

Pattern Matching Security Properties of Code using Dependence Graphs

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Comparison of Static Tools

Five static analysis tools trying to find security bugs

Tool	True Positives	False Positives	True Negatives	False Negatives
Flawfinder	96%	71%	29%	4%
ITS4	91%	52%	48%	9%
RATS	83%	67%	33%	17%
Splint	30%	19%	81%	70%
BOON	27%	31%	69%	73%

New Tools On The Block

- Cqual, Metal/xgcc, MOPS, IPSSA, Mjonir and Eau Claire
- Program models: CFG, AST, PDA, SSA ...
- Security flaws: buffer overflows, integer flaws, race conditions ...

Drawbacks

- Check for one or two flaws each
- Different models and analyses
- Textual modeling of flaws
- Textual feedback to user
- Lack of ranking

Textual Models

```
// Start state. Matches any copy_from_user
// call and puts parameter x in tainted state.
start: { copy_from_user(x, y, len) }
      ==> x.tainted
;
// Catch operations illegal on unsafe values.
x.tainted, x.need_ub, x.need_lb:
  { v[x] } ==>{ err("Dangerous index!"); }
...
;
```

Textual Feedback

Johns_program.c:7:3: Possible out-of-bounds store:

```
strcpy(buffer, input_string)
```

Unable to resolve constraint:

```
requires maxRead(input_string @ test.c:7:18) <= 7
```

needed to satisfy precondition:

```
requires maxSet(buffer @ test.c:7:10) >=
        maxRead(input_string @ test.c:7:18)
```

derived from strcpy precondition:

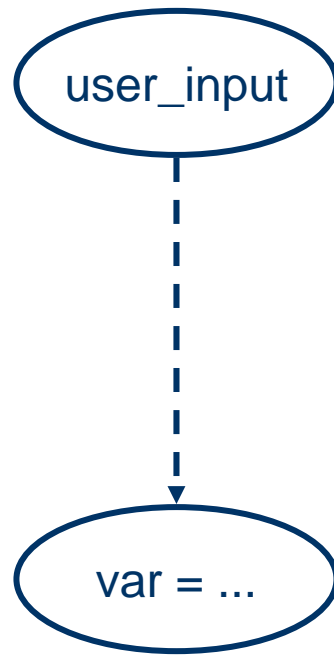
```
requires maxSet(<parameter 1>) >=
        maxRead(<parameter 2>)
```

Research Goal

- More generic formalism
- Ranking of potential flaws
- Visual communication

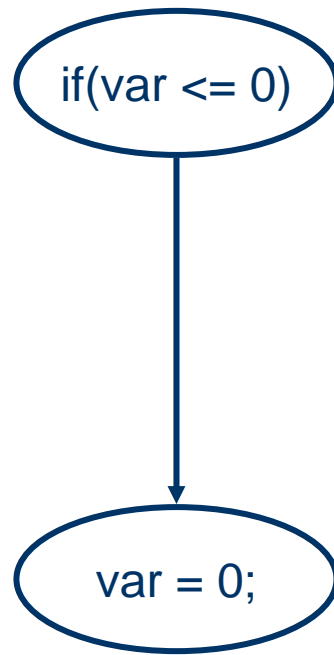
⇒ Our proposal is *dependence graphs*

Data Dependence



```
int func(int user_input){  
    int var;  
    ...  
    var = user_input * 5;  
    ...  
}
```

Control Dependence

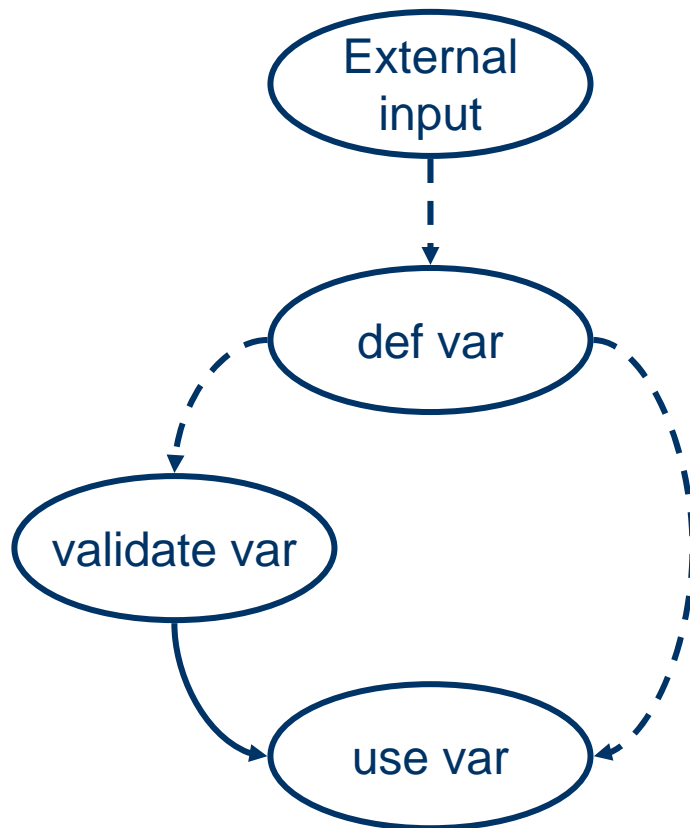


```
int func(int user_input){  
    int var;  
    ...  
    if(var <= 0)  
        var = 0;  
    ...  
}
```

Input Validation

```
int func(int user_input){
    int var;
    ...
    var = user_input * 5;
    ...
    if(var >= 0 && var < MAX)
        for(i = 0; i < var; i++)
            array[i] = 0;
    ...
}
```

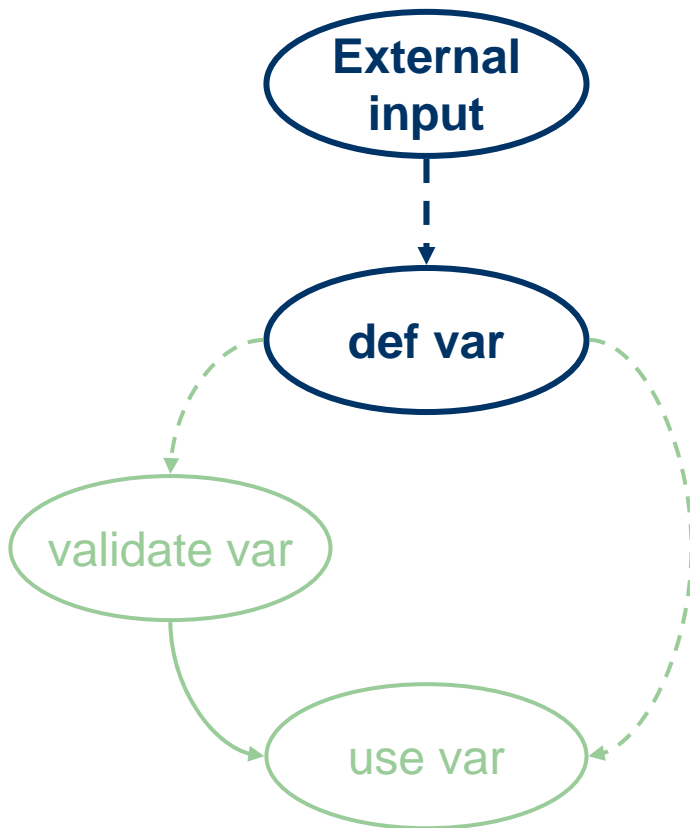
Input Validation



```
int func(int user_input){  
    int var;  
    ...  
    var = user_input * 5;  
    ...  
    if(var >= 0 && var < MAX)  
        for(i = 0; i < var; i++)  
            array[i] = 0;  
    ...  
}
```

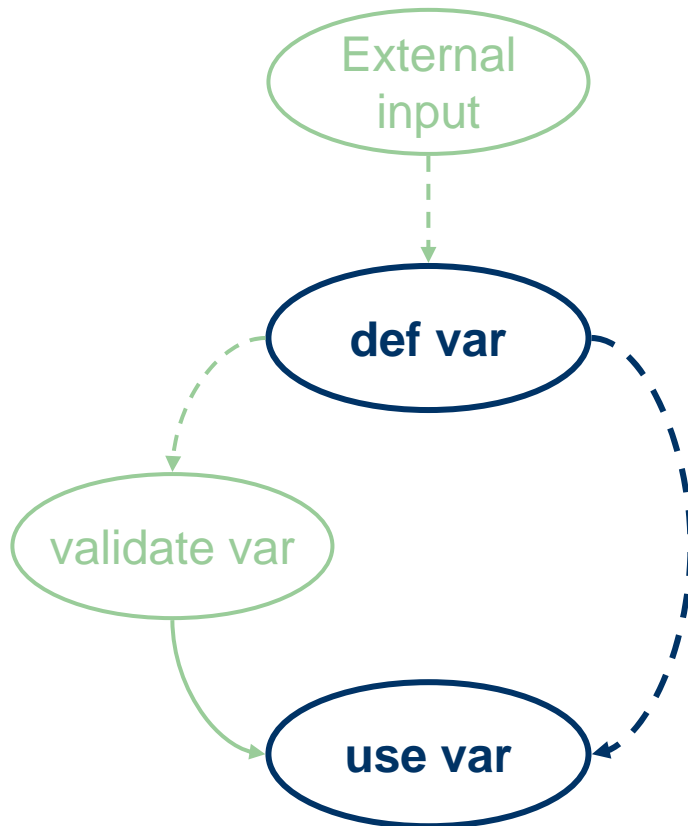
Model of good programming practice

Input Validation



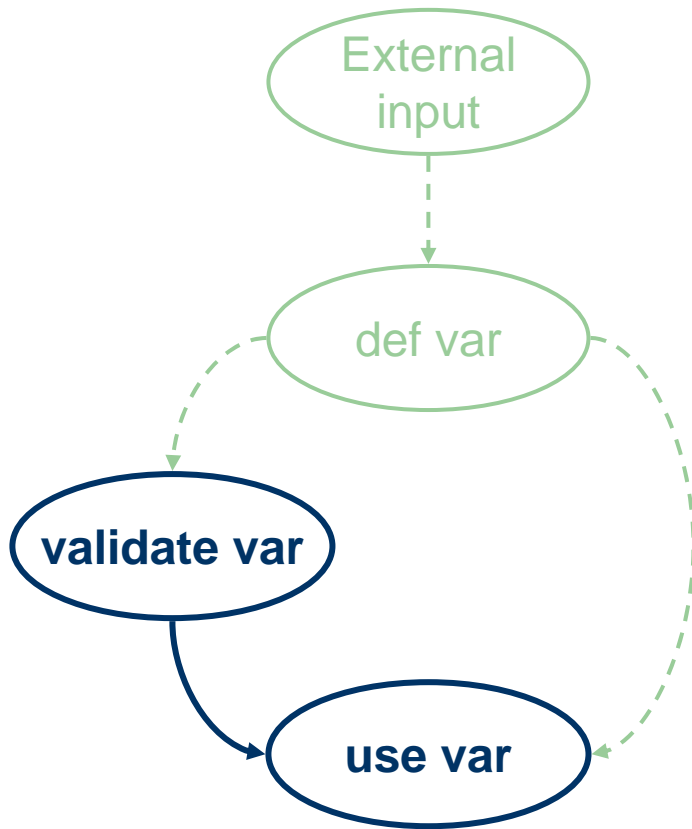
```
int func(int user_input){
    int var;
    ...
    var = user_input * 5;
    ...
    if(var >= 0 && var < MAX)
        for(i = 0; i < var; i++)
            array[i] = 0;
    ...
}
```

Input Validation



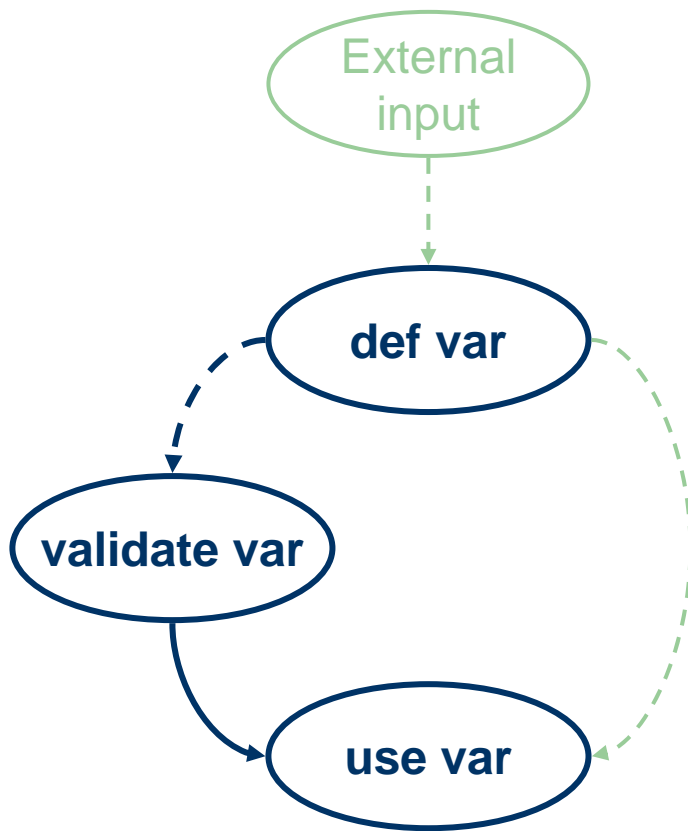
```
int func(int user_input){  
    int var;  
    ...  
    var = user_input * 5;  
    ...  
    if(var >= 0 && var < MAX)  
        for(i = 0; i < var; i++)  
            array[i] = 0;  
    ...  
}
```

Input Validation



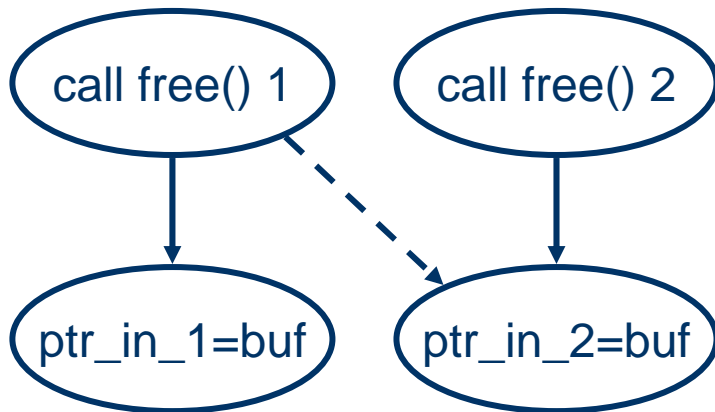
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int func(int user_input){
    int var;
    ...
    var = user_input * 5;
    ...
    if(var >= 0 && var < MAX)
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Input Validation



```
int func(int user_input){
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    ...
    if(var >= 0 && var < MAX)
        for(i = 0; i < var; i++)
            array[i] = 0;
    ...
}
```

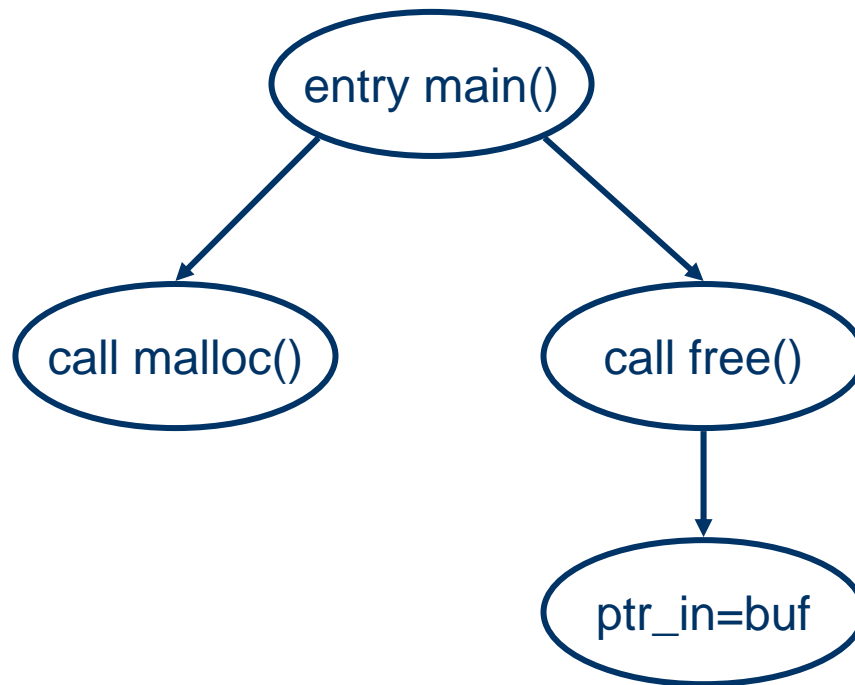
Double free



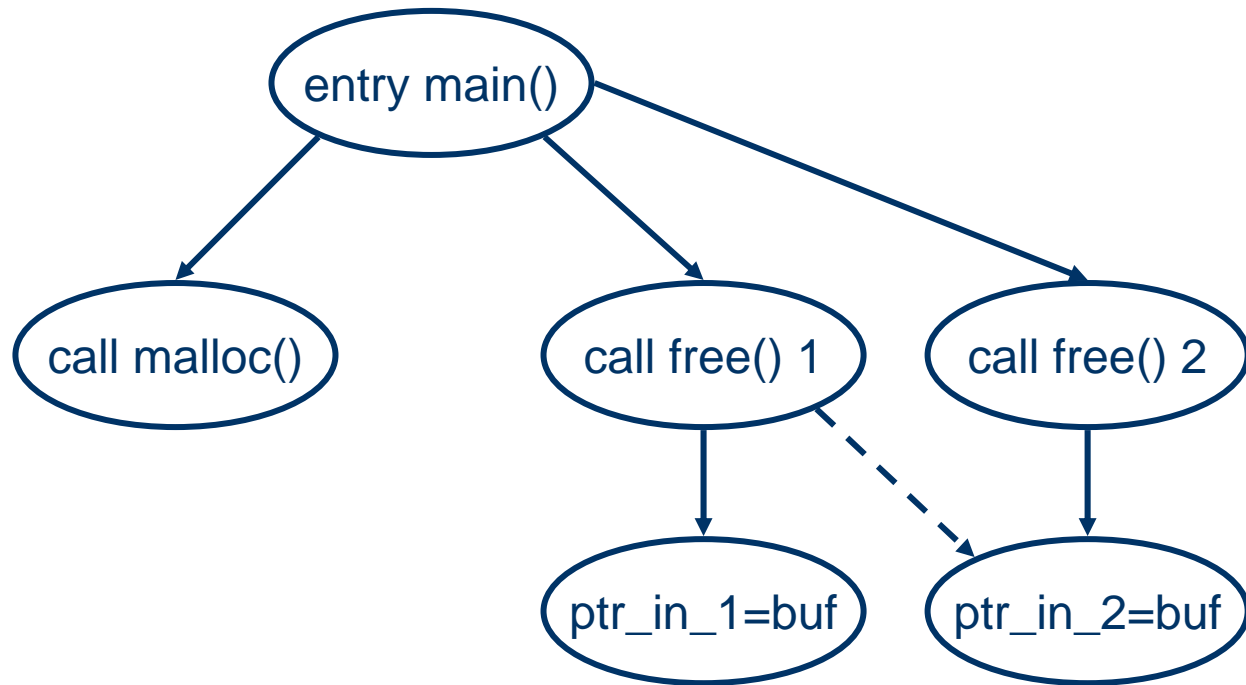
```
char *buf=(char *)malloc(MAX);  
...  
free(buf);  
...  
free(buf);
```

Model of bad programming practice

Double free



Double free



Current State

- CodeSurfer → XML → C++
- 15h for analysis of 20k lines of code
- Pattern matches integer input validation

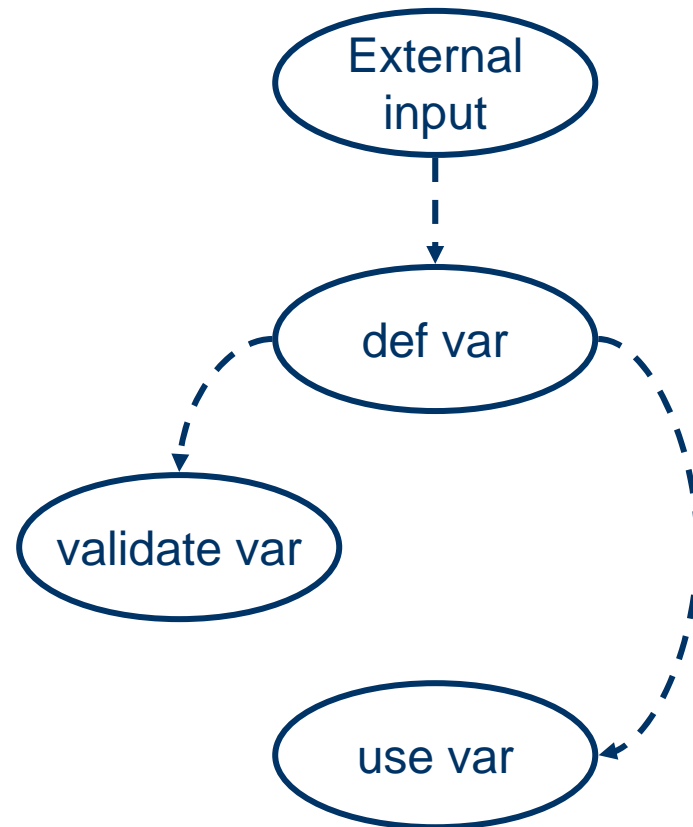
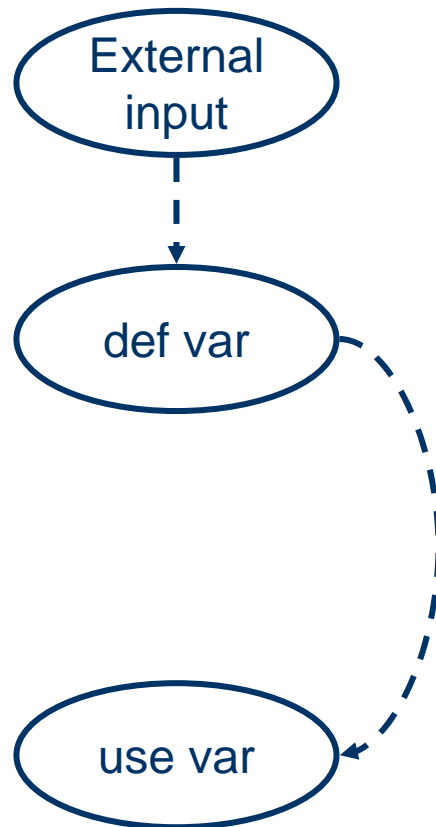
More Generic?

- We believe so
- Models for buffer overflow, integer flaws and double free

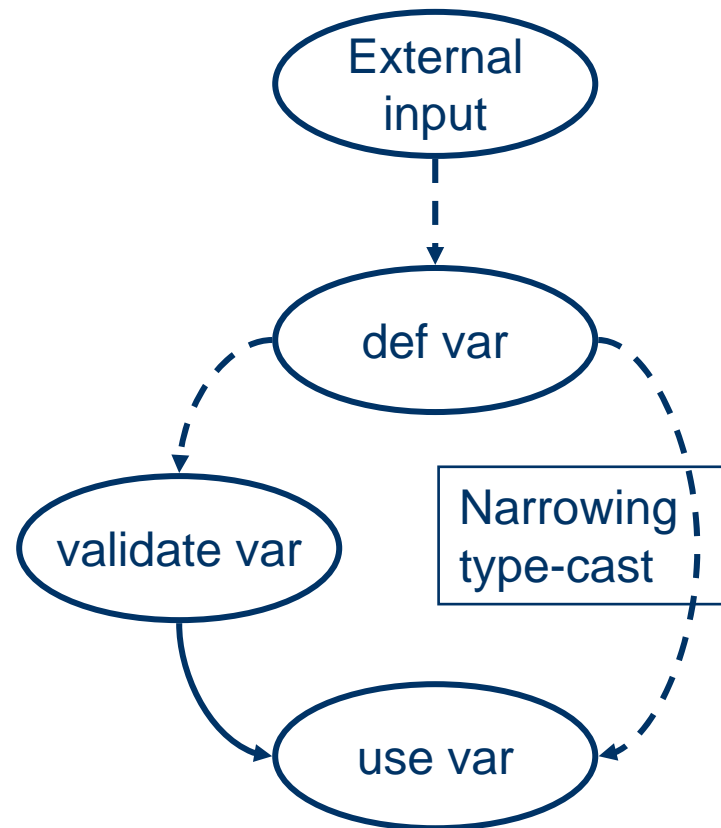
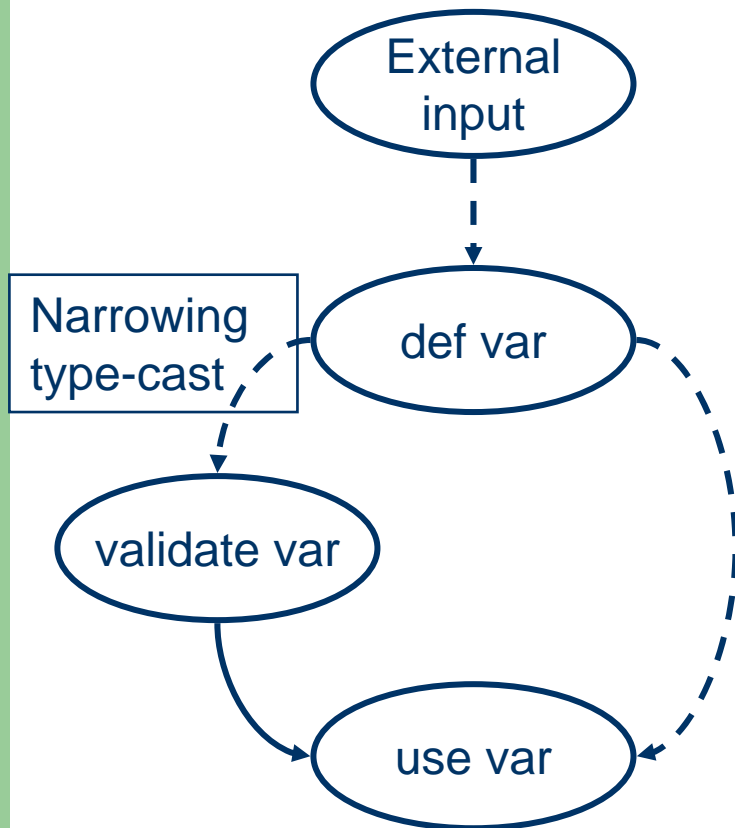
Ranking?

- More inaccuracy \Rightarrow lower rank
- Exploit *dual* of models

Ranking?



Ranking?



Visual?

- Graph models of flaw types
- Graph models of reported flaws

Future Work

- Complexity and scalability
- Accuracy
- Generality
- Usability
- Heuristic ranking
- Model Updates