reaching defs abstract semantics

- pp : $x = \{\$alloc, \$arith, \$cmp, \$copy, \$gep, \$gfp\}$ op...

  - DEF $= \{x\}$ $x = \$arith \; add \; y \; z$

  - USE $= \{op \mid op \; is \; a \; variable\}$ abstract store

  - ⌣ $\forall v \in USE, \; soln[pp] = soln[pp] \cup \sigma[v]$

  - $\sigma[x] = \{pp\}$

- pp : $x = \$addrof \; y$

  - DEF $= \{x\}$

  - USE $= \{\}$

  - $\sigma[x] = \{pp\}$

- pp : $x = \$load \; y$

  - DEF $= \{x\}$

  - USE $= \{y\} \cup \{v \in addr\_taken \mid type(v) = type(x)\}$

  strong updates → $- \forall v \in USE, \; soln[pp] = soln[pp] \cup \sigma[v]$

  - $\sigma[x] = \{pp\}$

  ex: let a:&int, b:int, c:&int, d:int

        entry:

entry:
```
a = $ addrof b
c = $alloc 1 [-a]
d = $ load c     ← USE = {c, b, fake-int}
```

- **pp: $store x op**
  - DEF = $\{v \in addr\text{-}taken \mid type(v) = type(op)\}$
  - USE = $\{x\} \cup \{op \mid op \text{ is a variable}\}$
  - *(weak update)* $\forall v \in USE, \; soln[pp] = soln[pp] \cup \sigma[v]$
  - $\forall v \in DEF, \; \sigma[v] = \sigma[v] \cup \{pp\}$

```
let a:int, b:&int, c:int
entry:
   b = $ addrof a
   a = $ copy 42
   c = $ copy 12
   $ store b 6
   $ ret x    ←  σ[a] = {entry.1, entry.3}
                 σ[c] = {entry.2}
```

- **pp: [x =] $call_{dir, idr, ext} id/fp (arg...)**
  - *(strong def)* SDEF = $\{x\}$
  - *(weak defs)* WDEF = $\{globals...\} \cup \{v \in addr\text{-}taken \mid$

    things that could defined via global or ptr

    $type(v) \in reachable\text{-}types(globals...)\} \cup$

    $\{v \in addr\text{-}taken \mid type(v) \in reachable\text{-}types(arg...)\}$

$$\{v \in addr\_taken \mid type(v) \in reachable\_types(arg...)\}$$

- $USE = \{fp\} \cup \{arg \mid arg \text{ is a variable}\} \cup WDEF$

- $\forall v \in USE, \; soln[pp] = soln[pp] \cup \sigma[v]$
- $\forall v \in WDEF, \; \sigma[v] = \sigma[v] \cup \{pp\}$
- $\sigma[x] = \{pp\}$

- pp: $\$jump$ bb, $\$branch$ op $bb1$ $bb2$, $\$ret$ op^2

  - $DEF = \{\}$
  - $USE = \{op \mid op \text{ is a variable}\}$
  - $\forall v \in USE, \; soln[pp] = soln[pp] \cup \sigma[v]$