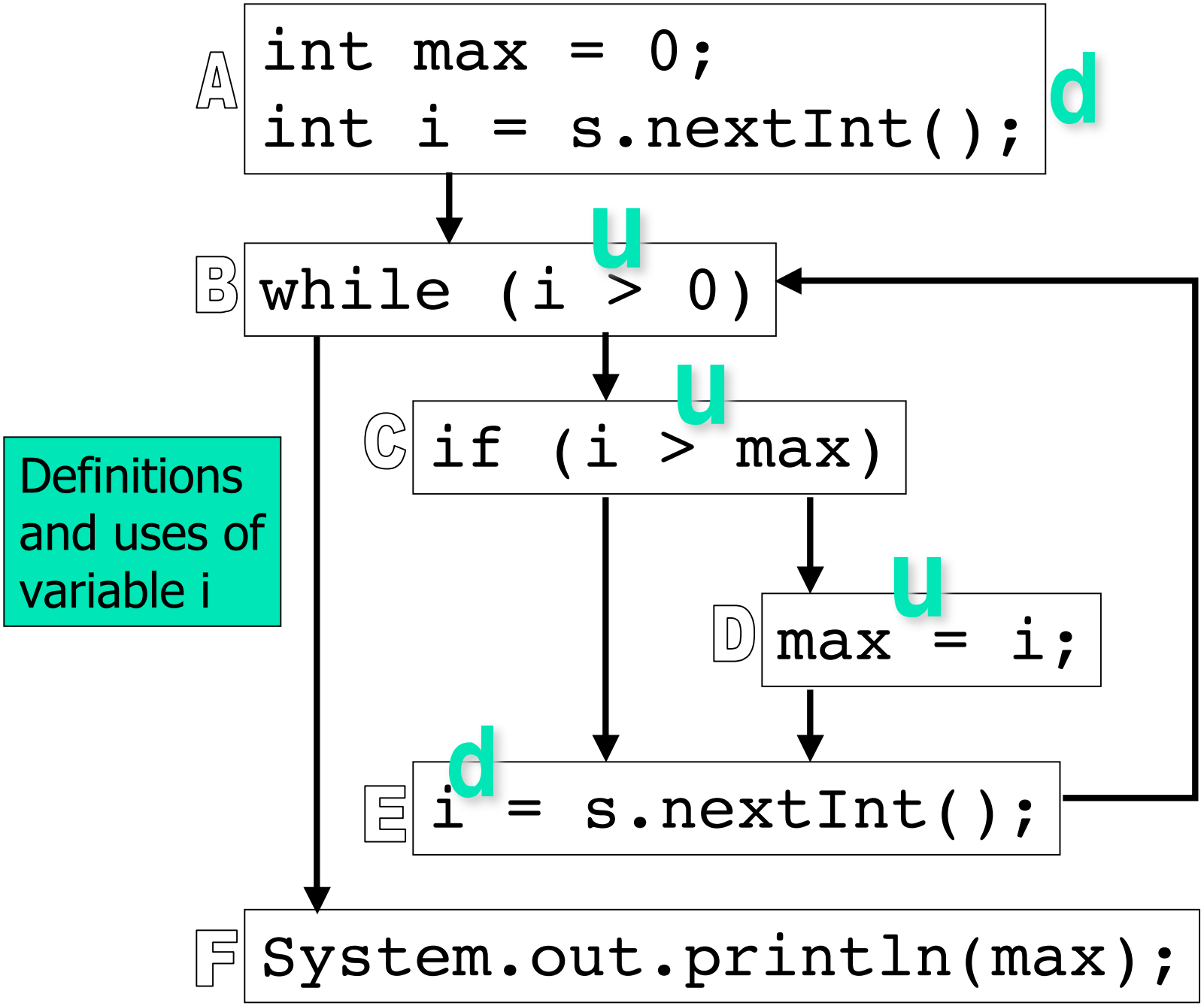


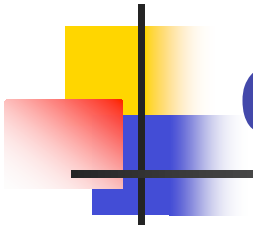
More Definitions

- A usage node is a predicate use (**P-Use**) if variable v appears in a predicate expression
- A usage node is a computation use (**C-Use**) if variable v appears in a computation
- A definition-use path (**du-path**) with respect to a variable v is a path whose first node is a defining node for v, and its last node is a usage node for v
- A du-path with no other defining node for v is a definition-clear path (**dc-path**)

An Example

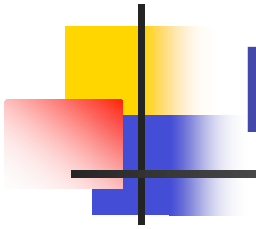

Definitions of max
A definition of i
P-uses of i
A C-use of i
int max = 0;
int i = s.nextInt();
while (i > 0)
if (i > max) {
max = i;
}
i = s.nextInt();
}
System.out.println(max);


A
int max = 0;
int i = s.nextInt();
d
B
while (i > 0)
u
C
if (i > max)
u
D
max = i;
u
E
i = s.nextInt();
d
F
System.out.println(max);
Definitions and uses of variable i



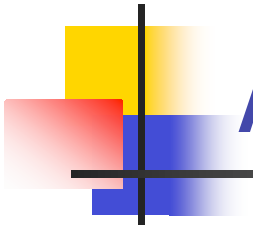
du-paths in example

- Variable i
  - AB, AC, AD, EB, EC, ED
- Variable max
  - AF, AC, DC, DF



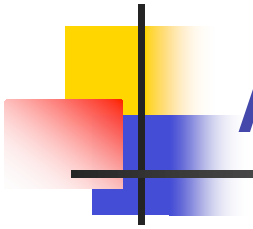
Data Flow Coverage Metrics

- Based on these definitions we can define a set of coverage metrics for a set of test cases
- We have already seen
  - All-Nodes
  - All-Edges
  - All-Paths



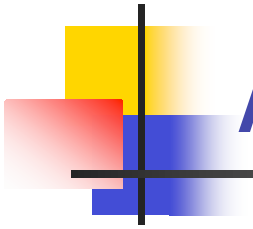
All-Defs Criterion

- For every variable v
- For every defining node d of v
  - There exists at least one test case that follows a path from d to a usage node of v



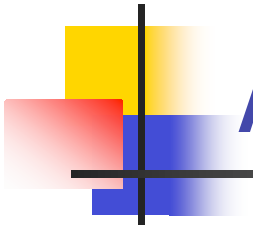
All-Uses Criterion

- For every variable v
- For every defining node d of v
- For every usage node u of v
  - There exists at least one test case that follows a path from d to u



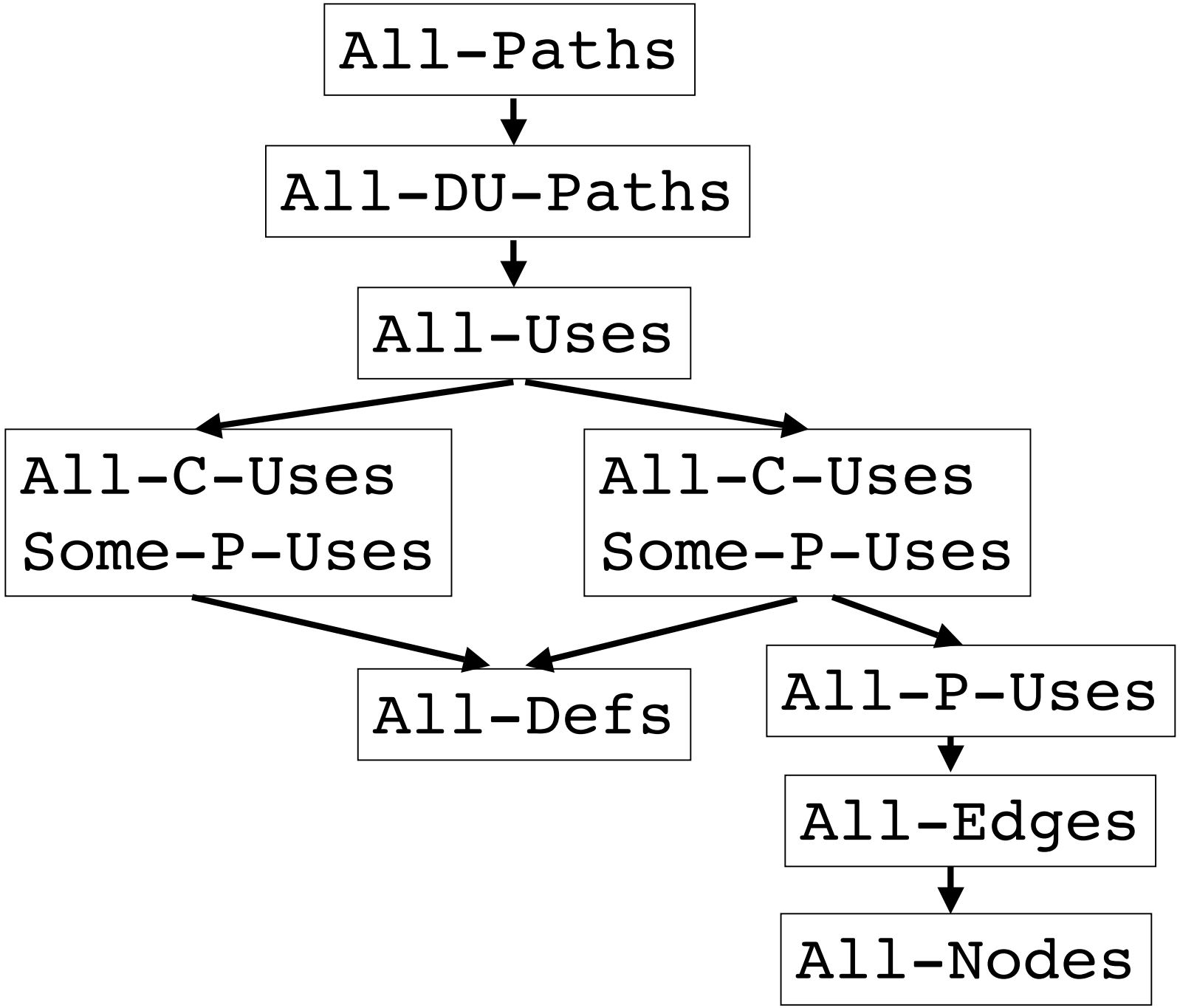
All-P-Uses / Some-C-Uses

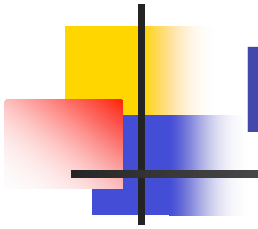
- For every variable v
- For every defining node d of v
- For every P-Use u of v
  - There exists at least one test case that follows a path from d to u
  - If there is no P-Use of v, there must exist at least one test case that follows a path from d to a C-Use of v



All-C-Uses / Some-P-Uses

- For every variable v
- For every defining node d of v
- For every C-Use u of v
  - There exists at least one test case that follows a path from d to u
  - If there is no C-Use of v, there must exist at least one test case that follows a path from d to a P-Use of v


All-Paths
All-DU-Paths
All-Uses
All-C-Uses
Some-P-Uses
All-C-Uses
Some-P-Uses
All-Defs
All-P-Uses
All-Edges
All-Nodes



Data flow analysis issues

- Aliasing of variables causes serious problems!
- Working things out by hand for anything but small methods is hopeless
- Compiler-based tools help in determining coverage values