Flow-Insensitive Pointer Analysis

drawbacks of flow-sensitivity

- Flow-sensitive pointer analysis is expensive
- Keep track of a different points-to graph at each program point
  - Can take a while for analysis to converge
  - Large storage requirements for large programs
- Can do flow-insensitive analysis instead

flow-insensitive analysis

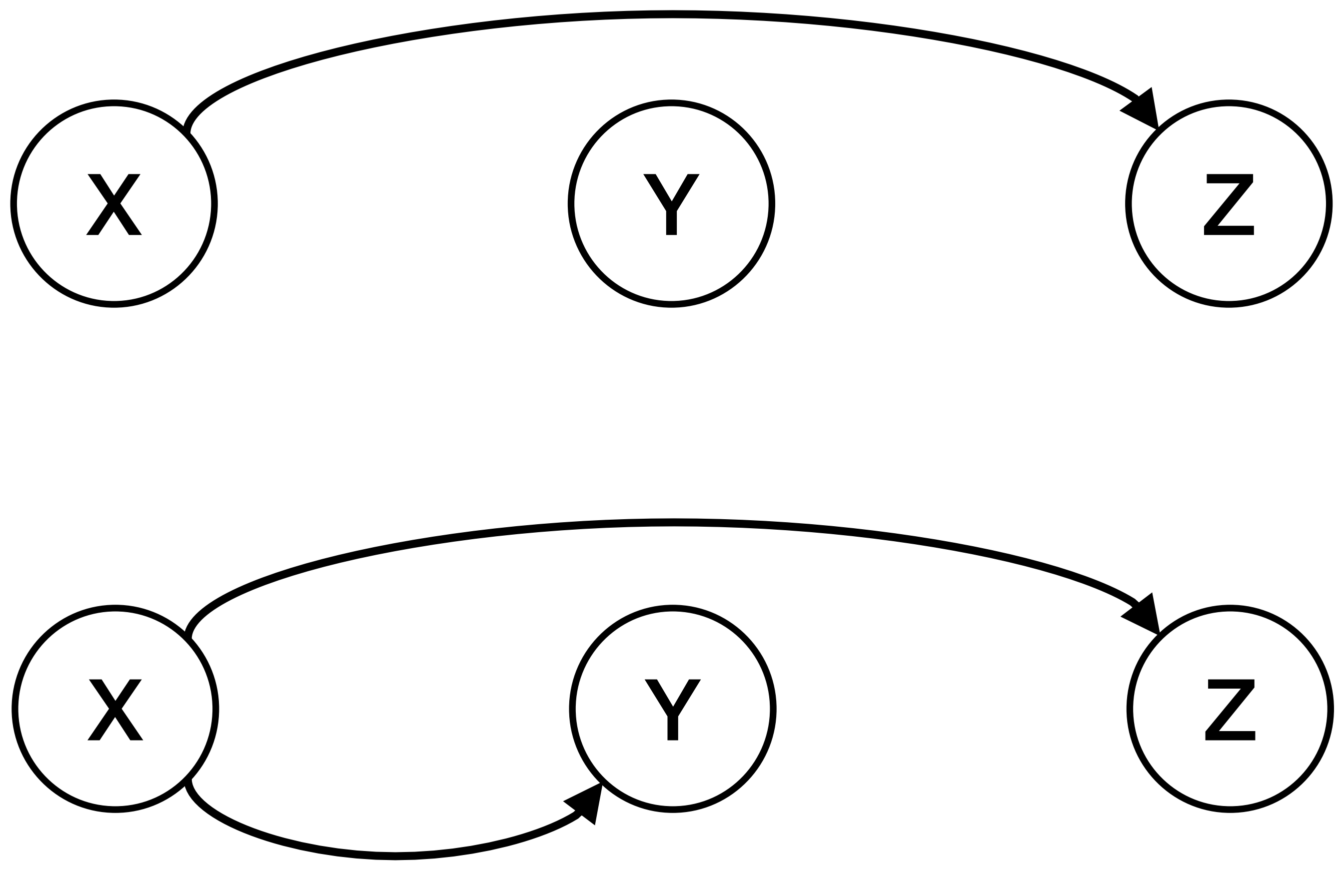
- Key idea: *ignore control flow*
- All statements in a function dumped into a single list
  - No loops, branching
- Compute a single points-to graph that is valid for the entire function *regardless of when and how often statements are executed*

weak updates

- Because we are computing a single points-to graph, and we do not know when a given statement executes, *we never remove information*
- Replace all strong updates with weak updates
- Update graph in place

address of
x = & y

$G' = G$ with $pt(\mathrm{x}) \cup\leftarrow \{\mathrm{y}\}$



Andersen's algorithm

- Compute points-to graph by formulating this as a series of set constraints
- Solve set constraints (same fix point algorithms we've seen before!)
- Only trick: when points-to sets are updated, loads and stores generate new constraints!

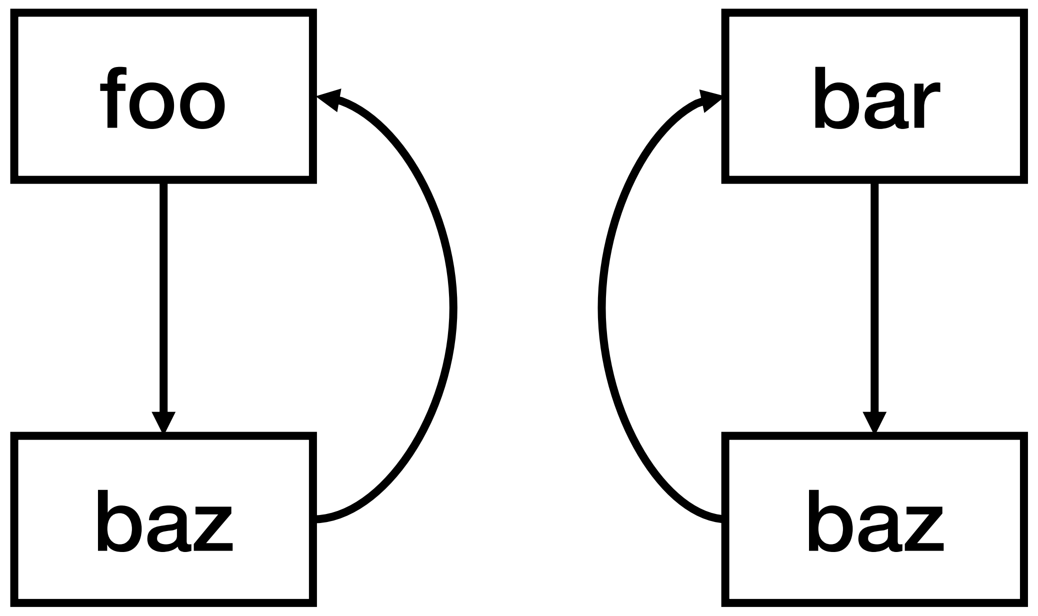
address of x = & y	$y \in pt(x)$	copy x = y	$pt(x) \supseteq pt(y)$
load x = * y	$\forall a \in pt(y). pt(x) \supseteq pt(a)$	store * x = y	$\forall a \in pt(x). pt(a) \supseteq pt(y)$

adding complexity

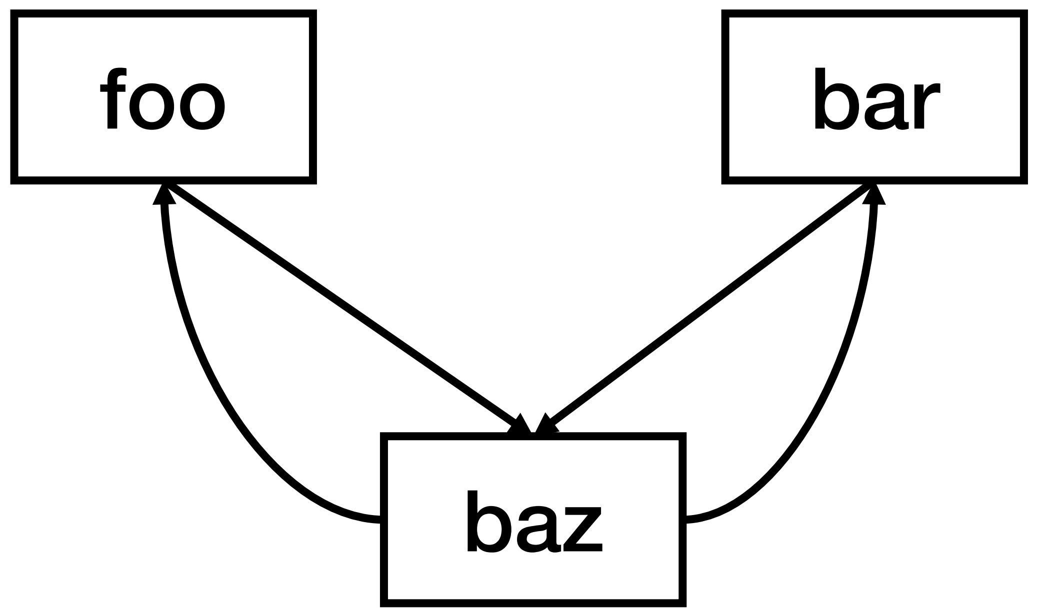
- What if you have multiple functions? Need to do **interprocedural analysis**
- Simple approach we've seen before: assume a function can do *anything*
- What can you do instead?
  - Execute *interprocedurally*
  - Propagate points-to information from caller to callee, back from callee to caller

interprocedural analysis

- We won't really cover this, but there are two basic approaches
- **Context-sensitive**: treat each function call separately, like in a real execution
  - Essentially, inline callee into caller
  - What do we do for recursion? Need to approximate
  - Pros: accurate. Cons: slow



- **Context-insensitive**: merge information from call sites of each function
  - Essentially, represent each function once in a control flow graph
  - Merge information from multiple callers within the callee
  - Pros: faster. Cons: inaccurate (information can flow from one caller to another!)



dealing with the heap

- What about heap allocations?
- Simple approach: one node represents "the heap."
  - x = malloc(…) makes x point to "the heap."
- More complicated approach: a different heap node for each malloc site
- Even more complicated: **shape analysis** to reason about how heap nodes point to *each other*