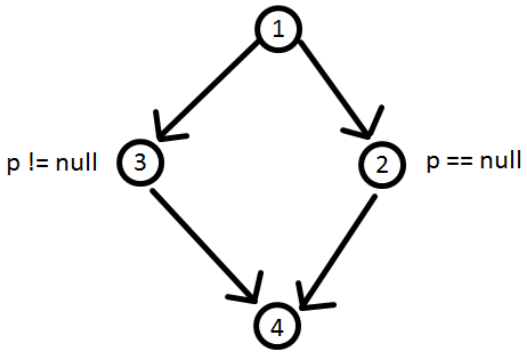
CS261 Lecture 5 (9/14)

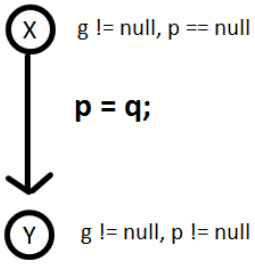
- **Pre-lecture Discussion**
  - Cell Phones
    - Mostly informal papers on vulnerabilities
    - Deal mostly with wifi
    - Mobile botnets not popular
      - Can't Monetize?
      - Non-uniformity platforms, no easy single attack
- **Project**
  - Previously seen ideas from past classes
    - Blacklist/regexps – 0% successful
      - s/</?SCRIPT[^>]*>//g
        - Attack via case sensitivity, spaces
        - <SCRI<SCRIPT>PT>
    - Whitelist tags+attributes – 70-80%
      - Dangerous tags like 'style'
    - Rewrite/transform/canonicalize – 90%
      - Broken if ambiguous parsing
      - UTF 7 bug with how greater than (or less than?) is encoded
  - HTML Filtering
    - Samy Worm on MySpace exploited filtering vulnerabilities
    - Send javascript to client to force correct parsing of html and rebuild the dom tree, rewrite document from newly formed tree
- **Static and Dynamic vulnerability detection**
  - Static Analysis
    - Suggests that you can detect vulnerabilities by running something directly on the code without executing it
    - Very recent field, came into the market within the last 4 years
    - Professor Wagner's simplest description of static analysis
      - Keep a set of predicates about the program, keep track of them at every point in the program
      - *Foo(char* p){*

        1) *if(p==null)*
        2) *return;*

        // infer p!=NULL before dereference, must prove over all executions that this holds true

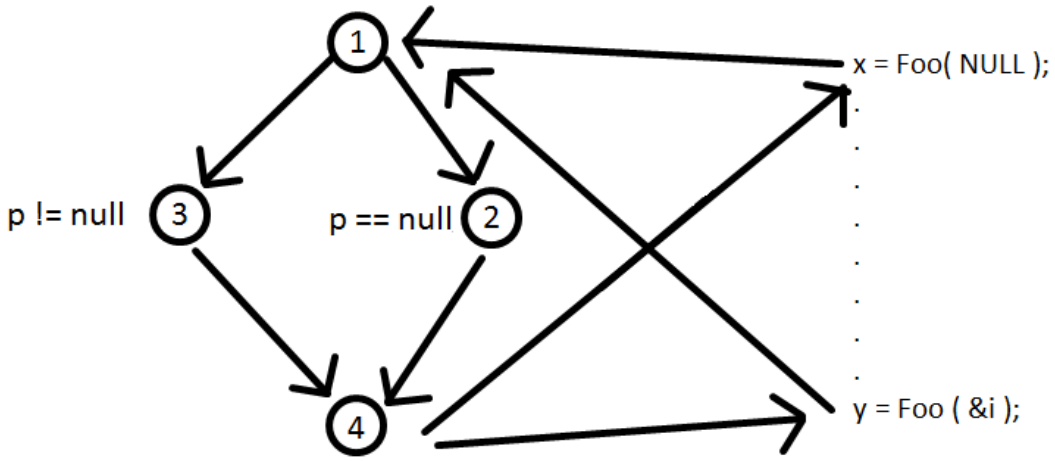
        3) **p = 'x'*
        4) *}*





- Evaluate predicates in topologically sorted order of these states
- Example above is very simplistic, leaves out:
  - Loops
  - possibly infinite number of predicates
  - points-to analysis (lose all information about the heap if a pointer into the heap gets written to)
  - data structures
  - virtual methods
  - functions that return values (simplistic analysis will not have any information about the value returned in the example above if it returned p instead of nothing)

```
Foo(char* p){
1) if(p==null)
2)         return p;
   // infer p!=NULL before dereference, must prove over all executions that this holds true
3) *p = 'x'
4) return p;
   }
```



  - Even worse if recursive (loops in the graph)
- All static analysis either misses bugs or gives false positives (or run forever…)
  - Commercial products try very hard to give a 30% false positive rate
  - Quality -> less false positives, more missed bugs
  - Security -> more false positives, try to hit more bugs
- Need to write this logic in arbitrary first order logic
  - Very tough, so most annotation languages are restricted to a smaller set and focus on a specific vulnerability (e.g. buffer overruns)
  - Also, need to annotate all functions. Very costly.
  - Microsoft SAL

- Dynamic Analysis
  - EXE
    - Boolean values per bit, reason symbolically about the state at each point of execution
    - Checks if there is any possible input to trigger an error via SAT solver
    - Example:
      - y = x + z
      - boolean variables α_{x0} …α_{x31} α_{y0}…α_{y31} α_{z0}…α_{z31}

        - generate a new boolean variable for addition via $\beta_{yi} = \alpha_{xi}$ XOR α_{zi}
    - Turns out that the number of constraints per instructions isn't that big and SAT solvers have gotten so good that it works well even on large programs
- Taint tracking
    - Constraints on taint propagation hard to do
    - Strings are hard to reason about (e.g. long, regex, other complex processing)
        - If you restrict string lengths, you can reason about it in a bitwise manner and use a SAT solver
- Hybrid analysis: using both symbolic execution and static analysis to try and find dangerous inputs