Assignment 2

Yulei Sui

University of Technology Sydney, Australia

Assignment 2: Quizzes + A Coding Task

- Two sets of quizzes (10 ponts)
  - LLVM compiler and its intermediate representation
  - Code graphs (including ICFG and PAG)
- One coding task (10 ponts)
  - **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 ponts)
  - LLVM compiler and its intermediate representation
  - Code graphs (including ICFG and PAG)
- One coding task (10 ponts)
  - **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 : src : ICFGNode   dst : ICFGNode
        path : vector⟨ICFGNode⟩   visited : set⟨ICFGNode⟩;
1  dfs(path, src, dst)
2    visited.insert(src)
3    path.push_back(src)
4    if src == dst then
6      print path
7    foreach edge ∈ src.getOutEdges() do
8      if edge.dst ∉ visited then
9        if edge.isIntraCFGEdge() then
10         if handleIntra(edge) then
11           dfs(path, edge.dst, dst)
12       else if edge.isCallCFGEdge() then
13         if handleCall(edge) then
14           dfs(path, edge.dst, dst)
15       else if edge.isRetCFGEdge() then
16         if handleRet(edge) then
17           dfs(path, edge.dst, dst)
18   visited.erase(src)
19   path.pop_back(src)
```

Algorithm 2 Handle intra ICFGEdge

```
1  handleIntra(intraEdge)
2    return true
```

Algorithm 3 Handle call ICFGEdge

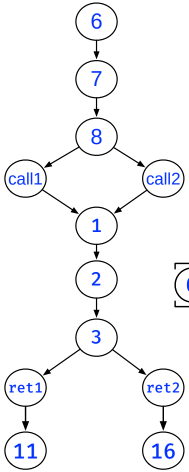
```
1  handleCall(callEdge)
2    callNode ← getSrcNode(callEdge)
3    callstack.push_back(callNode)
4    return true
```

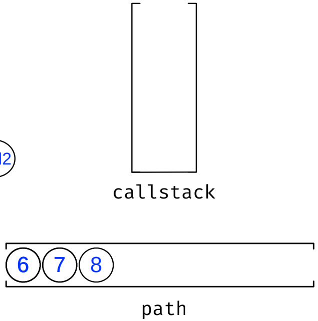
Algorithm 4 Handle return ICFGEdge

```
1  handleRet(retEdge)
2    retNode ← getDstNode(retEdge)
3    if callstack ≠ ∅ then
4      if callstack.back() == getCallICFGNode(retNode) then
5        callstack.pop()
6        return true
7      else
8        return false
9    return true
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG



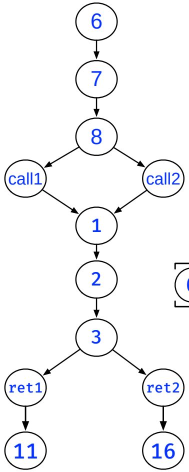


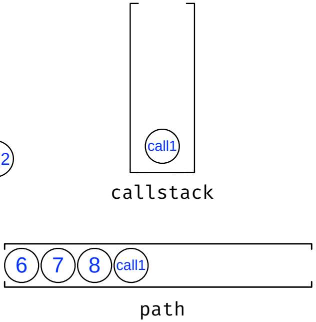
Algorithm 1 Context sensitive control-flow reachability

```
Input : src : ICFGNode   dst : ICFGNode
        path : vector⟨ICFGNode⟩   visited : set⟨ICFGNode⟩;
dfs(path, src, dst)
    visited.insert(src)
    path.push_back(src)
    if src == dst then
        print path
    foreach edge ∈ src.getOutEdges() do
        if edge.dst ∉ visited then
            if edge.isIntraCFGEdge() then
                if handleIntra(edge) then
                    dfs(path, edge.dst, dst)
            else if edge.isCallCFGEdge() then
                if handleCall(edge) then
                    dfs(path, edge.dst, dst)
            else if edge.isRetCFGEdge() then
                if handleRet(edge) then
                    dfs(path, edge.dst, dst)
    visited.erase(src)
    path.pop_back(src)
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG



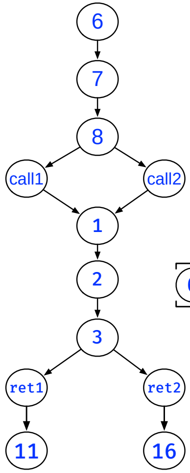


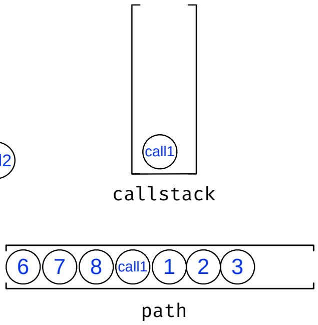
Algorithm 3 Handle call ICFGEdge

```
1 handleCall(callEdge)
2   callNode ← getSrcNode(callEdge)
3   callstack.push_back(callNode)
4   return true
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG





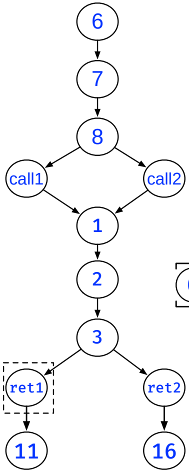
Algorithm 1 Context sensitive control-flow reachability

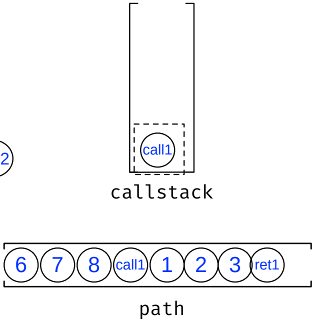
Input : src : ICFGNode dst : ICFGNode
  path : vector⟨ICFGNode⟩ visited : set⟨ICFGNode⟩;

```
dfs(path, src, dst)
  visited.insert(src)
  path.push_back(src)
  if src == dst then
    print path
  foreach edge ∈ src.getOutEdges() do
    if edge.dst ∉ visited then
      if edge.isIntraCFGEdge() then
        if handleIntra(edge) then
          dfs(path, edge.dst, dst)
      else if edge.isCallCFGEdge() then
        if handleCall(edge) then
          dfs(path, edge.dst, dst)
      else if edge.isRetCFGEdge() then
        if handleRet(edge) then
          dfs(path, edge.dst, dst)
  visited.erase(src)
  path.pop_back(src)
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG





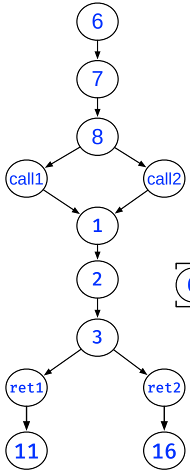
callsite matching

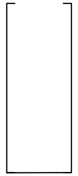
Algorithm 4 Handle return ICFGEdge

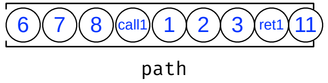
```
handleRet(retEdge)
  retNode ← getDstNode(retEdge)
  if callstack ≠ ∅ then
    if callstack.back() == getCallICFGNode(retNode) then
      callstack.pop()
      return true
    else
      return false
  return true
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG







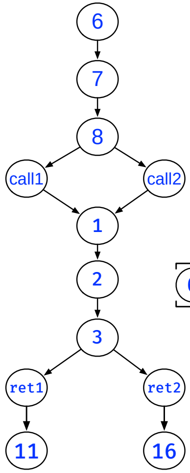
ICFG path:
6→7→8→call1→1→2→3→ret1→11

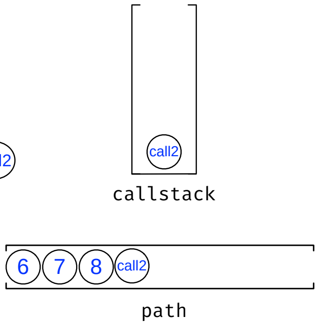
Algorithm 1 Context sensitive control-flow reachability

```
Input : src : ICFGNode   dst : ICFGNode
        path : vector⟨ICFGNode⟩   visited : set⟨ICFGNode⟩;
dfs(path, src, dst)
  visited.insert(src)
  path.push_back(src)
  if src == dst then
    print path
  foreach edge ∈ src.getOutEdges() do
    if edge.dst ∉ visited then
      if edge.isIntraCFGEdge() then
        if handleIntra(edge) then
          dfs(path, edge.dst, dst)
      else if edge.isCallCFGEdge() then
        if handleCall(edge) then
          dfs(path, edge.dst, dst)
      else if edge.isRetCFGEdge() then
        if handleRet(edge) then
          dfs(path, edge.dst, dst)
  visited.erase(src)
  path.pop_back(src)
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG



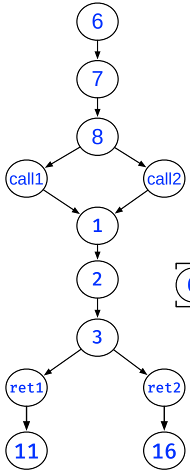


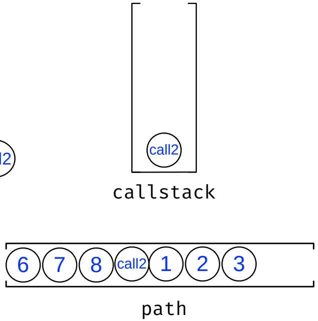
Algorithm 1 Context sensitive control-flow reachability

```
Input : src : ICFGNode   dst : ICFGNode
        path : vector⟨ICFGNode⟩   visited : set⟨ICFGNode⟩;
1  dfs(path, src, dst)
2    visited.insert(src)
3    path.push_back(src)
4    if src == dst then
5      print path
6    foreach edge ∈ src.getOutEdges() do
7      if edge.dst ∉ visited then
8        if edge.isIntraCFGEdge() then
9          if handleIntra(edge) then
10           dfs(path, edge.dst, dst)
11       else if edge.isCallCFGEdge() then
12         if handleCall(edge) then
13           dfs(path, edge.dst, dst)
14       else if edge.isRetCFGEdge() then
15         if handleRet(edge) then
16           dfs(path, edge.dst, dst)
17   visited.erase(src)
18   path.pop_back(src)
```

Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG



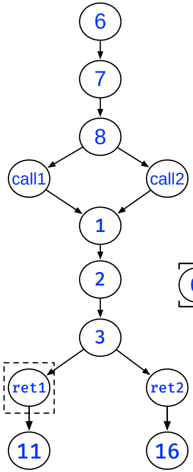


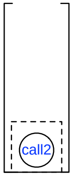
Algorithm 1 Context sensitive control-flow reachability

```
Input : src : ICFGNode   dst : ICFGNode
        path : vector⟨ICFGNode⟩   visited : set⟨ICFGNode⟩;
dfs(path, src, dst)
  visited.insert(src)
  path.push_back(src)
  if src == dst then
    print path
  foreach edge ∈ src.getOutEdges() do
    if edge.dst ∉ visited then
      if edge.isIntraCFGEdge() then
        if handleIntra(edge) then
          dfs(path, edge.dst, dst)
      else if edge.isCallCFGEdge() then
        if handleCall(edge) then
          dfs(path, edge.dst, dst)
      else if edge.isRetCFGEdge() then
        if handleRet(edge) then
          dfs(path, edge.dst, dst)
  visited.erase(src)
  path.pop_back(src)
```

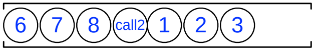
Context-Sensitive Control-Dependence

Obtaining a path from node 6 to node 11 on ICFG





callstack



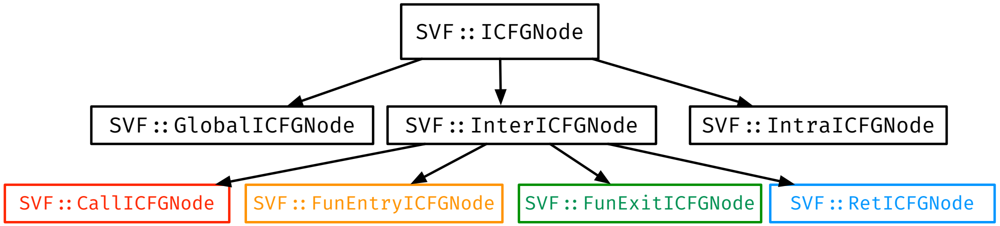
path

CallSite **not** matching

Algorithm 4 Handle return ICFGEdge

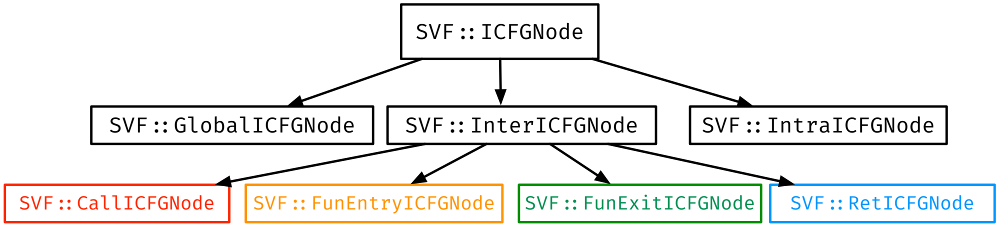
```
1 handleRet(retEdge)
2   retNode ← getDstNode(retEdge)
3   if callstack ≠ ∅ then
4     if callstack.back() == getCallICFGNode(retNode) then
5       callstack.pop()
6       return true
7     else
8       return false
9   return true
```

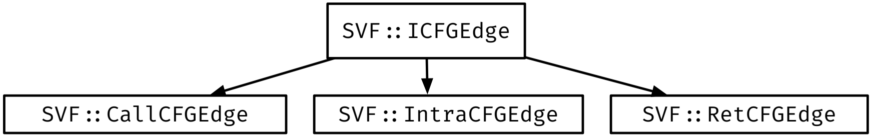
ICFG Node and Edge Classes



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/ICFGEdge.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);`
  - `CallCFGEdge* callEdge = SVFUtil::dyn_cast<CallCFGEdge>(ICFGEdge);`