Source Code Analysis for Security through LLVM

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HP Fortify
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Static Code Analyzer for Security

```
#import "HtmlViewController.h"

@implementation HtmlViewController

@synthesize webView, content = _content;

- (void)viewDidLoad {
    NSString *resourcePath = [[NSBundle mainBundle] resourcePath];
    NSURL *baseURL = [[NSURL alloc] initFileURLWithPath:
        resourcePath isDirectory:YES];

    if (_content) {
        // Render the existing content in the web view.
        [self.webView loadHTMLString:_content baseURL:baseURL];
    } else {
        // Display the "About iGoat" splash screen as a default.
        NSError *error;
        NSString *filePath = [[NSBundle mainBundle]
            pathForResource:@"splash.html" ofType: nil];
        NSString *fileContents = [[NSString alloc]
            initWithContentsOfFile:filePath encoding:
            NSUTF8StringEncoding error:&error];
        NSString *version = [[[NSBundle mainBundle] infoDictionary
            ] objectForKey:@"CFBundleShortVersionString"];

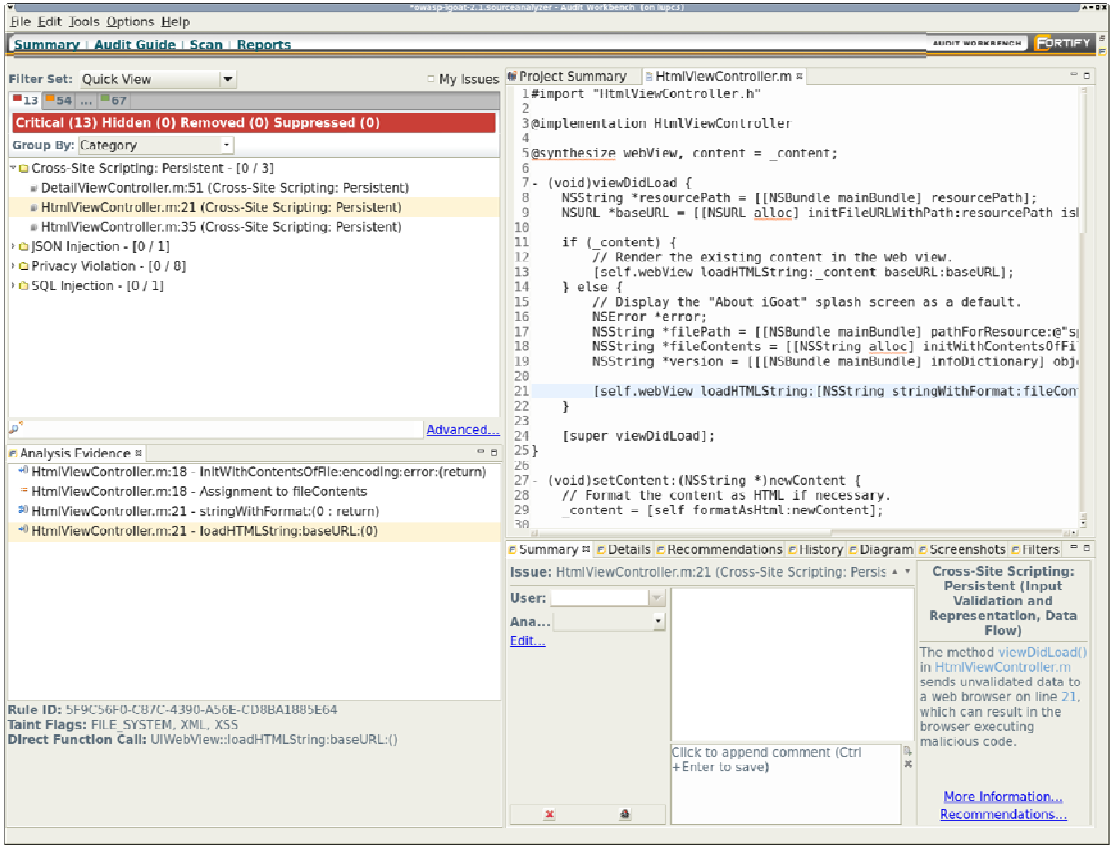
        [self.webView loadHTMLString:[NSString stringWithFormat:
            fileContents, version] baseURL:baseURL];
    }

    [super viewDidLoad];
}

- (void)setContent:(NSString *)newContent {
    // Format the content as HTML if necessary.
    _content = [self formatAsHtml:newContent];

    // Render the content in the web view.
    // TODO: DRY this up (see above).
    NSString *resourcePath = [[NSBundle mainBundle] resourcePath];
    NSURL *baseURL = [[NSURL alloc] initFileURLWithPath:
```

Fortify SCA



*owasp-igoat-2.1.sourceanalyzer - Audit Workbench (on lupc3)

File Edit Tools Options Help

Summary | Audit Guide | Scan | Reports

AUDIT WORKBENCH FORTIFY

Filter Set: Quick View

My Issues

13 54 ... 67

Critical (13) Hidden (0) Removed (0) Suppressed (0)

Group By: Category

- Cross-Site Scripting: Persistent - [0 / 3]
  - DetailViewController.m:51 (Cross-Site Scripting: Persistent)
  - HtmlViewController.m:21 (Cross-Site Scripting: Persistent)
  - HtmlViewController.m:35 (Cross-Site Scripting: Persistent)
- JSON Injection - [0 / 1]
- Privacy Violation - [0 / 8]
- SQL Injection - [0 / 1]

Advanced...

Analysis Evidence

- HtmlViewController.m:18 - initWithContentsOfFile:encoding:error:(return)
- HtmlViewController.m:18 - Assignment to fileContents
- HtmlViewController.m:21 - stringWithFormat:(0 : return)
- HtmlViewController.m:21 - loadHTMLString:baseURL:(0)

Rule ID: 5F9C56F0-C87C-4390-A56E-CD8BA1885E64
Taint Flags: FILE_SYSTEM, XML, XSS
Direct Function Call: UIWebView::loadHTMLString:baseURL:()

Project Summary | HtmlViewController.m

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1 #import "HtmlViewController.h"
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3 @implementation HtmlViewController
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5 @synthesize webView, content = _content;
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14    } else {
15        // Display the "About iGoat" splash screen as a default.
16        NSError *error;
17        NSString *filePath = [[NSBundle mainBundle] pathForResource:@"s
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19        NSString *version = [[[NSBundle mainBundle] infoDictionary] obj
20
21        [self.webView loadHTMLString:[NSString stringWithFormat:fileCon
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Summary | Details | Recommendations | History | Diagram | Screenshots | Filters

Issue: HtmlViewController.m:21 (Cross-Site Scripting: Persis

User:

Ana...

Edit...

Click to append comment (Ctrl +Enter to save)

Cross-Site Scripting: Persistent (Input Validation and Representation, Data Flow)

The method viewDidLoad() in HtmlViewController.m sends unvalidated data to a web browser on line 21, which can result in the browser executing malicious code.

More Information...

Recommendations...

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More Information...

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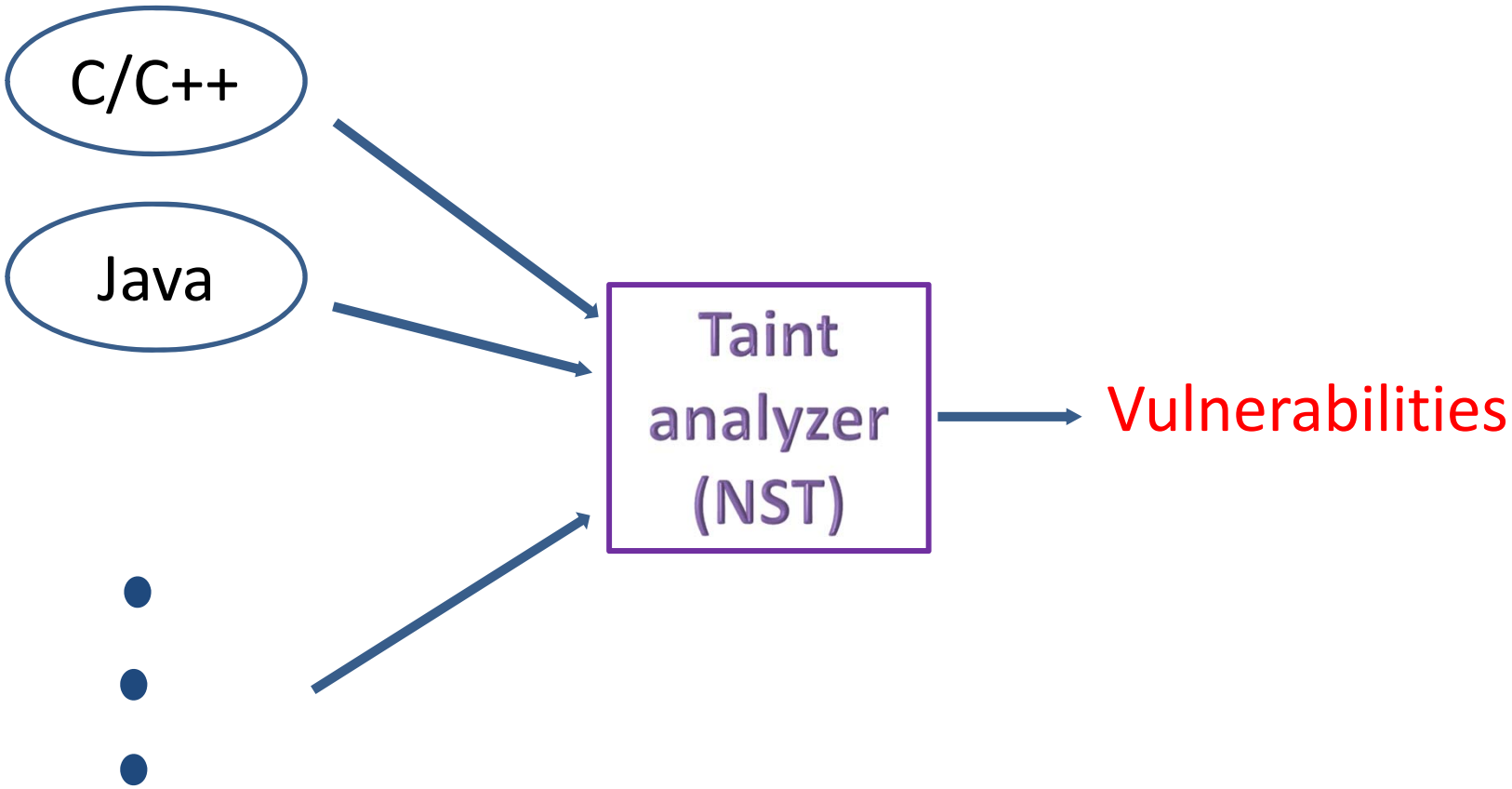
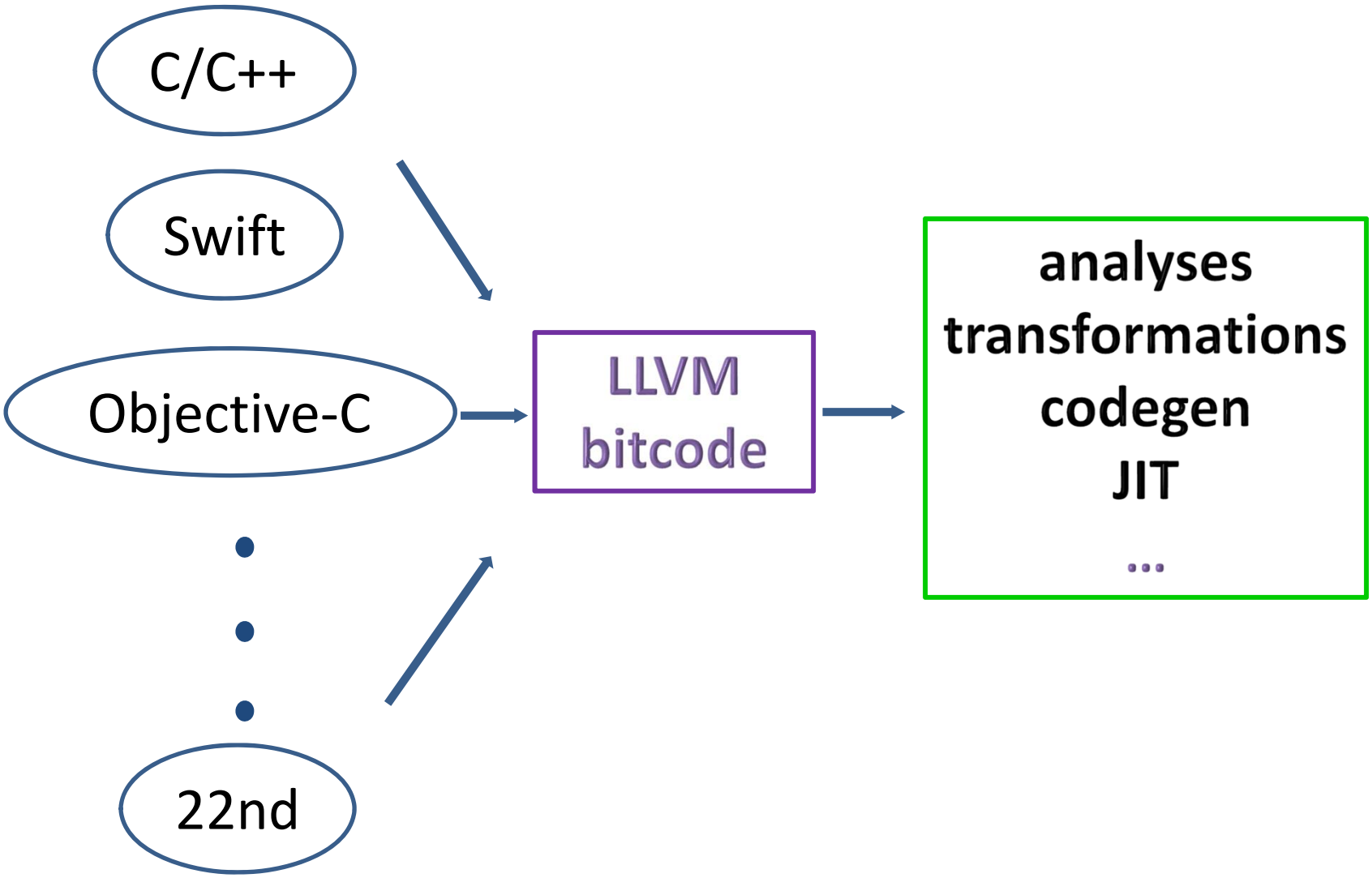
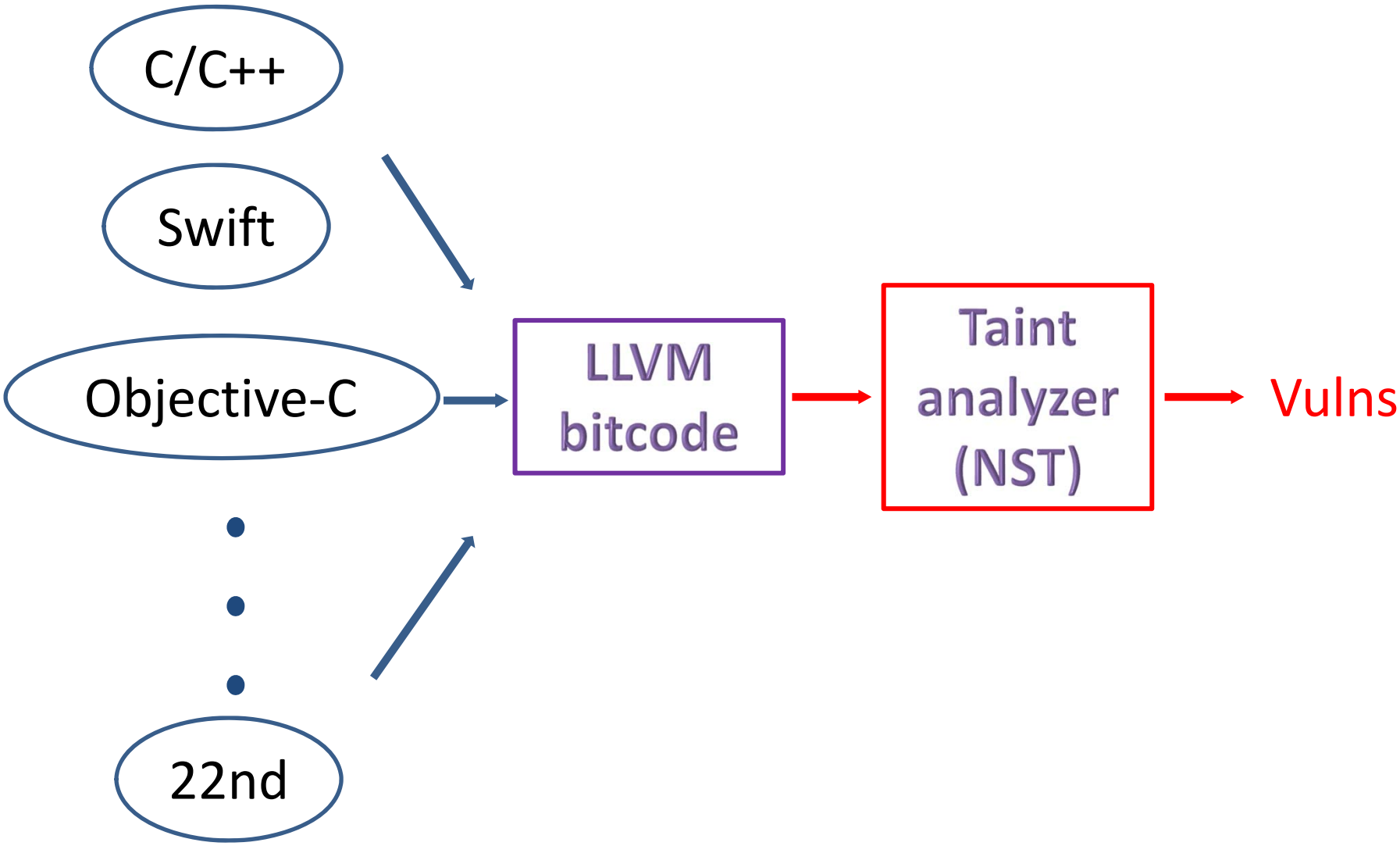
Static Code Analyzer for Security (HP Fortify SCA)



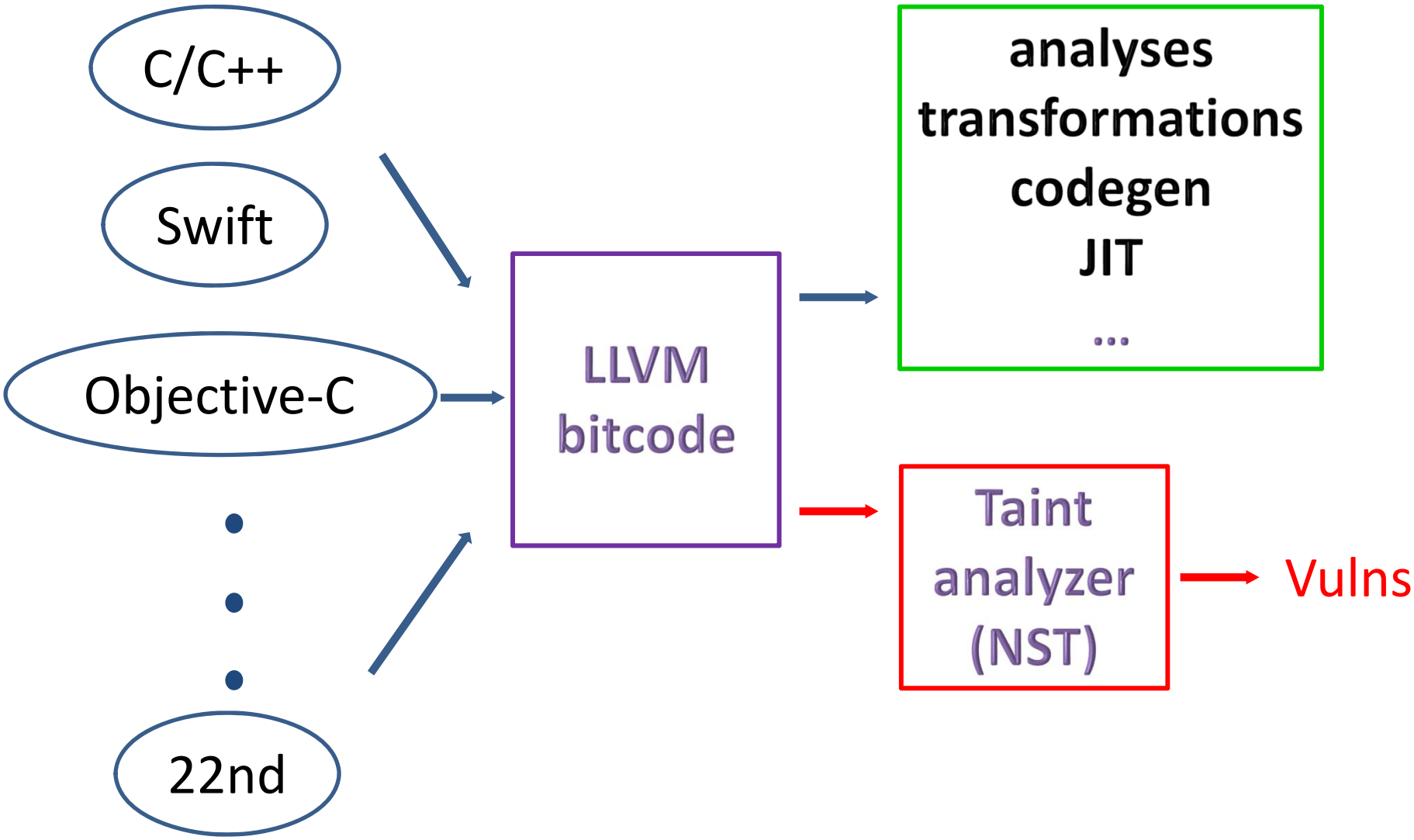
LLVM Language-independent Services



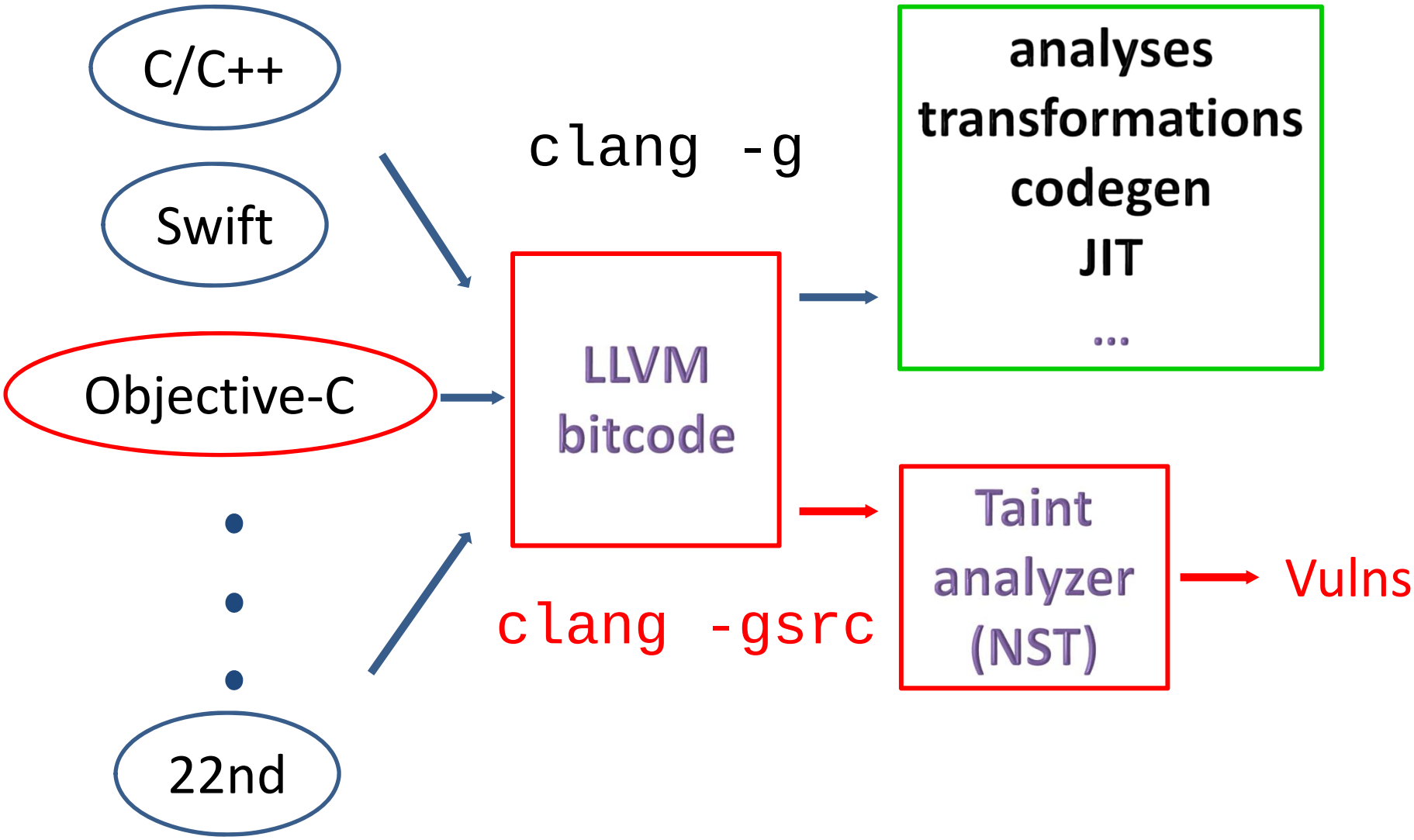
Bitcode for Source Analysis?



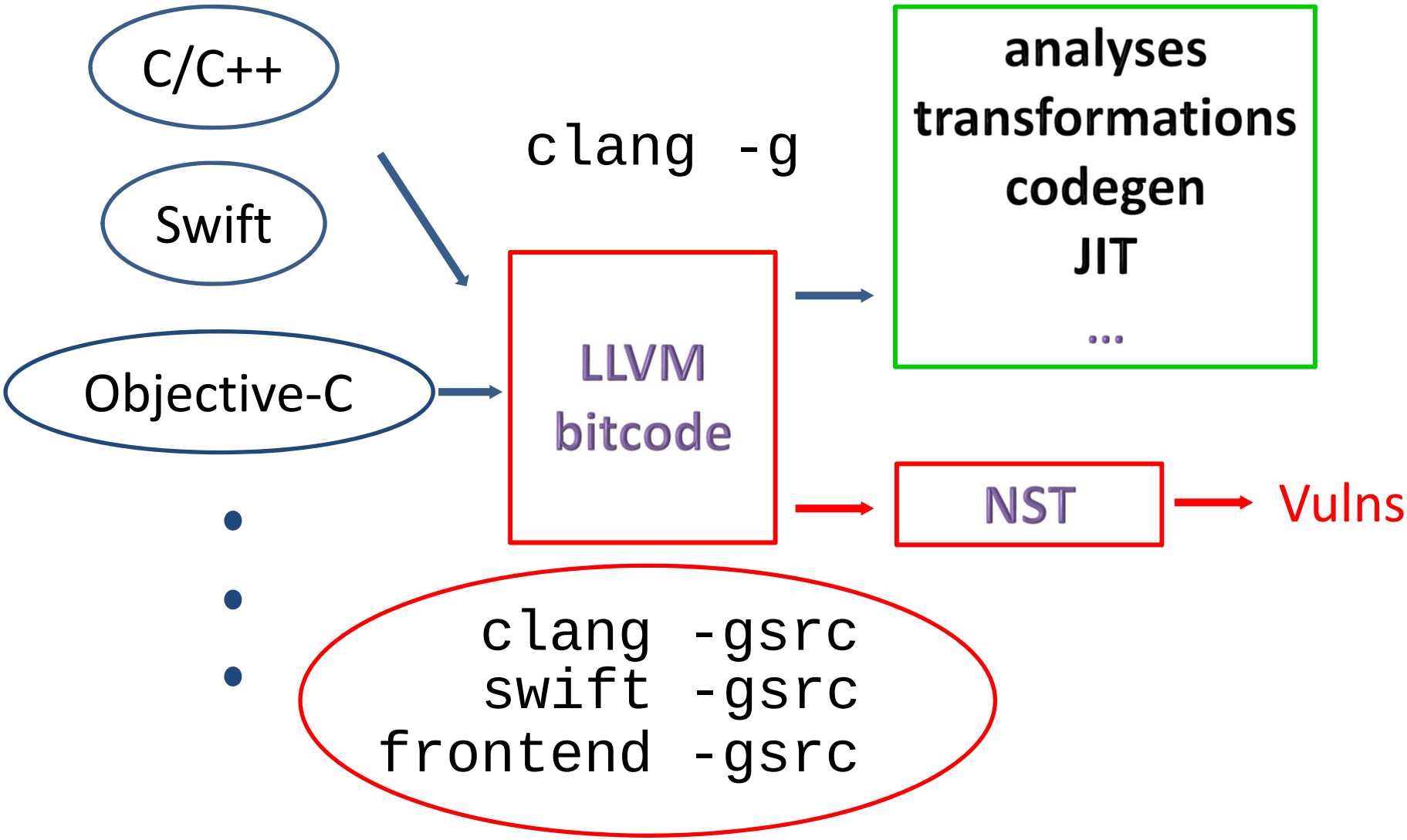
Bitcode for Source Analysis?



HP Fortify SCA for Objective-C



Bitcode with Enhanced Source Info



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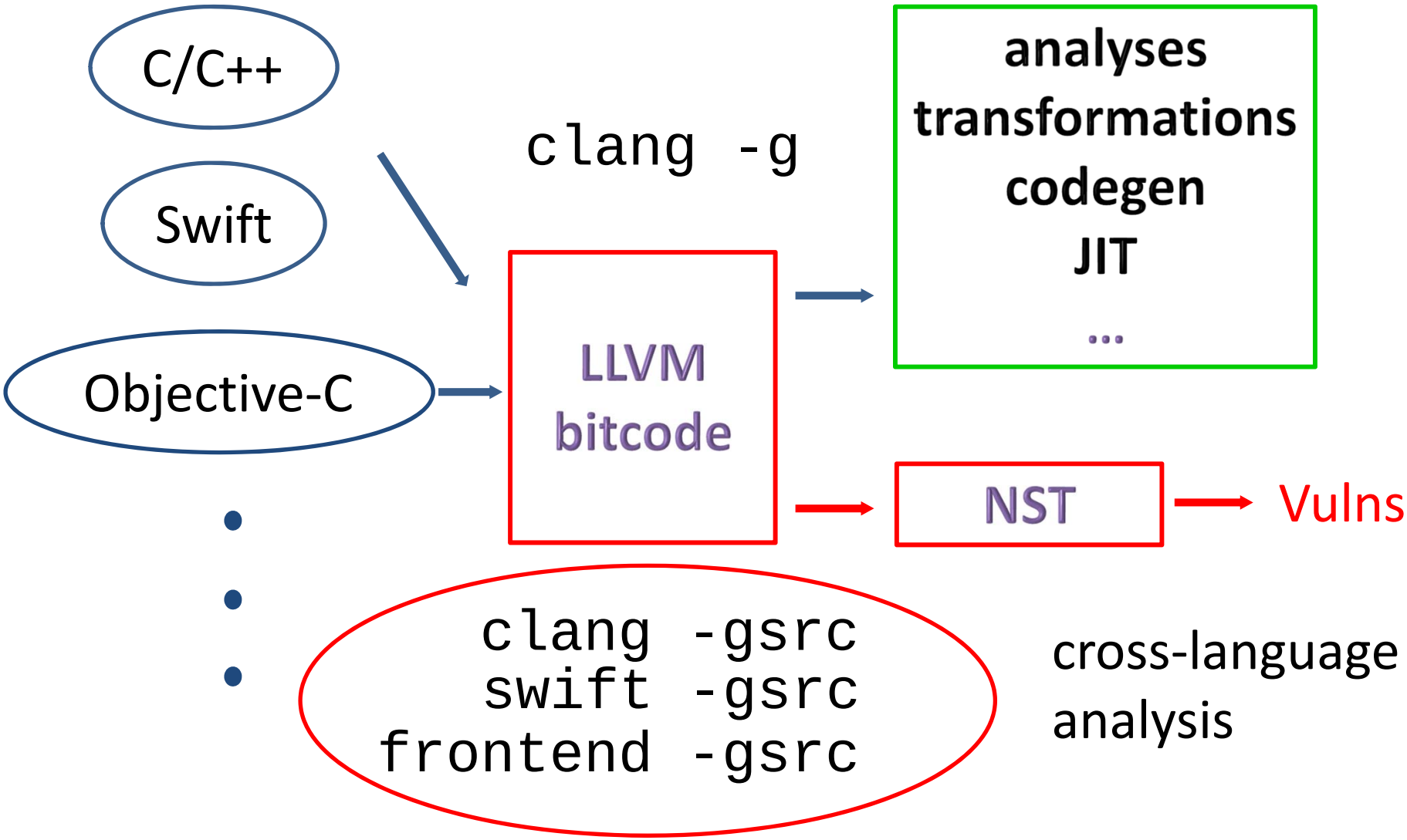
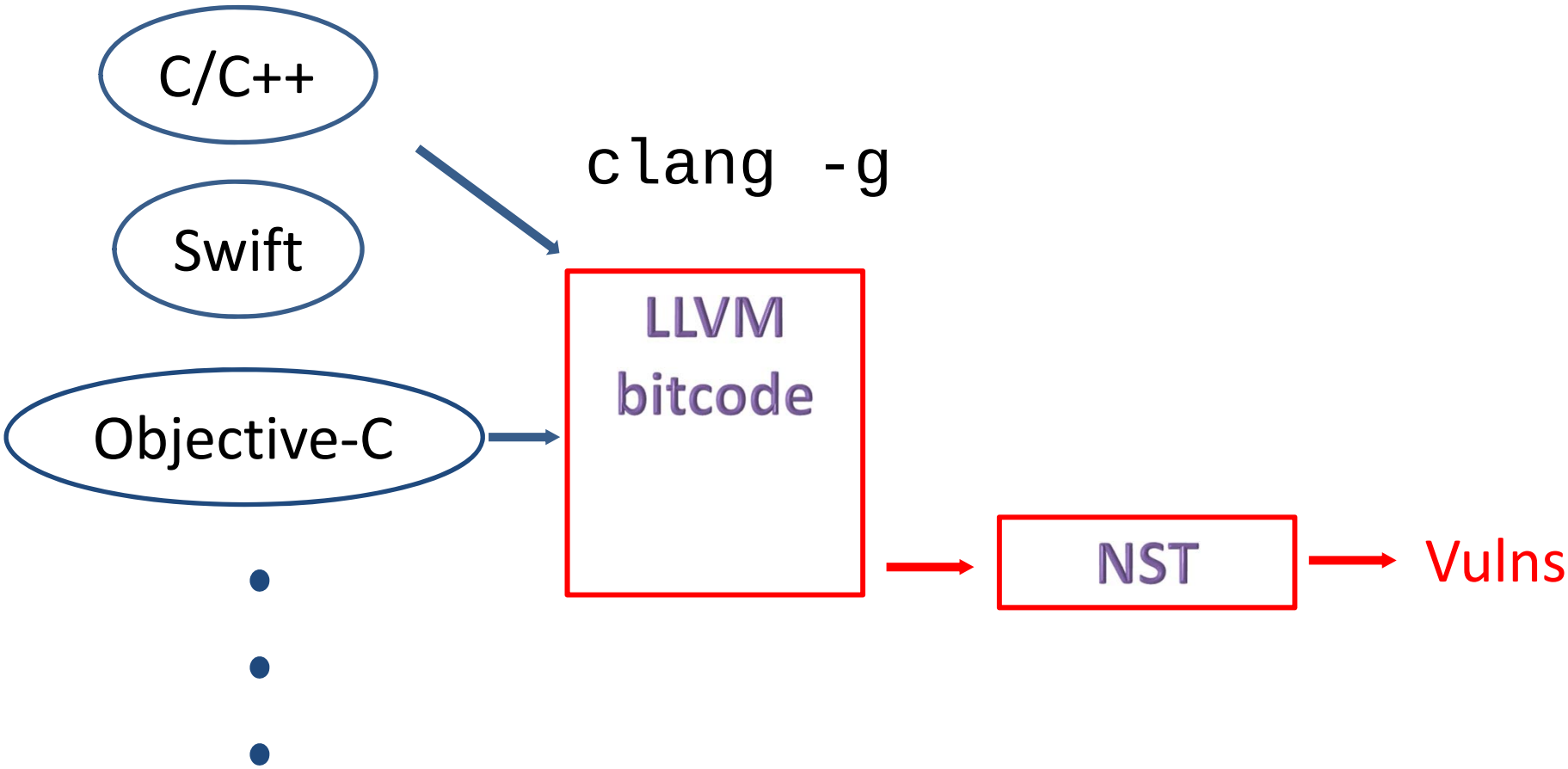


Why we cannot do this today?



Objective-C Static Taint Analyzer

```
@implementation HtmlViewController
- (void)viewDidLoad {
    if (_content) {
        …
    } else {
        // Display the "About iGoat" splash screen as a default.
        …
        NSString *fileContents =
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encoding:NSUTF8StringEncoding error:&error];
        NSString *version = [[[NSBundle mainBundle] infoDictionary]
objectForKey:@"CFBundleShortVersionString"];
        [self.webView loadHTMLString:[NSString
stringWithFormat:fileContents, version] baseURL:baseURL];
    }
}
…
@end
```

Objective-C Static Taint Analyzer

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@implementation HtmlViewController
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…
@end
```

taint source by API doc

Objective-C Static Taint Analyzer

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        NSString *version = [[[NSBundle mainBundle] infoDictionary]
objectForKey:@"CFBundleShortVersionString"];
        [self.webView loadHTMLString:[NSString
stringWithFormat:fileContents, version] baseURL:baseURL];
    }
}
…
@end
```

taint sink by API doc

Objective-C Static Taint Analyzer

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    } else {
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        …
        NSString *fileContents =
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        NSString *version = [[[NSBundle mainBundle] infoDictionary]
objectForKey:@"CFBundleShortVersionString"];
        [self.webView loadHTMLString:[NSString
stringWithFormat:fileContents, version] baseURL:baseURL];
    }
}
…
@end
```

taint source

taint sink

Objective-C Static Taint Analyzer

- Our taint source or taint sink is written in a declarative fashion, which is matched by the analyzer against its method signature.

```
NodeType: TaintSource
ClassName: NSArray | NSString | NSData |
NSConstantString
MethodSig: arrayWithContentsOfFile: |
(string|init)WithContentsOfFile:(usedE|e)ncoding:err
or: |initWithContentsOfFile: |
(data|init)WithContentsOfFile:(options:error:)?
Output: return
TaintFlags: FILE_SYSTEM,XSS
```

A Source-friendly IR

- A method signature

```
public class NSString extends NSObject {
  public virtual NSString*
initWithContentsOfFile$encoding$error$(
                                NSString* this, …);
}
```

From Bitcode to Source

```
int convert(unsigned u) { return 0; }
```

```
define i32 @convert(i32 %u) #0 {
entry:
  ret i32 0
}
```

```
!4 = metadata !{i32 786478, metadata
!1, metadata !5, metadata !"convert",
metadata !"convert“,...} ; [
DW_TAG_subprogram ] [line 25] [def]
[convert]
```

From Bitcode to Source

```
NamedMDNode *M_Nodes =
M->getNamedMetadata("llvm.dbg.cu");
DIArray SPs = CU.getSubprograms();
for (unsigned i2 = 1,
             e2 = SPs.getNumElements();
             i2 != e2; ++i2) {
   DISubprogram DISP(SPs.getElement(i2));
   DICompositeType DIC(DISP.getType());
   DIArray Tys = DIC.getTypeArray();
   // Tys[0] return type
   // others are parameter types
}
```

No Metadata for Declarations

```
extern int convert(unsigned u);

declare i32 @convert(i32 %u) #2;
```

No metadata describing `@convert`.

No Metadata for Declarations

```
extern int convert(unsigned u);

declare i32 @convert(i32 %u) #2;
```

Metadata emission is a subprocess during code emission. **No code generation, no metadata.**

Generate Bitcode with Rich Source Info

- Decouple metadata emission and code generation.
- Control rich metadata emission by using -gsrc

```
$ clang –gsrc –O0 –c –emit-llvm –S
HtmlViewController.m
```

Bitcode with Rich Source Info

```
declare extern_weak i8* @"-[NSString
initWithContentsOfFile:encoding:error:]"
(%1*, i8*, %1*, i64, %3**)

!1538 = metadata !{i32 786478, metadata
!4, metadata !302, metadata !"-[NSString
initWithContentsOfFile:encoding:error:]"
,...} ; [ DW_TAG_subprogram ]...
```

Bitcode with Rich Source Info

```
Type signature: (NSString*,
objc_selector*, NSString*,
NSStringEncoding, NSError**) ->
NSString*

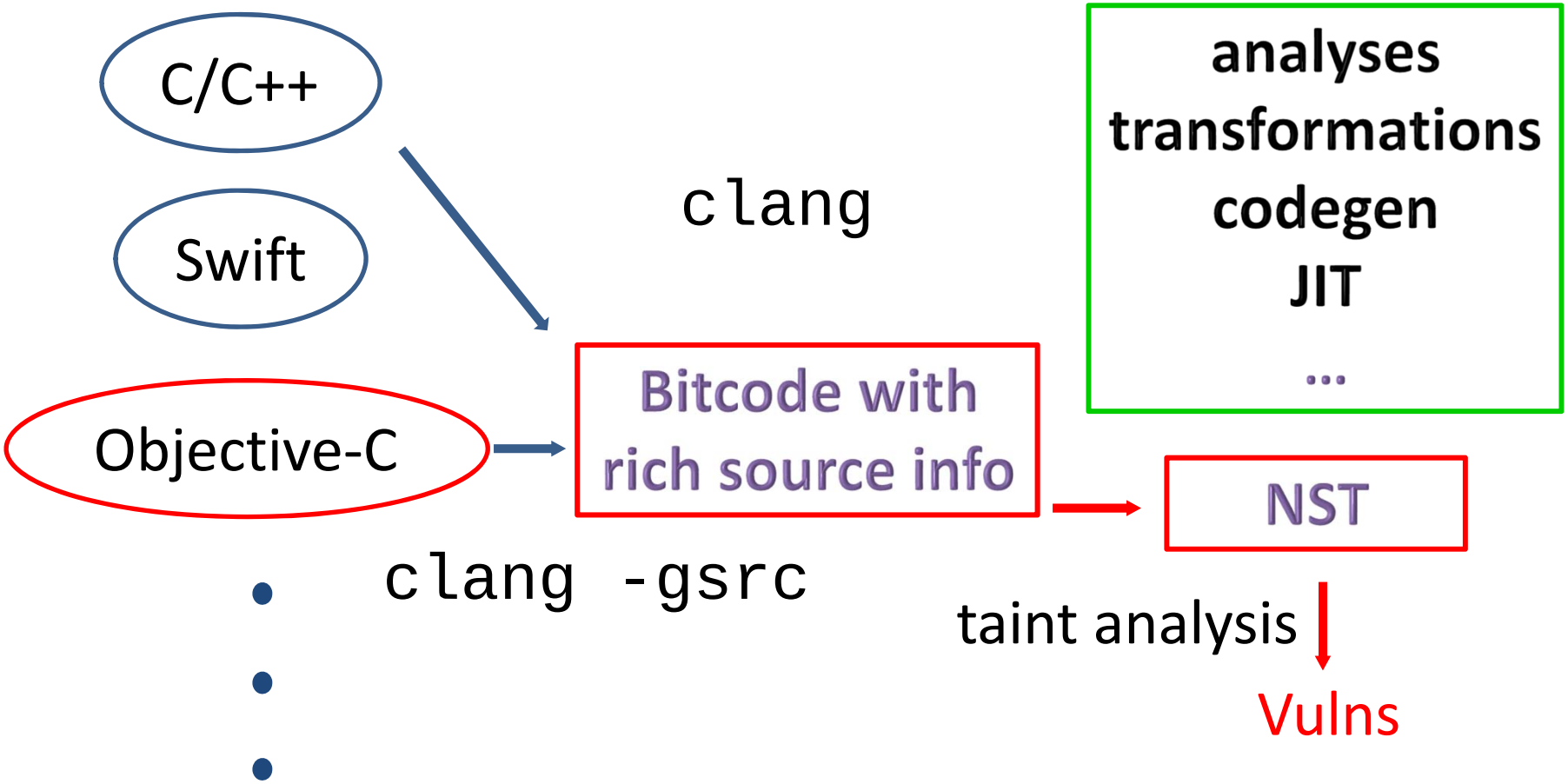
typedef: NSStringEncoding,
         NSUInteger,
         long unsigned int
```

A Source-friendly IR

- NST

```
public class NSString extends NSObject {
  public virtual NSString*
initWithContentsOfFile$encoding$error$(
                                NSString* this, …);
}
```

Bitcode with Enhanced Source Info



Small Modification Big Opportunity

- Entire patch to Clang/LLVM has 543 lines for 3.3 (git diff)
- Upgrading to 3.5

Small Modification Big Opportunity

- All frontends should implement this feature