Systems and Internet Infrastructure Security

Network and Security Research Center
Department of Computer Science and Engineering
Pennsylvania State University, University Park PA

Wrap-Up

December 5, 2011

What do I think you know?

- Exam
- Sharir-Pnueli
- Key elements of papers

Exam

- Vulnerability – definition
- Static analysis – Chapter 2
  - Definitions for basic concepts
  - Abstract domain
  - Dataflow problem
  - Join/Meet and Path
  - Join-over-all-paths
  - Join-over-all-valid-paths

Exam

- Somewhat more complex topics
  - Flow-sensitivity or not … Context-sensitivity or not
    - Would you know it if you saw it applied?
  - Configurations and past/future
    - P-automaton and prestar and poststar and
    - What's the point? Relate concepts to specifics?
  - Weighted pushdown system concepts
    - Assume you know what an FSA and PDA are
    - Good for asking about dataflow problems
    - Probably I'll have to explain a bit

Exam

- Lots of abstract domains and composition functions and join/meet functions
    - What do they mean? How might they affect results?
    - I'll have to help with these

Exam

- Key concepts
  - Every paper has a key concept
  - What do you think it is?

Return-oriented programming

- The execution model
- Instruction pointer is stack
    - Followed by executing until a return occurs
    - Data is also on the stack (push and pop into registers)
    - Connecting gadgets together

Control-Flow Integrity

- Approach enforces possible *valid control flows (paths)*
  - A calls B at instruction X
  - B must return to X+1
- However, there are difficulties due to imprecision
  - What are these and how are they dealt with?

Metal and MC

- Cast bug finding as a dataflow problem
- Each variable is associated with a state
- Transition rules change among states
  - Source state, pattern, destination state
- Dataflow problem
  - ICFG
  - Join semilattice
  - Initial value
  - Assignment

Information Flow Analysis

- Systems and programs define data flows
  - How do you make a graph?
- Information flow policy as lattice
- Some nodes are labeled using lattice levels
- Find information flow errors
  - What is an information flow error?
  - How does this relate to dataflow problem?

SAT Solvers

- Several different techniques applied
- The exam required Stalmark and Sakallah
- How do those work?

Compiler

- Ccured has a specific goal
  - What is it?
- LLVM paper was about vision
  - What is their vision?

Namespaces

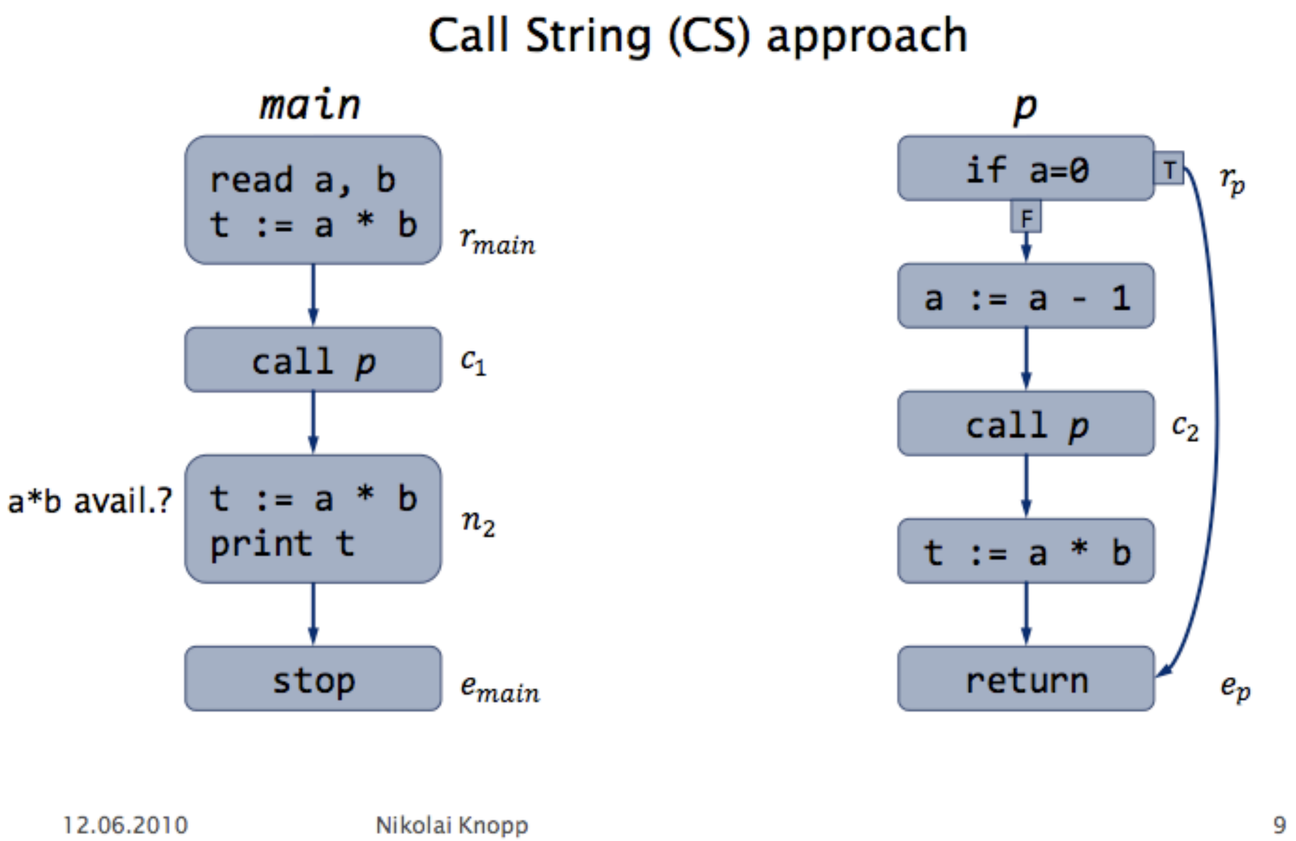
- Each paper has a major claim
  - What are they?
  - What do they mean?
- Chari et al
- Cai et al

Attack Graphs

- MulVal
  - How does it express attacks?
- Datalog
  - Clauses
  - Limitations
- Our approach
  - Information flow and cuts

Sharir-Pnueli

- Call Strings



Call String (CS) approach

main

read a, b
t := a * b

r_{main}

call *p*

c_1

a*b avail.?

t := a * b
print t

n_2

stop

e_{main}

p

if a=0

T

F

r_p

a := a - 1

call *p*

c_2

t := a * b

return

e_p

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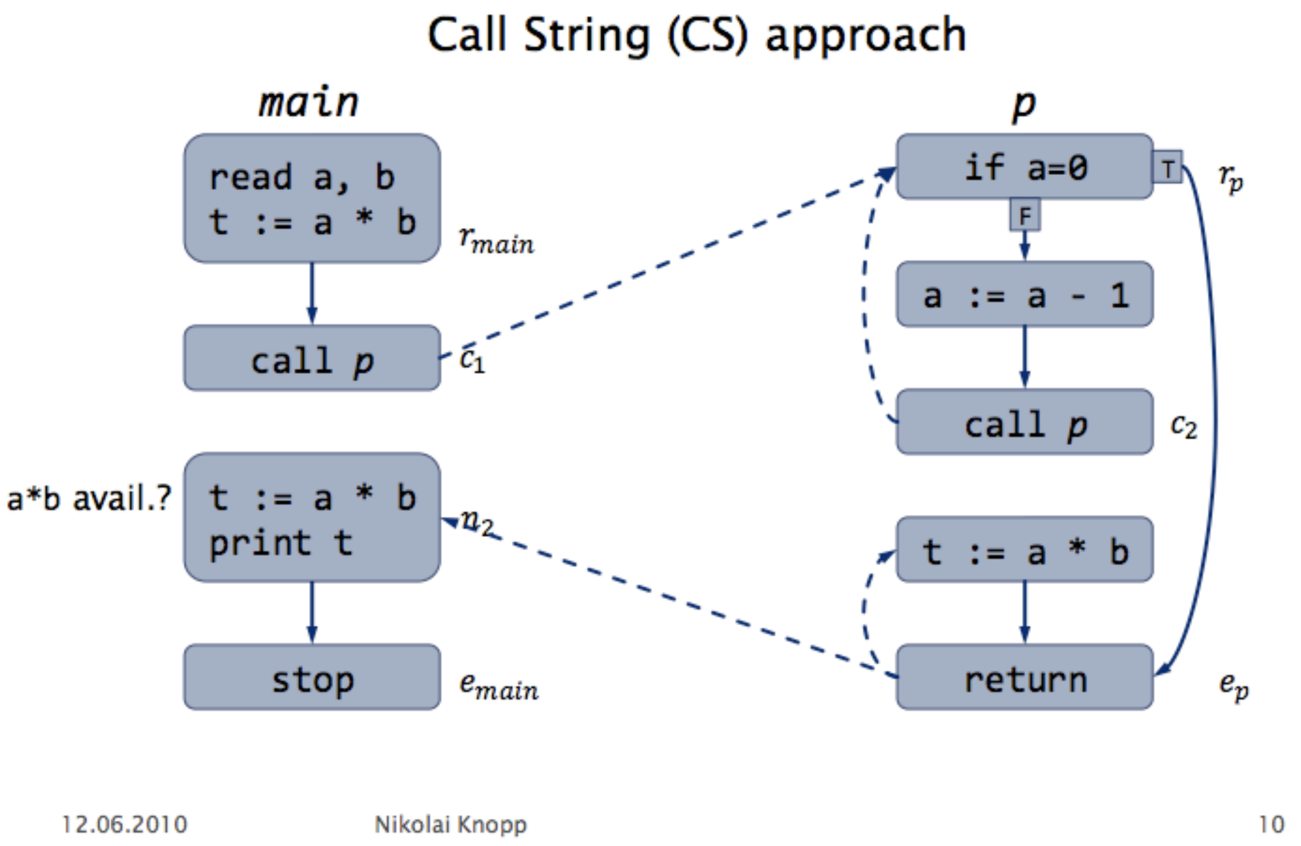
Sharir-Pnueli

- Call Strings



Call String (CS) approach

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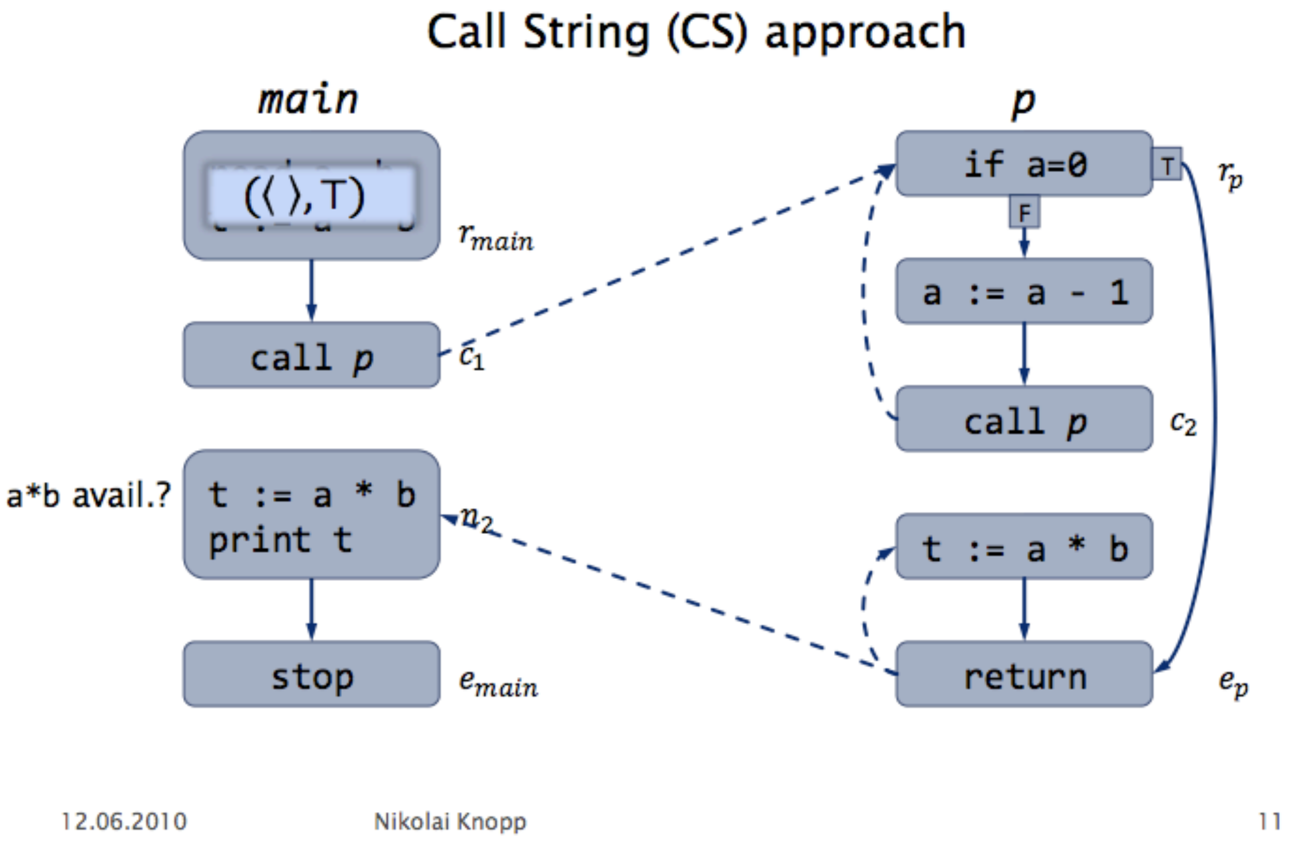
Sharir-Pnueli

- Call Strings



Call String (CS) approach

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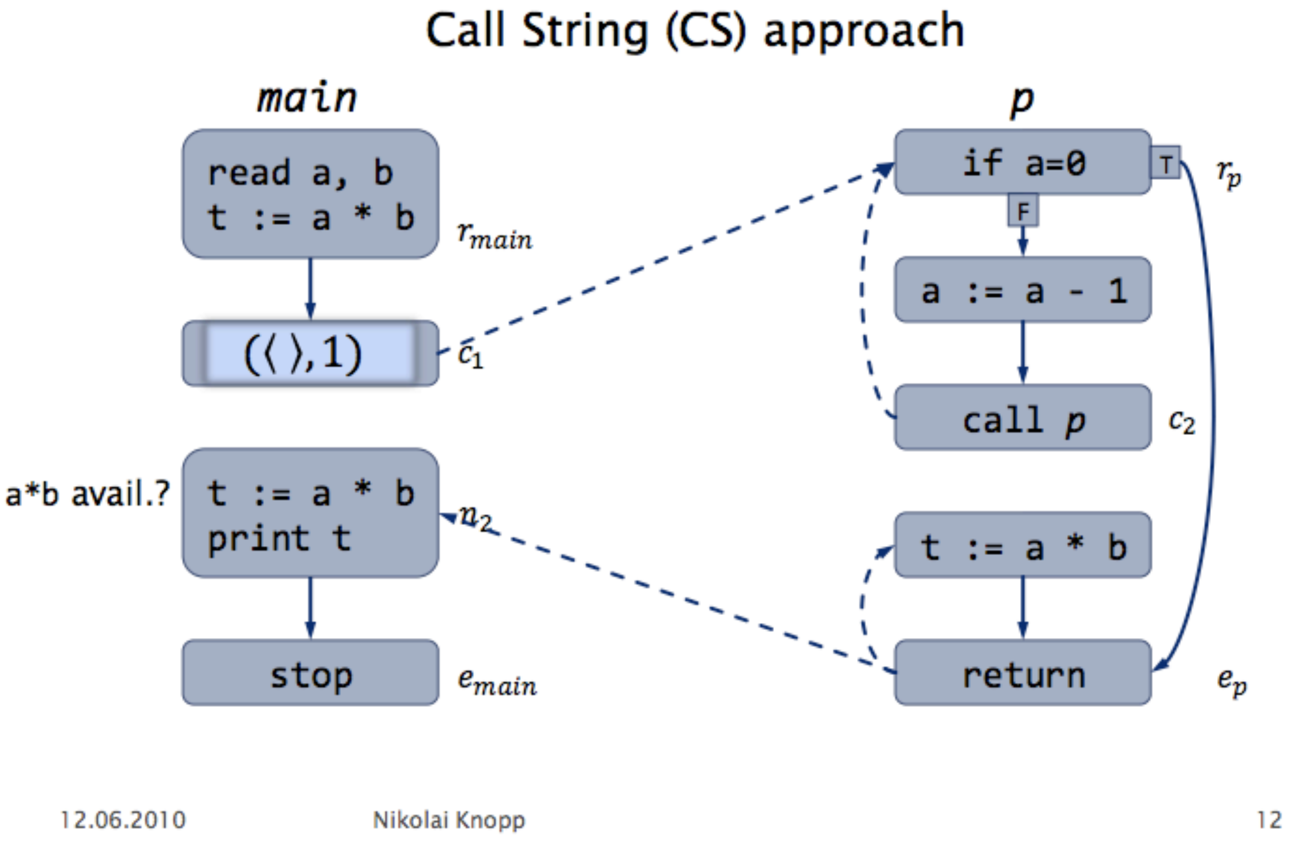

Call String (CS) approach

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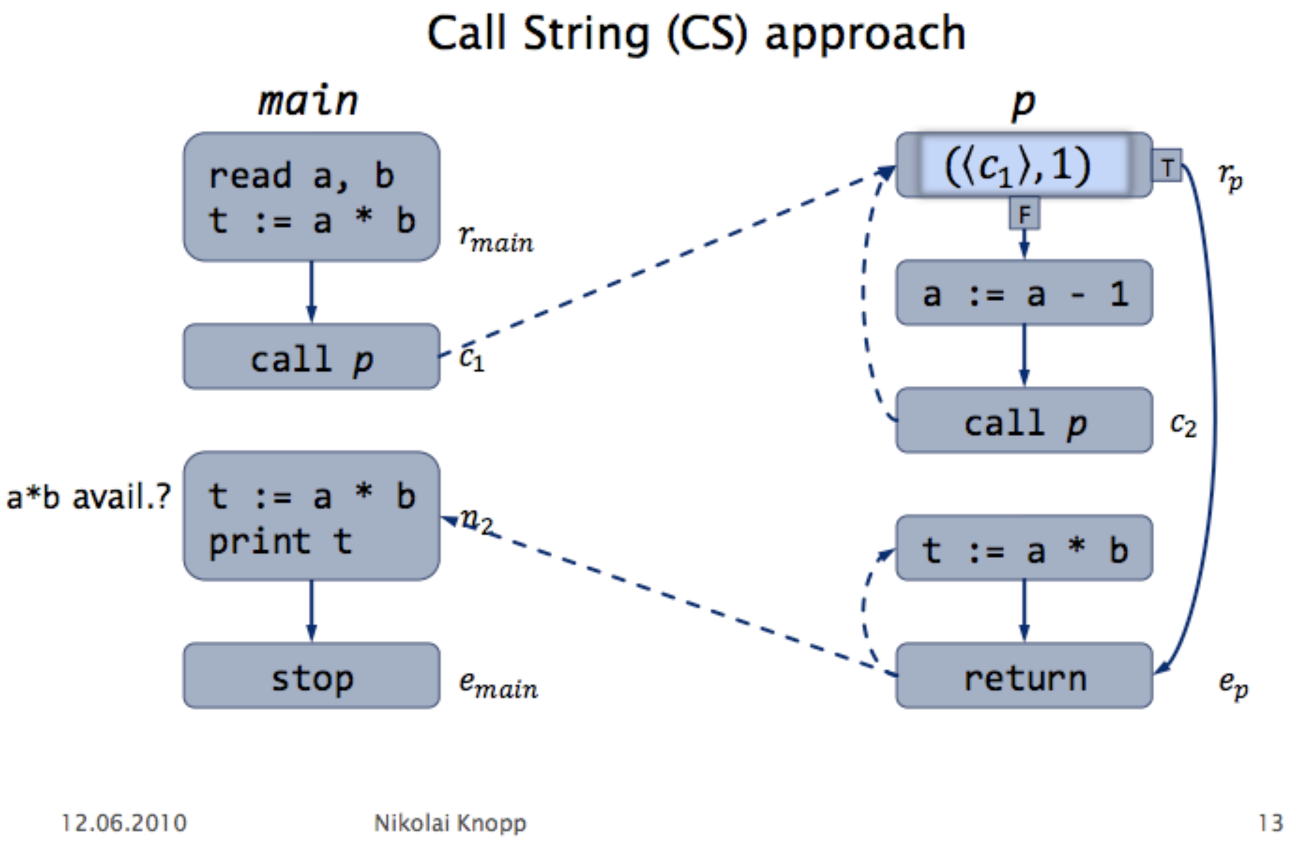

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t := a * b
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```
call p
```

```
t := a * b
print t
```

```
stop
```

p

```
a := a - 1
```

```
call p
```

```
t := a * b
```

```
return
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Sharir-Pnueli

- Call Strings

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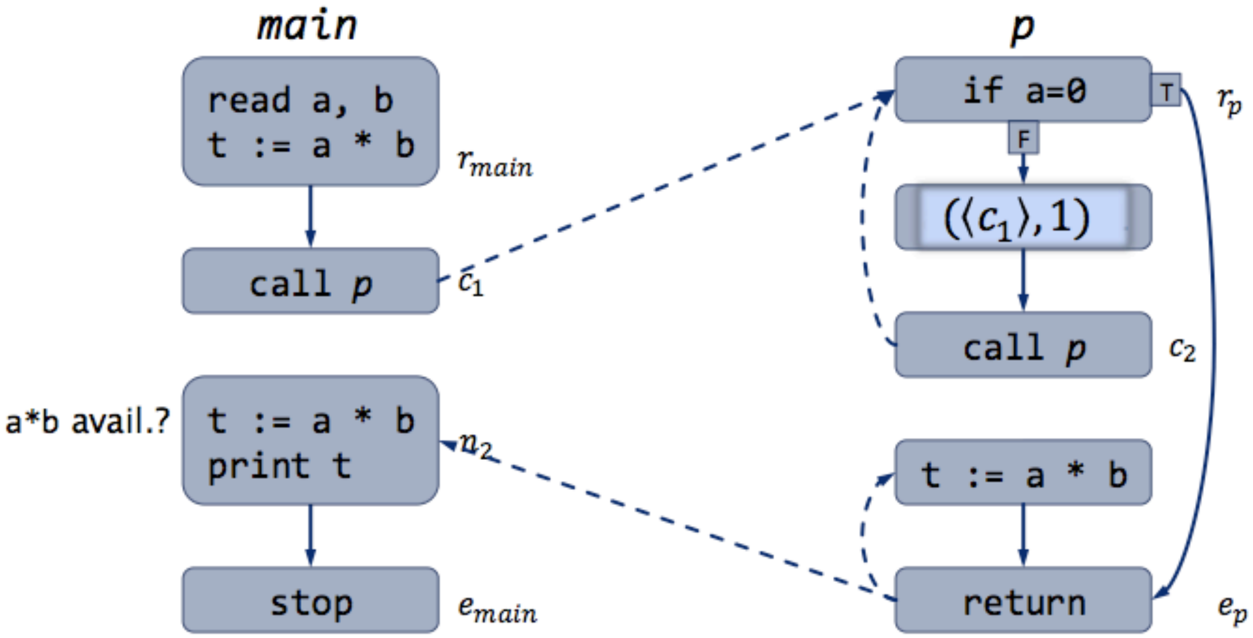

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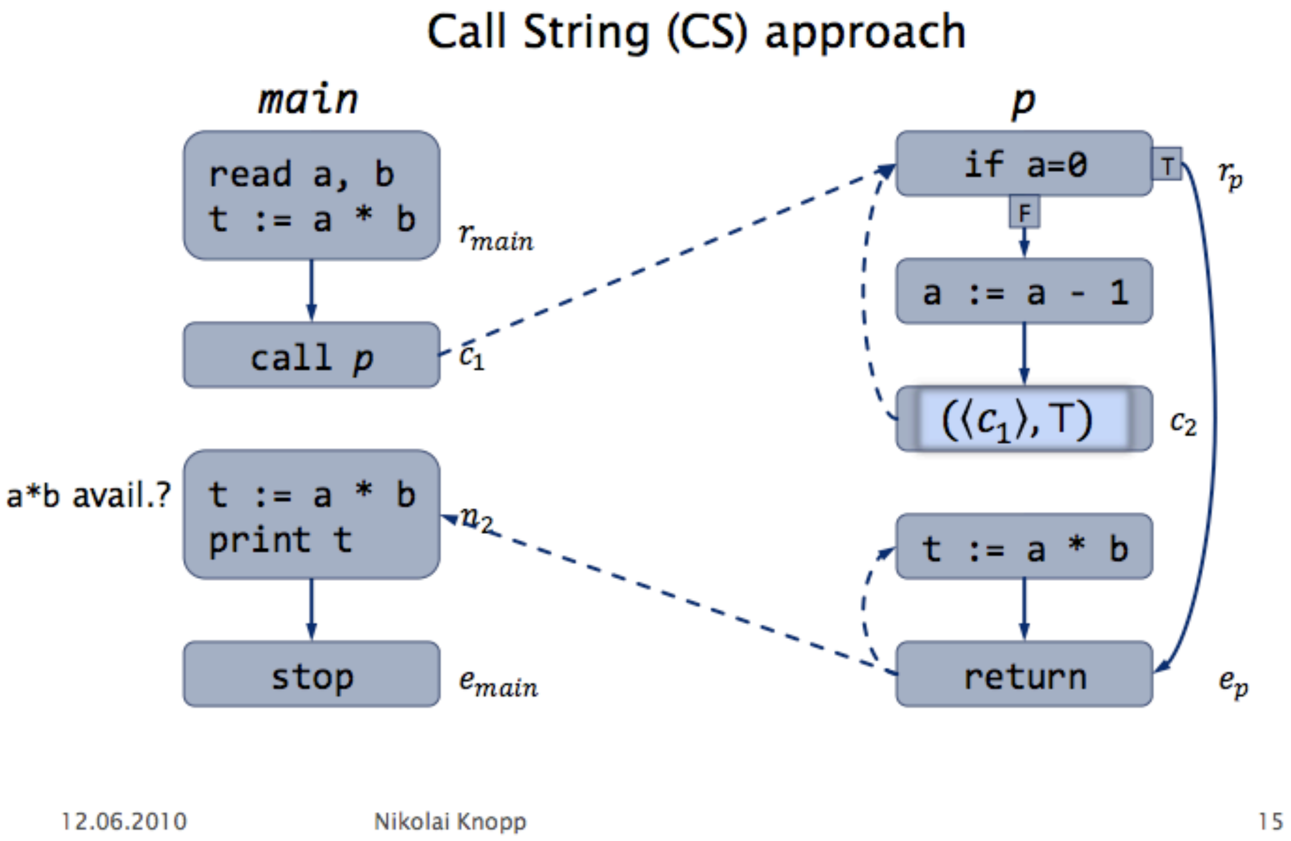
- Call Strings



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t := a * b
print t
```

```
stop
```

p

```
if a=0
```

```
a := a - 1
```

$(\langle c_1 \rangle, \mathrm{T})$

```
t := a * b
```

```
return
```

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Sharir-Pnueli

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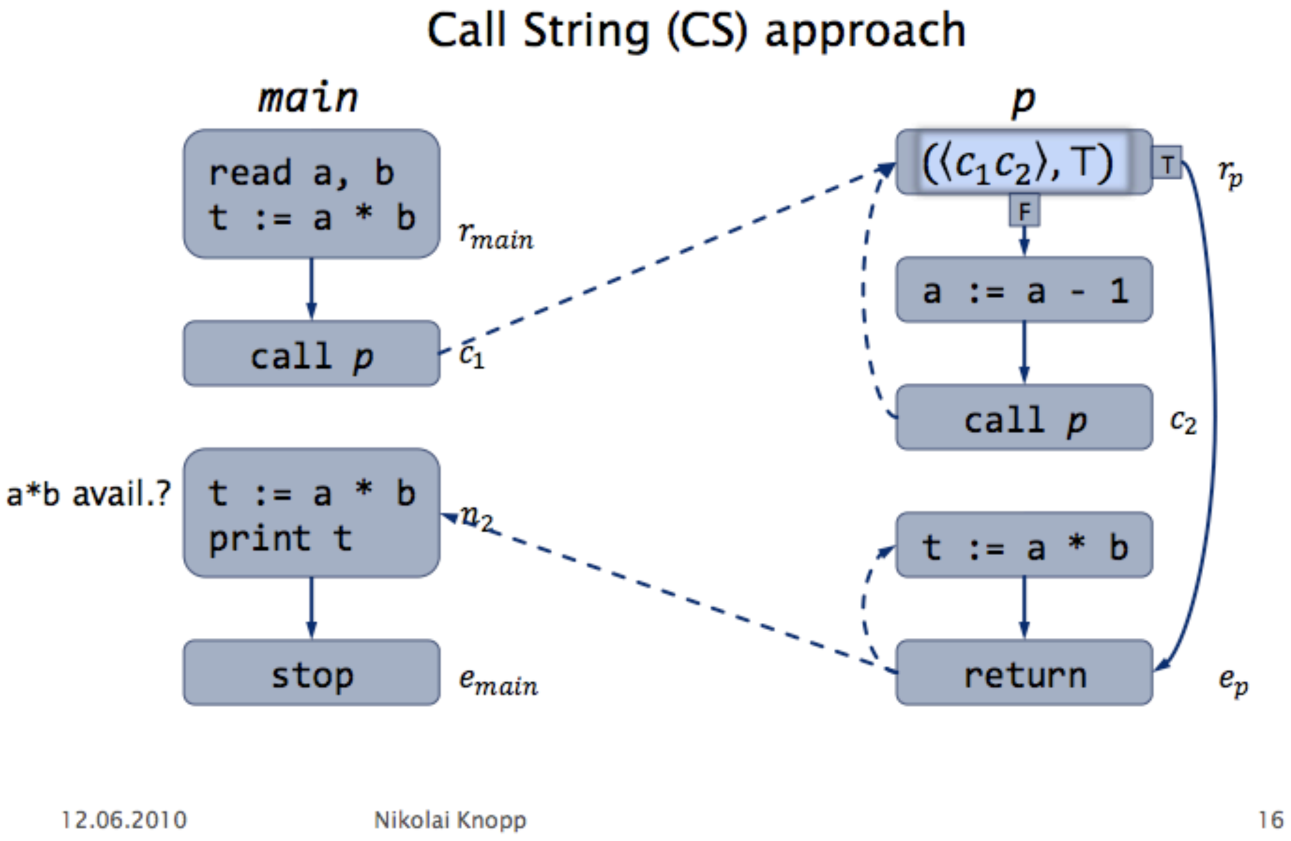

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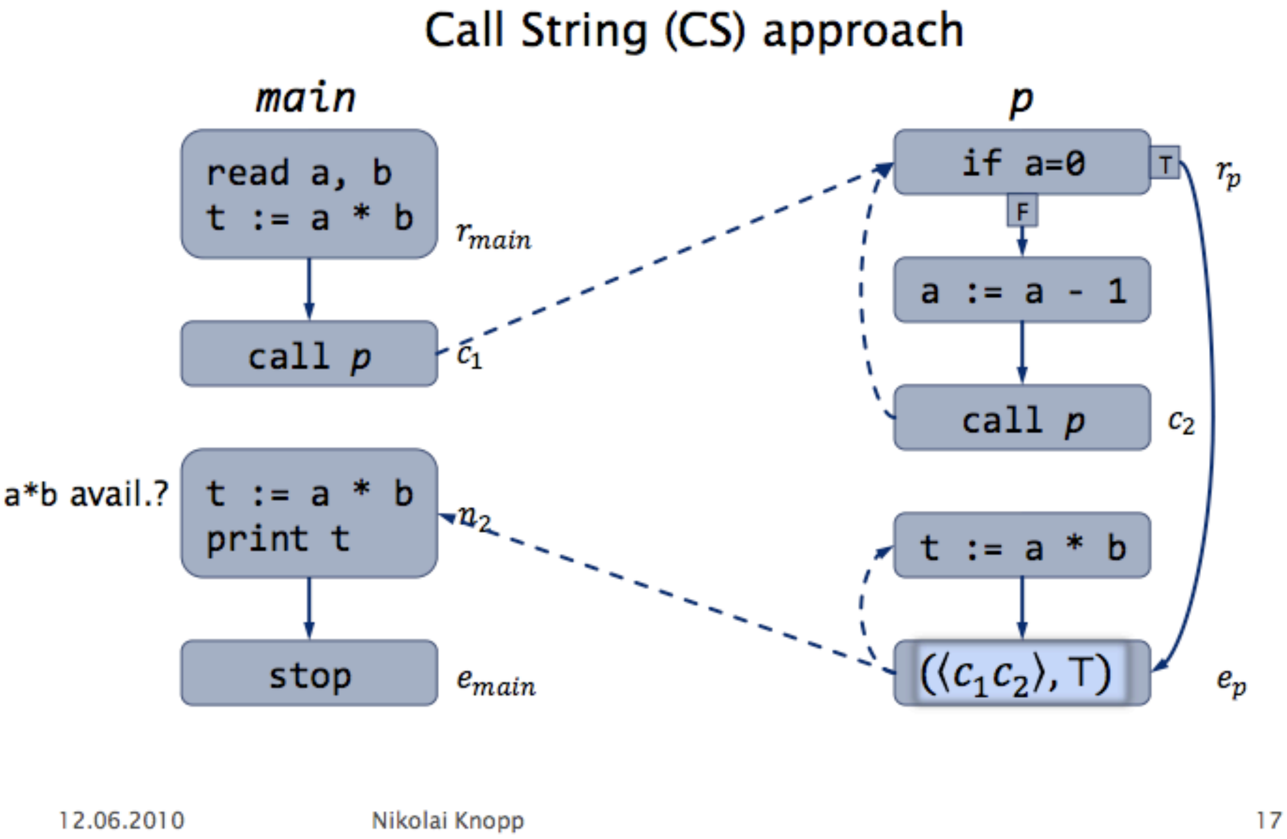

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Sharir-Pnueli

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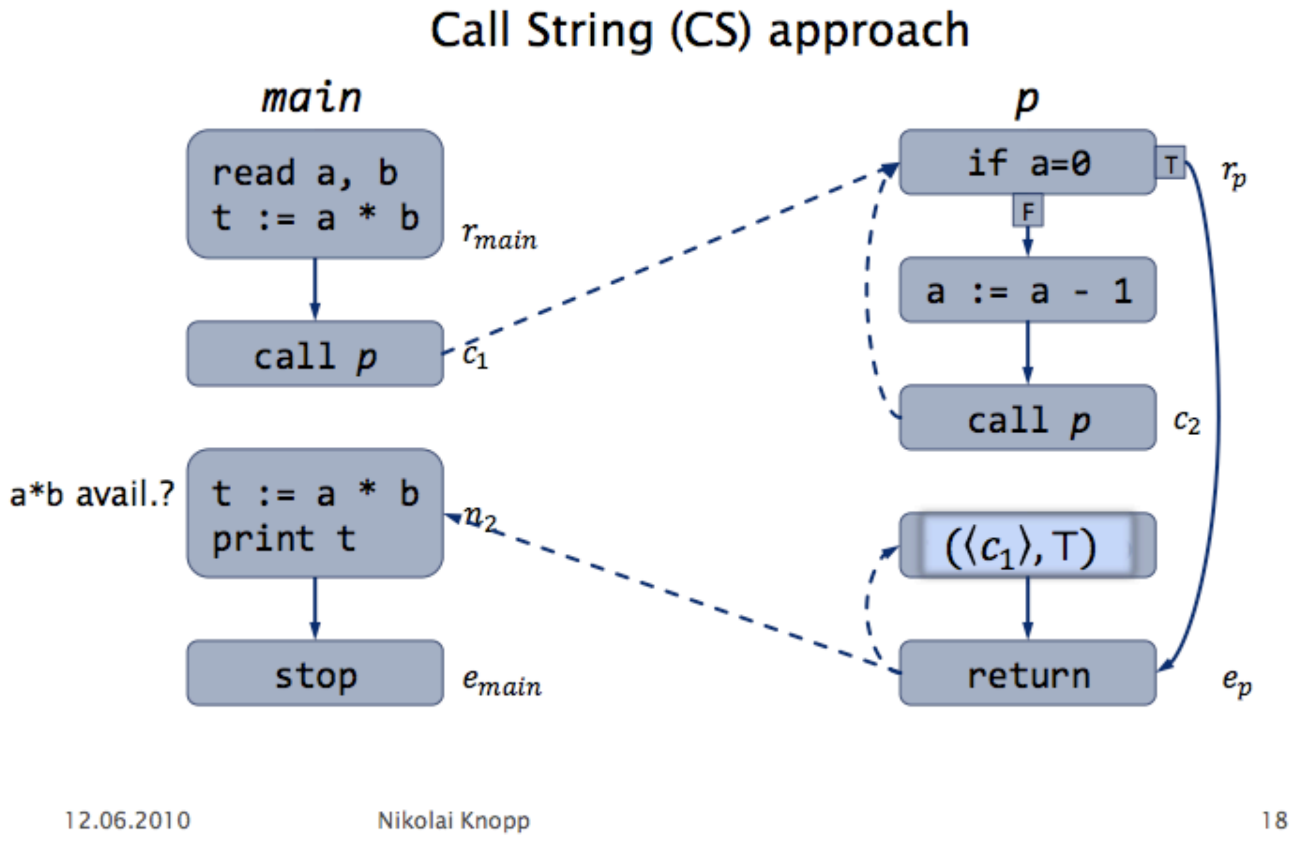

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$(\langle c_1 \rangle, \top)$

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e_p

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Sharir-Pnueli

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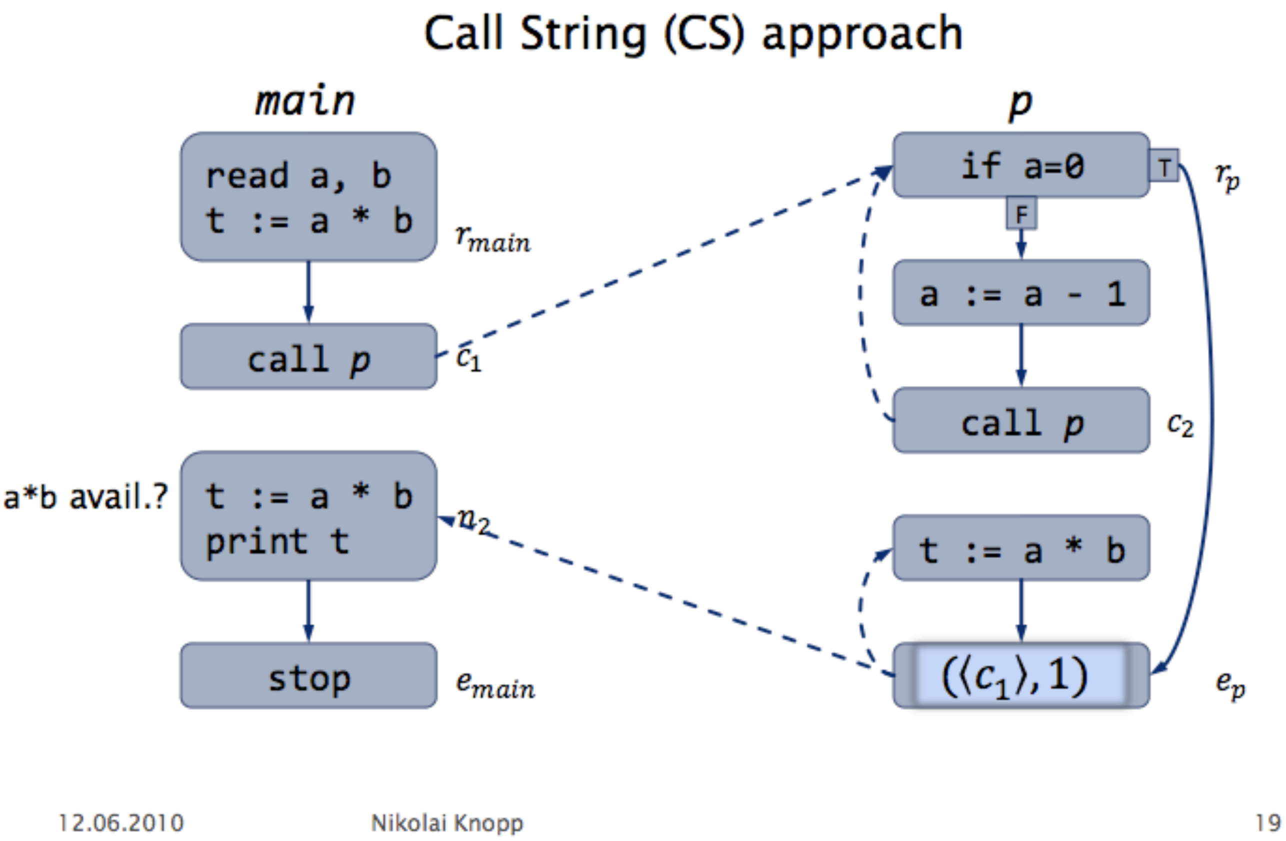

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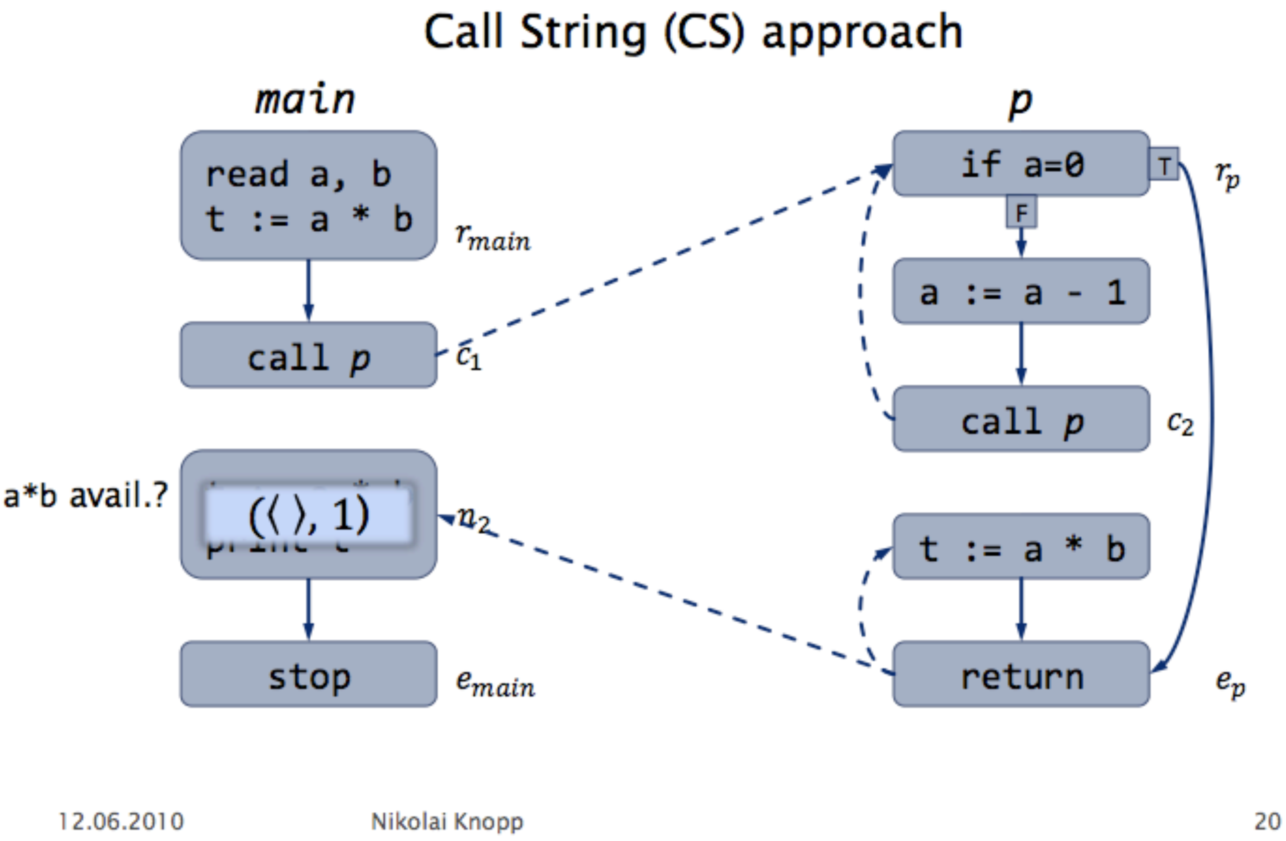

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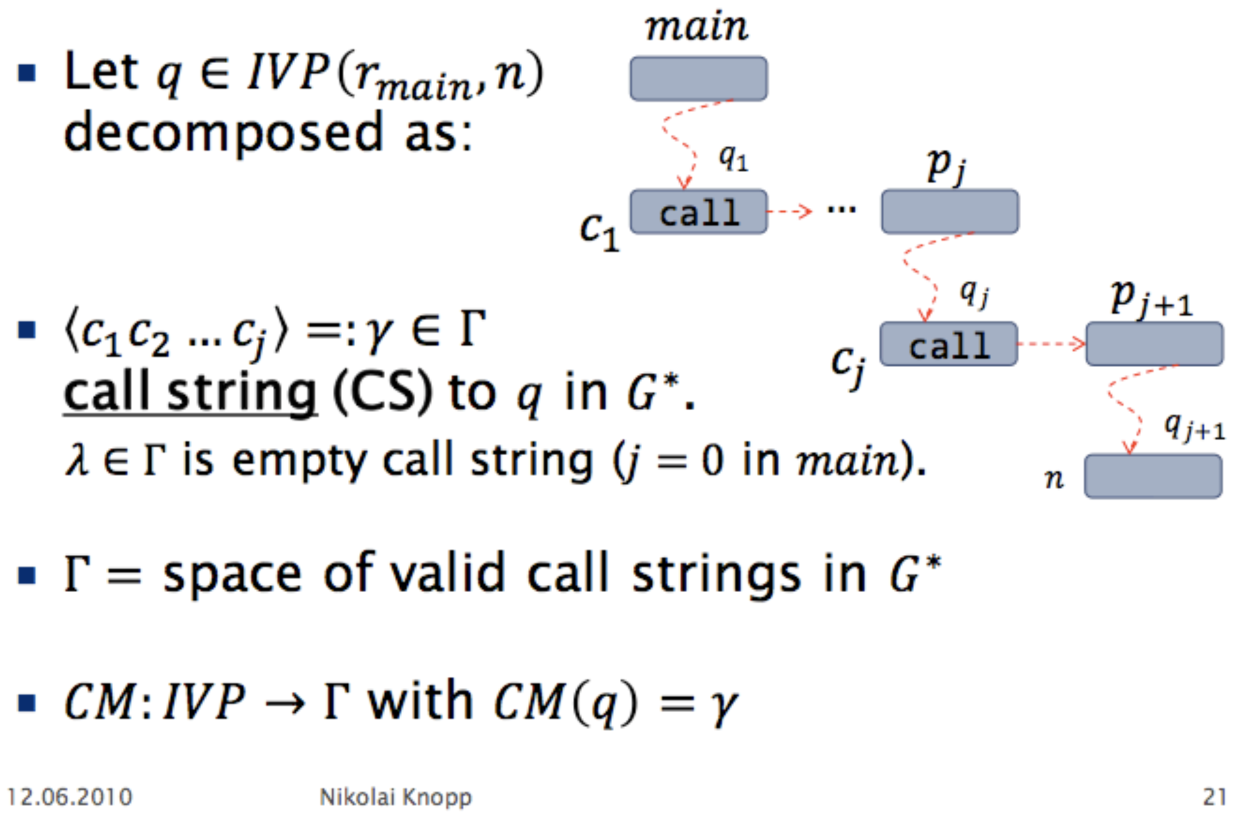

- Let $q \in IVP(r_{main}, n)$ decomposed as:
- $\langle c_1 c_2 \ldots c_j \rangle =: \gamma \in \Gamma$ call string (CS) to q in G^*.
  $\lambda \in \Gamma$ is empty call string ($j = 0$ in $main$).
- $\Gamma =$ space of valid call strings in G^*
- $CM: IVP \to \Gamma$ with $CM(q) = \gamma$

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Sharir-Pnueli

- Tracks calls, returns
- Prevents invalid flows
  - Why?

Exam

- 13 - Context inlining
  - Versus summary function approach
- 14 - GRASP (Sakallah approach)
  - Adding new constraints
- 15 – Ccured
  - Qualifiers? SAFE, SEQ, DYNQ
  - Constraints on qualifier values – find valid solution (ARITH, CONV, POINTSTO, TYPEEQ)
  - Constraint solving and minimality

Exam

- 16 - ROP
  - Stack 10, 20, 30, 50
  - Add constant: 10, CONST, 20, 30, 50
  - Gadget 10 must push output, and gadget 20 must pop constant and output
- 17 – Creative
- 18 – abstract domain and dataflow problem
  - Domain: A set of states defined by rules
  - CFG: CFG
  - Join – probably a union
  - Initial value is null
  - Assignments – transitions in rules

Exam

- 19 – Code
  - (a) PDS: should be able to do that
  - (b, c) Valid flow – should be able to identify valid and invalid flows
  - (d) P-automaton
    - Configuration {<p, e_main>}
    - P → e_main → accept
    - Configuration {<p, e_main … n6n9>}
    - P→sequence of transitions for valid→ accept

Exam

- (e) Prestar
  - Configuration {<p, e_main … n6n9>}
  - (p, n5) → (p, n6) & (p,n6) → (p, n9) & (p, n9) →(acc,e)
  - (p, n5, acc)
  - Basically, all reachability paths to n9 via configuration (i.e., in the P-Automaton) lead to accepting state

Exam

- 20 – Policy
  - (a) Build dataflow graph
  - (b) Reachability from and to t
  - (c) Stoller rule-specific
  - (d) Stoller TCB
  - (e) DLM – intersection of readers