

Assignment 2

Yulei Sui

University of Technology Sydney, Australia

Assignment 2: Quizzes + A Coding Task

- Two sets of quizzes (10 points)
 - LLVM compiler and its intermediate representation
 - Code graphs (including ICFG and PAG)
- One coding task (10 points)
 - **Goal:** implement a context-sensitive graph traversal on ICFG and print **feasible** paths from a source node to a sink node on the graph

Assignment 2: Quizzes + A Coding Task

- Two sets of quizzes (10 points)
 - LLVM compiler and its intermediate representation
 - Code graphs (including ICFG and PAG)
- One coding task (10 points)
 - **Goal:** implement a context-sensitive graph traversal on ICFG and print **feasible** paths from a source node to a sink node on the graph
 - **Specification and code template:** <https://github.com/SVF-tools/Teaching-Software-Verification/wiki/Assignment-2>
 - **SVF CPP API** <https://github.com/SVF-tools/Teaching-Software-Verification/wiki/SVF-APIs>

You are encouraged to finish the quizzes before starting your coding task.

Context-Sensitive Control-Dependence

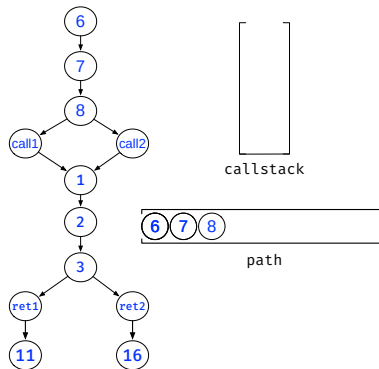
Algorithm 1 Context sensitive control-flow reachability

Input : curEdge : ICFGEdge dst : ICFGNode path : vector<ICFGEEdge> visited : set<ICFGEEdge, callstack>;

```
1 dfs(path, curEdge, dst)
2   curItem  $\leftarrow$  <curEdge, callstack>
3   visited.insert(curItem)
4   path.push_back(curEdge)
5   if src == dst then
6     printICFGPath(path)
7   foreach edge  $\in$  curEdge.dst.getOutEdges() do
8     if edge.dst  $\notin$  visited then
9       if edge.isIntraCFGEEdge() then
10         dfs(path, edge, dst)
11       else if edge.isCallCFGEEdge() then
12         callNode  $\leftarrow$  getSrcNode(edge)
13         callstack.push_back(callNode)
14         dfs(path, edge, dst)
15       else if edge.isRetCFGEEdge() then
16         if callstack  $\neq \emptyset$  && callstack.back() == edge.getCallSite() then
17           callstack.pop()
18           dfs(path, edge, dst)
19         else if callstack ==  $\emptyset$  then
20           dfs(path, edge, dst)
21   visited.erase(curItem)
22   path.pop_back()
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG

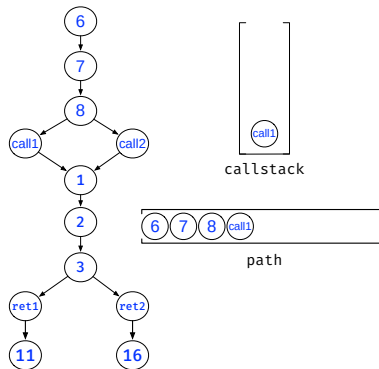


Algorithm 1 Context sensitive control-flow reachability

```
Input : curEdge : ICFGEdge  dst : ICFGNode path : vector(ICFGE)  visited : set(ICFGE, callstack);  
1  dfs(curEdge, dst)  
2  curItem ← (curEdge, callstack)  
3  visited.insert(curItem)  
4  path.push_back(curEdge)  
5  if src == dst then  
6  | printICFGPath(path)  
7  foreach edge ∈ curEdge.dst.getOutEdges() do  
8  | if edge.dst ∉ visited then  
9  | | if edge.isIntraCFGE() then  
10 | | | dfs(path, edge, dst)  
11 | | else if edge.isCallCFGE() then  
12 | | | callNode ← getSrcNode(edge)  
13 | | | callstack.push_back(callNode)  
14 | | | dfs(path, edge, dst)  
15 | | else if edge.isRetCFGE() then  
16 | | | if callstack ≠ ∅ && callstack.back() == edge.getCallSite() then  
17 | | | | callstack.pop()  
18 | | | | dfs(path, edge, dst)  
19 | | | else if callstack == ∅ then  
20 | | | | dfs(path, edge, dst)  
21  visited.erase(curItem)  
22  path.pop_back()
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG

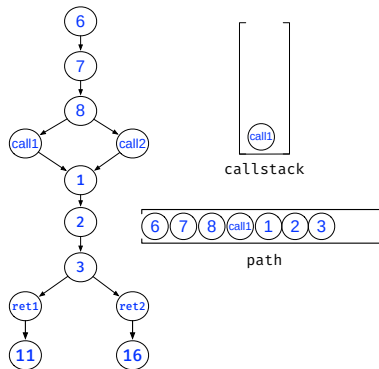


Algorithm 1 Context sensitive control-flow reachability

```
Input : curEdge : ICFGEdge  dst : ICFGNode path : vector(ICFGEEdge)  visited : set(ICFGEEdge, callstack);  
1 dfs(curEdge, dst)  
2   curItem ← (curEdge, callstack)  
3   visited.insert(curItem)  
4   path.push_back(curEdge)  
5   if src == dst then  
6   | printICFGPath(path)  
7   foreach edge ∈ curEdge.dst.getOutEdges() do  
8   | if edge.dst ∉ visited then  
9   | | if edge.isIntraCFGEEdge() then  
10  | | | dfs(path, edge, dst)  
11  | | else if edge.isCallCFGEEdge() then  
12  | | | callNode ← getSrcNode(edge)  
13  | | | callstack.push_back(callNode)  
14  | | | dfs(path, edge, dst)  
15  | | else if edge.isRetCFGEEdge() then  
16  | | | if callstack ≠ ∅ && callstack.back() == edge.getCallSite() then  
17  | | | | callstack.pop()  
18  | | | | dfs(path, edge, dst)  
19  | | | else if callstack == ∅ then  
20  | | | | dfs(path, edge, dst)  
21  visited.erase(curItem)  
22  path.pop_back()
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG

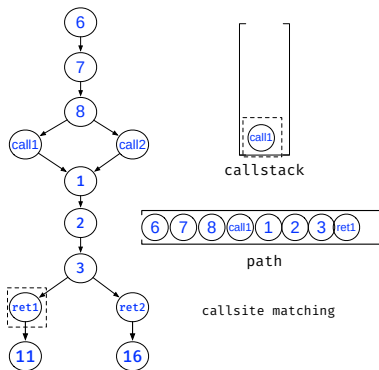


Algorithm 1 Context sensitive control-flow reachability

```
Input : curEdge : ICFGEdge  dst : ICFGNode path : vector(ICFGE)  visited : set(ICFGE, callstack);  
1  dfs(curEdge, dst)  
2  curItem ← (curEdge, callstack)  
3  visited.insert(curItem)  
4  path.push_back(curEdge)  
5  if src == dst then  
6    printICFGPath(path)  
7  foreach edge ∈ curEdge.dst.getOutEdges() do  
8    if edge.dst ∉ visited then  
9      if edge.isIntraCFGE() then  
10         dfs(path, edge, dst)  
11      else if edge.isCallCFGE() then  
12         callNode ← getSrcNode(edge)  
13         callstack.push_back(callNode)  
14         dfs(path, edge, dst)  
15      else if edge.isRetCFGE() then  
16         if callstack ≠ ∅ && callstack.back() == edge.getCallSite() then  
17           callstack.pop()  
18           dfs(path, edge, dst)  
19         else if callstack == ∅ then  
20           dfs(path, edge, dst)  
21  visited.erase(curItem)  
22  path.pop_back()
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG

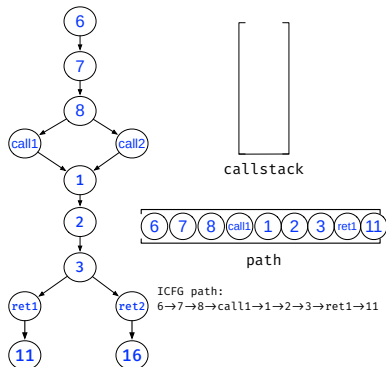


Algorithm 1 Context sensitive control-flow reachability

```
Input : curEdge : ICFGEdge  dst : ICFGNode path : vector(ICFGE)  visited : set(ICFGE, callstack);  
1 dfs(curEdge, dst)  
2   curItem  $\leftarrow$  (curEdge, callstack)  
3   visited.insert(curItem)  
4   path.push_back(curEdge)  
5   if src == dst then  
6   | printICFGPath(path)  
7   foreach edge  $\in$  curEdge.dst.getOutEdges() do  
8   | if edge.dst  $\notin$  visited then  
9   | | if edge.isIntraCFGE() then  
10  | | | dfs(path, edge, dst)  
11  | | else if edge.isCallCFGE() then  
12  | | | callNode  $\leftarrow$  getSrcNode(edge)  
13  | | | callstack.push_back(callNode)  
14  | | | dfs(path, edge, dst)  
15  | | else if edge.isRetCFGE() then  
16  | | | if callstack  $\neq \emptyset$  && callstack.back() == edge.getCallSite() then  
17  | | | | callstack.pop()  
18  | | | | dfs(path, edge, dst)  
19  | | | else if callstack ==  $\emptyset$  then  
20  | | | | dfs(path, edge, dst)  
21  visited.erase(curItem)  
22  path.pop_back()
```


Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG

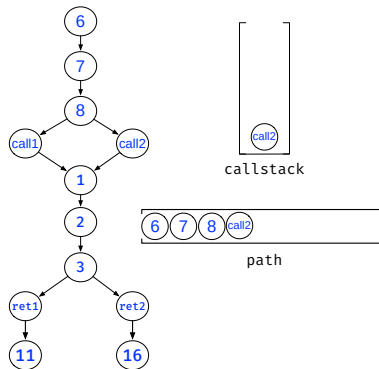


Algorithm 1 Context sensitive control-flow reachability

```
Input : curEdge : ICFGEdge  dst : ICFGNode path : vector(ICFGEEdge)  visited : set(ICFGEEdge, callstack);  
1 dfs(curEdge, dst)  
2   curItem ← (curEdge, callstack)  
3   visited.insert(curItem)  
4   path.push_back(curEdge)  
5   if src == dst then  
6     printICFGPath(path)  
7   foreach edge ∈ curEdge.dst.getOutEdges() do  
8     if edge.dst ∉ visited then  
9       if edge.isIntraCFGEEdge() then  
10        dfs(path, edge, dst)  
11      else if edge.isCallCFGEEdge() then  
12        callNode ← getSrcNode(edge)  
13        callstack.push_back(callNode)  
14        dfs(path, edge, dst)  
15      else if edge.isRetCFGEEdge() then  
16        if callstack ≠ ∅ && callstack.back() == edge.getCallSite() then  
17          callstack.pop()  
18          dfs(path, edge, dst)  
19        else if callstack == ∅ then  
20          dfs(path, edge, dst)  
21   visited.erase(curItem)  
22   path.pop_back()
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG

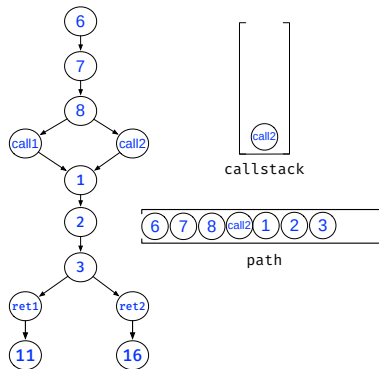


Algorithm 1 Context sensitive control-flow reachability

```
Input : curEdge : ICFGEdge  dst : ICFGNode path : vector(ICFGE)  visited : set(ICFGE, callstack);  
1 dfs(curEdge, dst)  
2   curItem  $\leftarrow$  (curEdge, callstack)  
3   visited.insert(curItem)  
4   path.push_back(curEdge)  
5   if src == dst then  
6   | printICFGPath(path)  
7   foreach edge  $\in$  curEdge.dst.getOutEdges() do  
8   | if edge.dst  $\notin$  visited then  
9   | | if edge.isIntraCFGE() then  
10  | | | dfs(path, edge, dst)  
11  | | else if edge.isCallCFGE() then  
12  | | | callNode  $\leftarrow$  getSrcNode(edge)  
13  | | | callstack.push_back(callNode)  
14  | | | dfs(path, edge, dst)  
15  | | else if edge.isRetCFGE() then  
16  | | | if callstack  $\neq \emptyset$  && callstack.back() == edge.getCallSite() then  
17  | | | | callstack.pop()  
18  | | | | dfs(path, edge, dst)  
19  | | | else if callstack ==  $\emptyset$  then  
20  | | | | dfs(path, edge, dst)  
21  visited.erase(curItem)  
22  path.pop_back()
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG

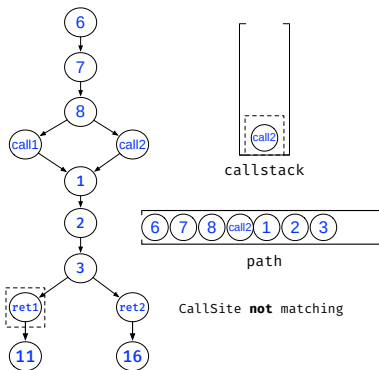


Algorithm 1 Context sensitive control-flow reachability

```
Input : curEdge : ICFGEdge  dst : ICFGNode path : vector(ICFGE)  visited : set(ICFGE, callstack);  
1  dfs(curEdge, dst)  
2  curItem  $\leftarrow$  (curEdge, callstack)  
3  visited.insert(curItem)  
4  path.push_back(curEdge)  
5  if src == dst then  
6  | printICFGPath(path)  
7  foreach edge  $\in$  curEdge.dst.getOutEdges() do  
8  | if edge.dst  $\notin$  visited then  
9  | | if edge.isIntraCFGE() then  
10 | | | dfs(path, edge, dst)  
11 | | else if edge.isCallCFGE() then  
12 | | | callNode  $\leftarrow$  getSrcNode(edge)  
13 | | | callstack.push_back(callNode)  
14 | | | dfs(path, edge, dst)  
15 | | else if edge.isRetCFGE() then  
16 | | | if callstack  $\neq \emptyset$  && callstack.back() == edge.getCallSite() then  
17 | | | | callstack.pop()  
18 | | | | dfs(path, edge, dst)  
19 | | | else if callstack ==  $\emptyset$  then  
20 | | | | dfs(path, edge, dst)  
21 | visited.erase(curItem)  
22 | path.pop_back()
```

Context-Sensitive Control-Dependence

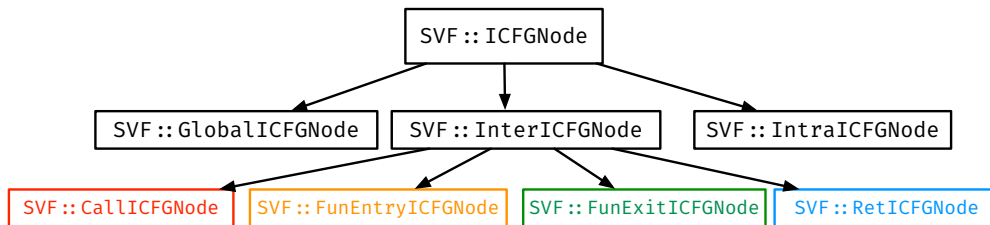
Obtaining a path from node 6 to node 11 on ICFG



Algorithm 1 Context sensitive control-flow reachability

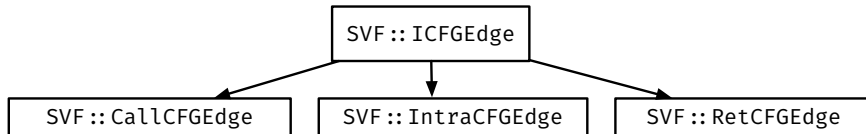
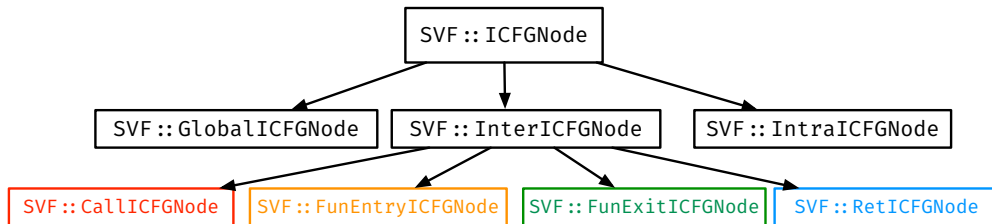
```
Input : curEdge : ICFGEdge  dst : ICFGNode path : vector(ICFGE)  visited : set(ICFGE, callstack);  
1 dfs(curEdge, dst)  
2   curItem  $\leftarrow$  (curEdge, callstack)  
3   visited.insert(curItem)  
4   path.push_back(curEdge)  
5   if src == dst then  
6   | printICFGPath(path)  
7   foreach edge  $\in$  curEdge.dst.getOutEdges() do  
8   | if edge.dst  $\notin$  visited then  
9   | | if edge.isIntraCFGE() then  
10  | | | dfs(path, edge, dst)  
11  | | else if edge.isCallCFGE() then  
12  | | | callNode  $\leftarrow$  getSrcNode(edge)  
13  | | | callstack.push_back(callNode)  
14  | | | dfs(path, edge, dst)  
15  | | else if edge.isRetCFGE() then  
16  | | | if callstack  $\neq \emptyset$  && callstack.back() == edge.getCallSite() then  
17  | | | | callstack.pop()  
18  | | | | dfs(path, edge, dst)  
19  | | | else if callstack ==  $\emptyset$  then  
20  | | | | dfs(path, edge, dst)  
21  visited.erase(curItem)  
22  path.pop_back()
```

ICFG Node and Edge Classes



<https://github.com/SVF-tools/SVF/blob/master/include/Graphs/ICFGNode.h>

ICFG Node and Edge Classes



<https://github.com/SVF-tools/SVF/blob/master/include/Graphs/ICFGEde.h>

cast and dyn_cast

- C++ Inheritance: see slides in Week 2.
- Casting a **parent** class pointer to pointer of a **Child** type:
 - `SVFUtil::cast`
 - Casts a pointer or reference to an instance of a specified class. This cast fails and aborts the program if the object or reference is not the specified class at runtime.
 - `SVFUtil::dyn_cast`
 - "Checked cast" operation. Checks to see if the operand is of the specified type, and if so, returns a pointer to it (this operator does not work with references). If the operand is not of the correct type, a null pointer is returned.
 - Works very much like the `dynamic_cast<>` operator in C++, and should be used in the same circumstances.
- Example: accessing the attributes of the child class via casting.
 - `RetBlockNode* retNode = SVFUtil::cast<RetBlockNode>(ICFGNode);`
 - `CallCFGEde* callEdge = SVFUtil::dyn_cast<CallCFGEde>(ICFGEde);`