DEVIEW
2019

눈발자국

박한범
Kosslab
NAVER

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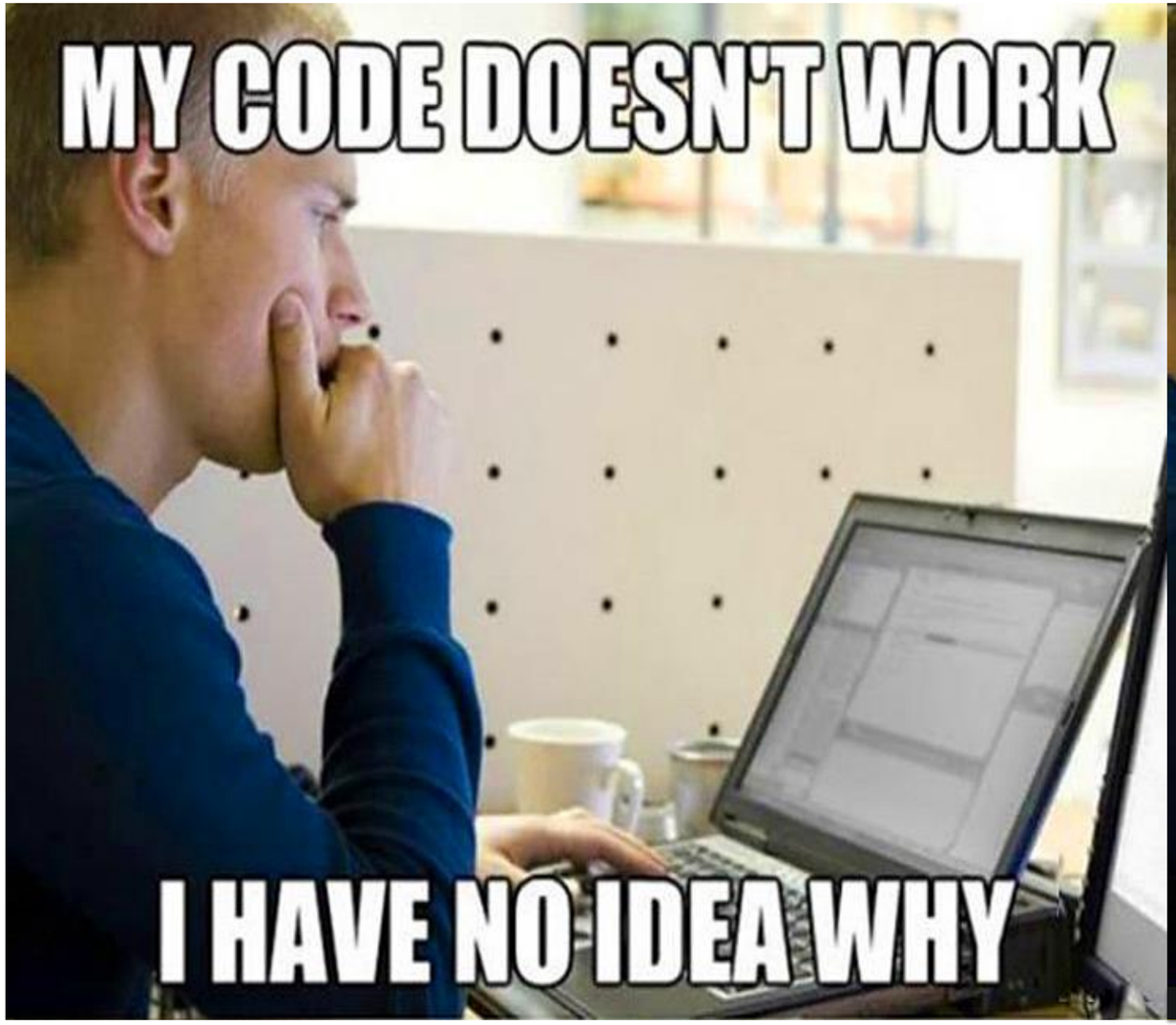
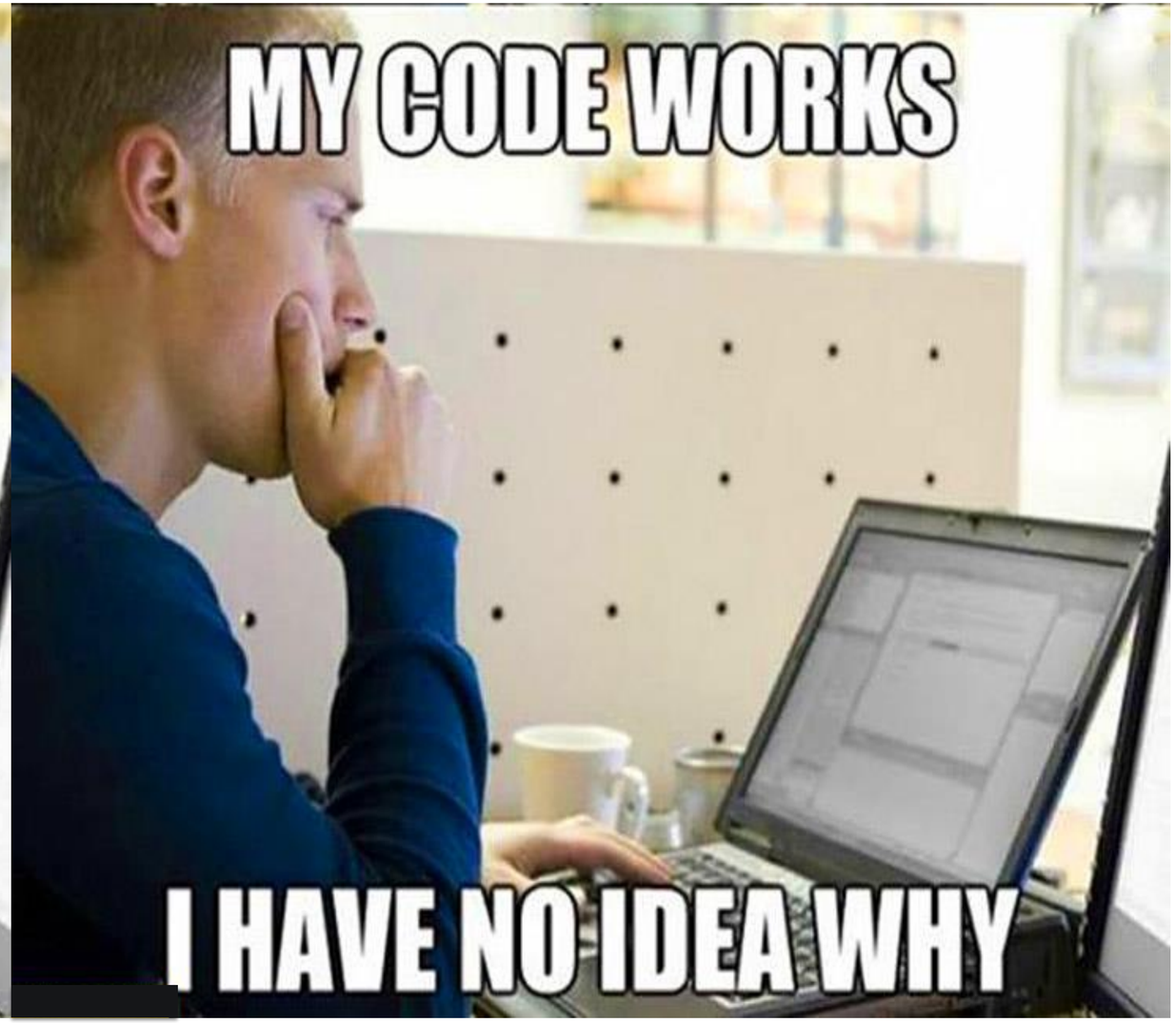
Tracing 소개

Printf is nothing, or everything

프로그래밍은 쉬운 적이 없죠





코드의 시각화를 위한 Printf 문의 발전

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```
Printf(“function entry : %d %d\n”, a, b);
```

```
Static bool debug = true;
if (debug)
  Printf(“function entry : %d %d\n”, a, b);
```

```
#ifdef DEBUG
  #define DBGPR(a, args...) printf("%s(%s:%d) " a, __func__,__FILE__, __LINE_
#else
  #define DBGPR(a, args...)
#endif
DBGPR("%d %d\n", a, b);
```

Printf is nothing, or everything

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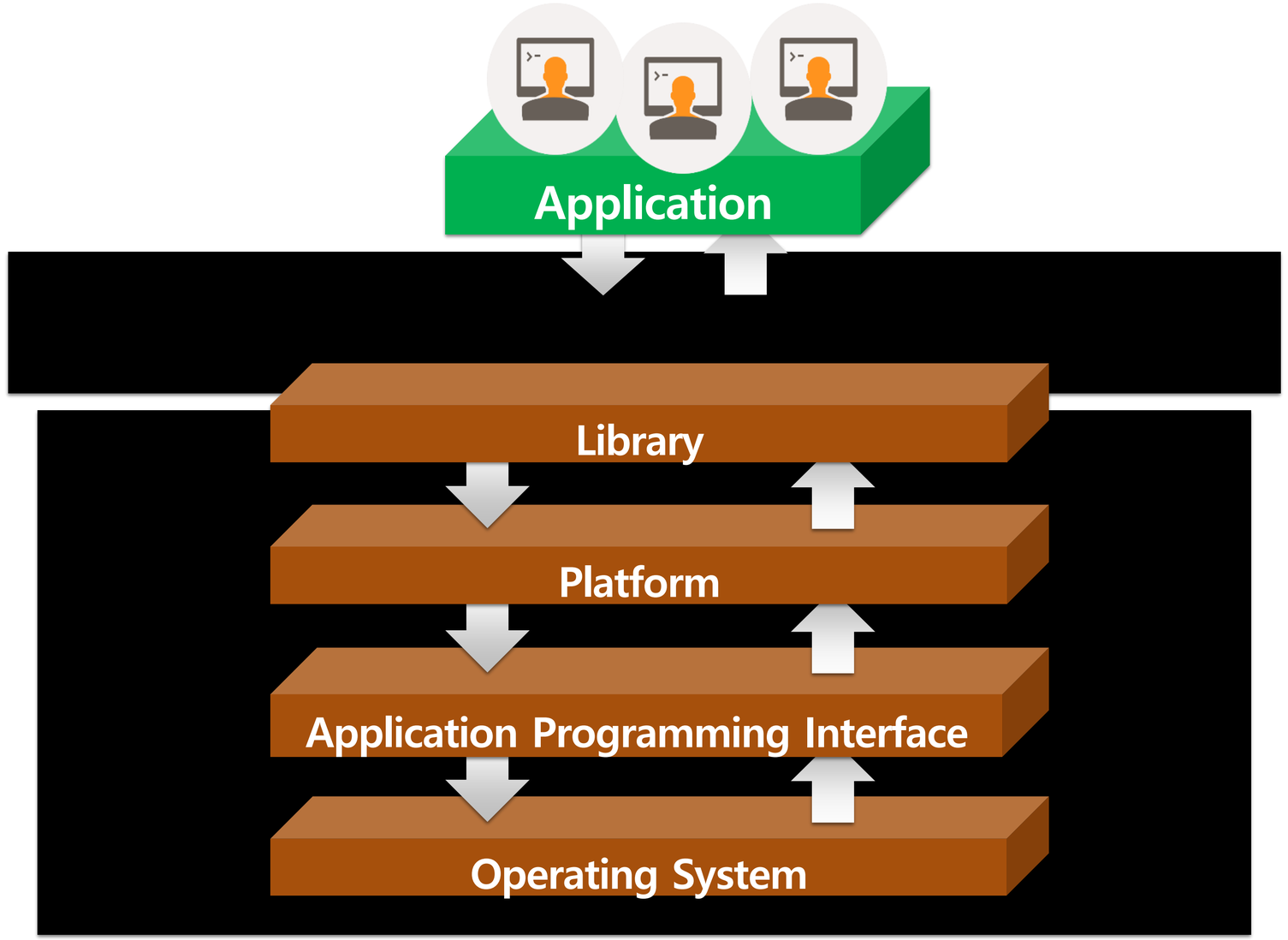
개발자가 Printf 를 활용하는 방식 = Tracing

> Tracing, “프로그램의 실행 동안의 변화를 다각도로 기록하고 이를 검토하는 일”

기록을 위한 장치 = 계측기 = Printf = instrument

Printf 보다 고도화 된 Instrument의 필요성

계측기=Printf
필요



Printf, Printf, Printf, Printf 를 가능케 하라

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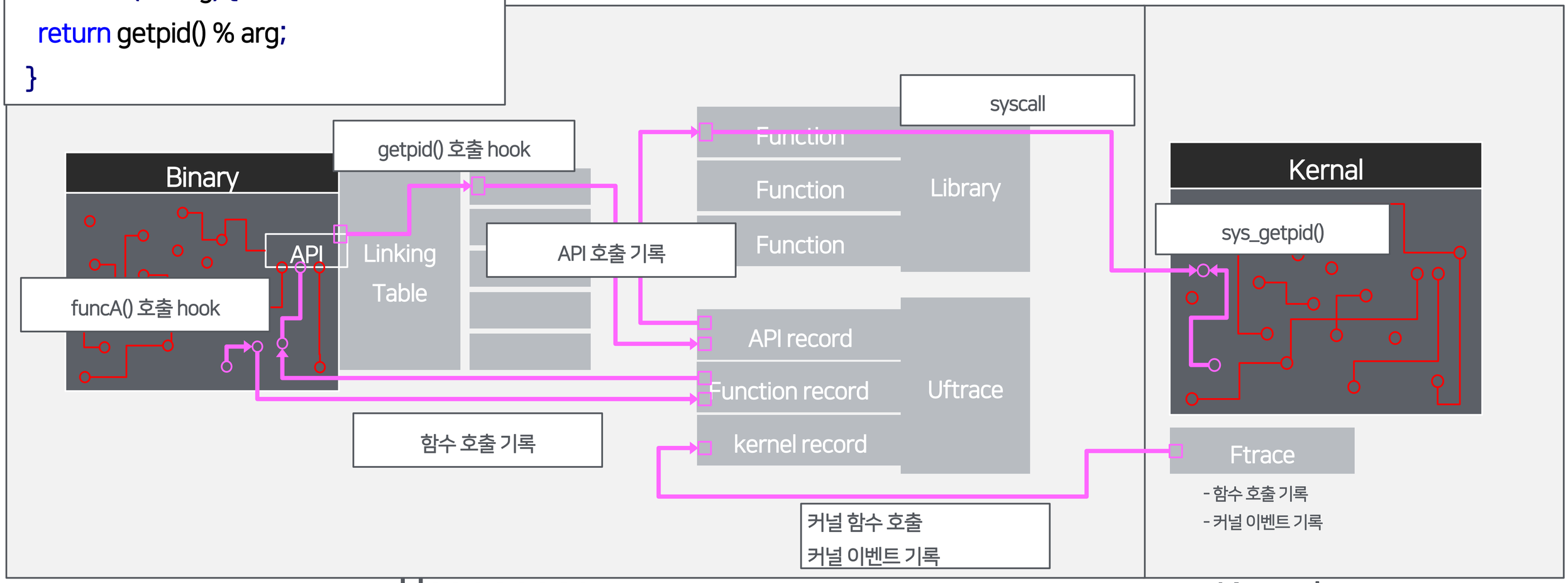
```
int funcA(int arg) {
  return getpid() % arg;
}
```



Printf 안되면 되게 하라!

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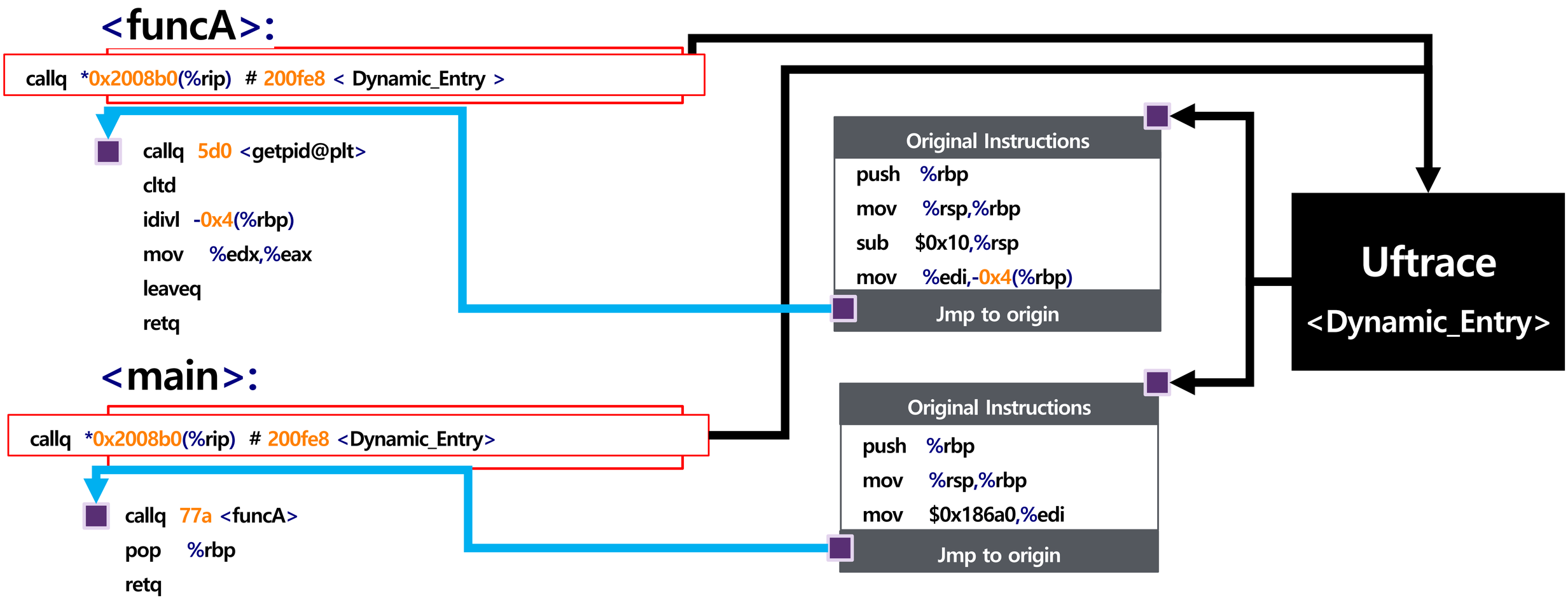

모든 영역에서 Printf-ing 하다

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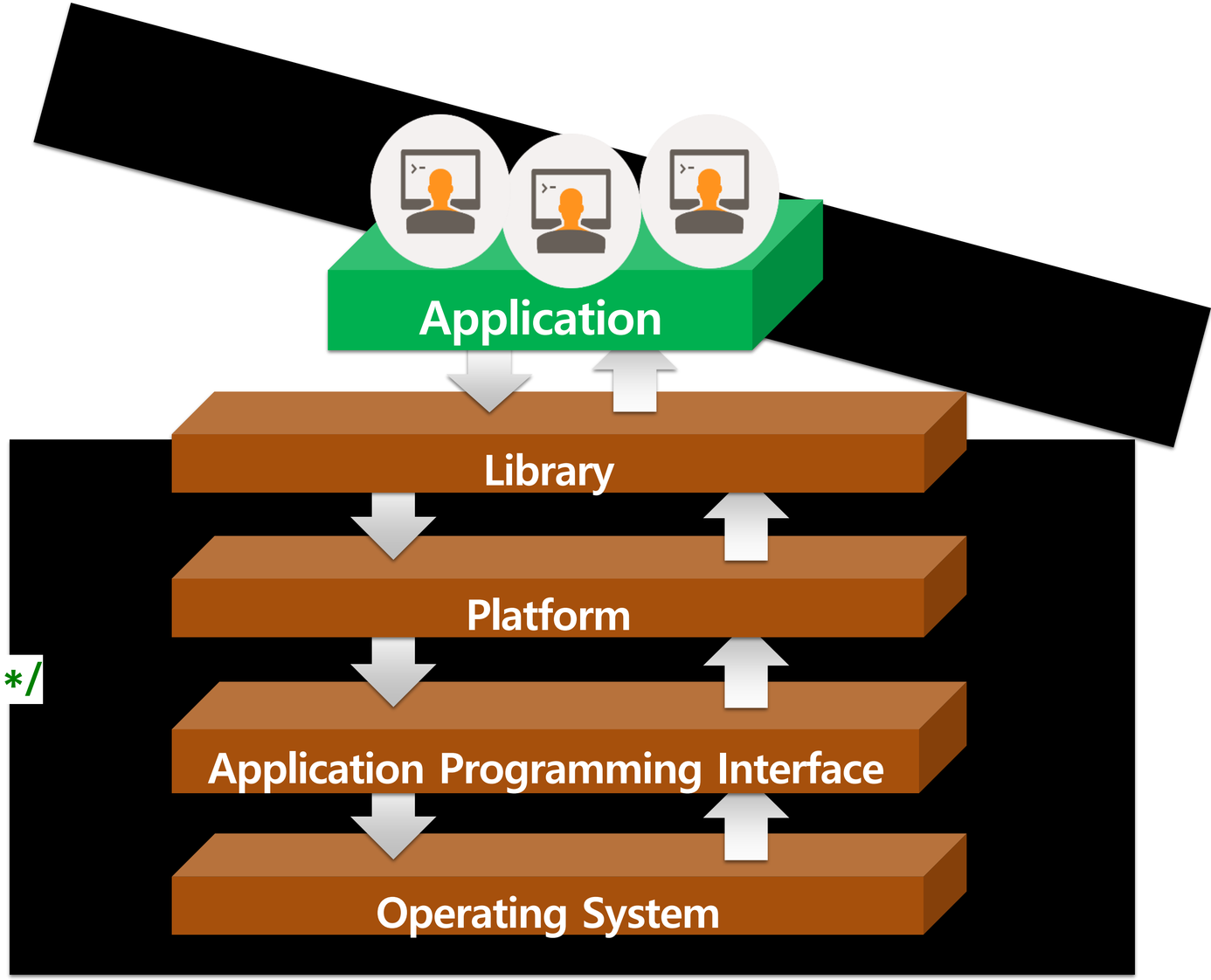
```
$ sudo ./uftrace -L. -k -a test
# DURATION     TID     FUNCTION
            [  1598] ¦ main() {
            [  1598] ¦   funcA(100000) {
            [  1598] ¦     getpid() {
   0.269 us [  1598] ¦       sys_getpid();
   1.375 us [  1598] ¦     } = 1598; /* getpid */
   1.375 us [  1598] ¦   } = 1598; /* funcA */
   2.355 us [  1598] ¦ } = 1598; /* main */
```



기록했으니 검토를 시작해야죠…

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Tracing, “프로그램의 실행 동안의 변화를 다각도로 기록하고 이를 검토하는 일”

- 함수 호출
- API 호출
- 커널 함수 호출
- 함수 호출 인자
- 함수 반환 인자

- 호출 기록 검토
- 시각화

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Tracing
도움이 되는 요소들

Gcc에서 만난 문제를 추적했던 경우


```
static inline __attribute__((always_inline)) char* get_msg() {
  char str[64] = "Hello world\n";
  return (char*)str;
}
int main() {
  char* p;
  p = get_msg();
  puts(p);
  return 0;
}
```

```
$ ./compile_by_gcc
Segmentation fault (core dumped)
```

```
$ ./compile_by_clang
Hello world
```

Mitigation도 좋지만 해결책을 찾아볼까?


```
static inline __attribute__((always_inline)) char* get_msg() {
  char* str = "Hello world\n";
  return str;
}
```

Mitigation 방안 #1 - 문자를 수정 못함

```
static inline __attribute__((always_inline)) char* get_msg() {
  const char* str = "Hello world\n";
  char* p = malloc(strlen(str));
  strcpy(p, str);
  return p;
}
```

Mitigation 방안 #2 - 메모리 해제가 강제됨

개발자가 남긴 #1 Warning Message


```
$ gcc inline.c
inline.c: In function ‘get_msg:
inline.c:6:9: warning: function returns address of local variable
[-Wreturn-local-addr]
return (char *)str;
```

Warning Message 로 찾은 문제지점


```
if (DECL_P (inner)
    && !DECL_EXTERNAL (inner)
    && !TREE_STATIC (inner)
    && !DECL_DECLARED_INLINE_P(current_function_decl)
    && DECL_CONTEXT (inner) == cu
    warning_at(loc, OPT_Wreturn_local_addr,
    "function returns address of local variabl
    tree zero = build_zero_cst(TREE_TYPE(res
    t = build2(COMPOUND_EXPR, TREE_TYP
  }
}
```

return 될 tree가 속한 함수가
inline 으로 선언되어 있으면
NULL 로 바꾸지 마세요!

Current_function_decl.function_decl	
static_flag = 1	declared_inline_flag = 1

개발자가 남긴 #2 Debug 용 로그

$ gcc –O1 –fdump-tree-all-details inline.c

```
;; Function get_msg (get_msg, funcdef_no=0, decl_uid=1792,
cgraph_uid=0, symbol_order=0)
Deleted dead store: str = "Hello world₩n";
__attribute__((a                inline)) get_msg ()
{
    char str[64];
    <bb 2> [0.00
    str ={v} {CLOB
    return &str;
}
```

inline.c.040t.dse1

Deleted dead store: str = "Hello world₩n";

메모리 최적화 때문일까?


```
if (DECL_P (inner) && !DECL_EXTERNAL (inner)
    && !TREE_STATIC (inner)
    && !DECL_DECLARED_INLINE_P(current_function_decl)
    && DECL_CONTEXT (inner) == current_function_decl)
```

```
warning_at(loc, OPT_Wreturn_local_addr,
"function returns address of local variable");
```

```
else if (DECL_DECLARED_INLINE_P(current_function_decl))
  inner->base.volatile_flag = true;
```

메모리 관련 최적화
Disable

개발자가 남긴 메시지의 중요성


```
Dump of assembler code for function main:
<+4>:     movabs $0x6f77206f6c6c6548,%rax
<+14>:    mov    $0xa646c72,%edx
<+19>:    mov    %rax,(%rsp)
<+23>:    mov    %rdx,0x8(%rsp)
<+28>:    movq   $0x0,0x10(%rsp)
<+37>:    movq   $0x0,0x18(%rsp)
<+46>:    movq   $0x0,0x20(%rsp)
<+55>:    movq   $0x0,0x28(%rsp)
<+64>:    movq   $0x0,0x30(%rsp)
<+73>:    movq   $0x0,0x38(%rsp)
<+82>:    mov    %rsp,%rdi
<+85>:    callq  0x400400 <puts@plt>
```

O1

$ gcc –O1 inline.c

$ ./a.out

Hello world

```
Dump of assembler code for function main:
<+4>:     movdqa 0x1b4(%rip),%xmm0
<+12>:    mov    %rsp,%rdi
<+15>:    movaps %xmm0,(%rsp)
<+19>:    pxor   %xmm0,%xmm0
<+23>:    movaps %xmm0,0x10(%rsp)
<+28>:    movaps %xmm0,0x20(%rsp)
<+33>:    movaps %xmm0,0x30(%rsp)
<+38>:    callq  0x400400 <puts@plt>
```

O2

$ gcc –O2 inline.c

$ ./a.out

Hello world

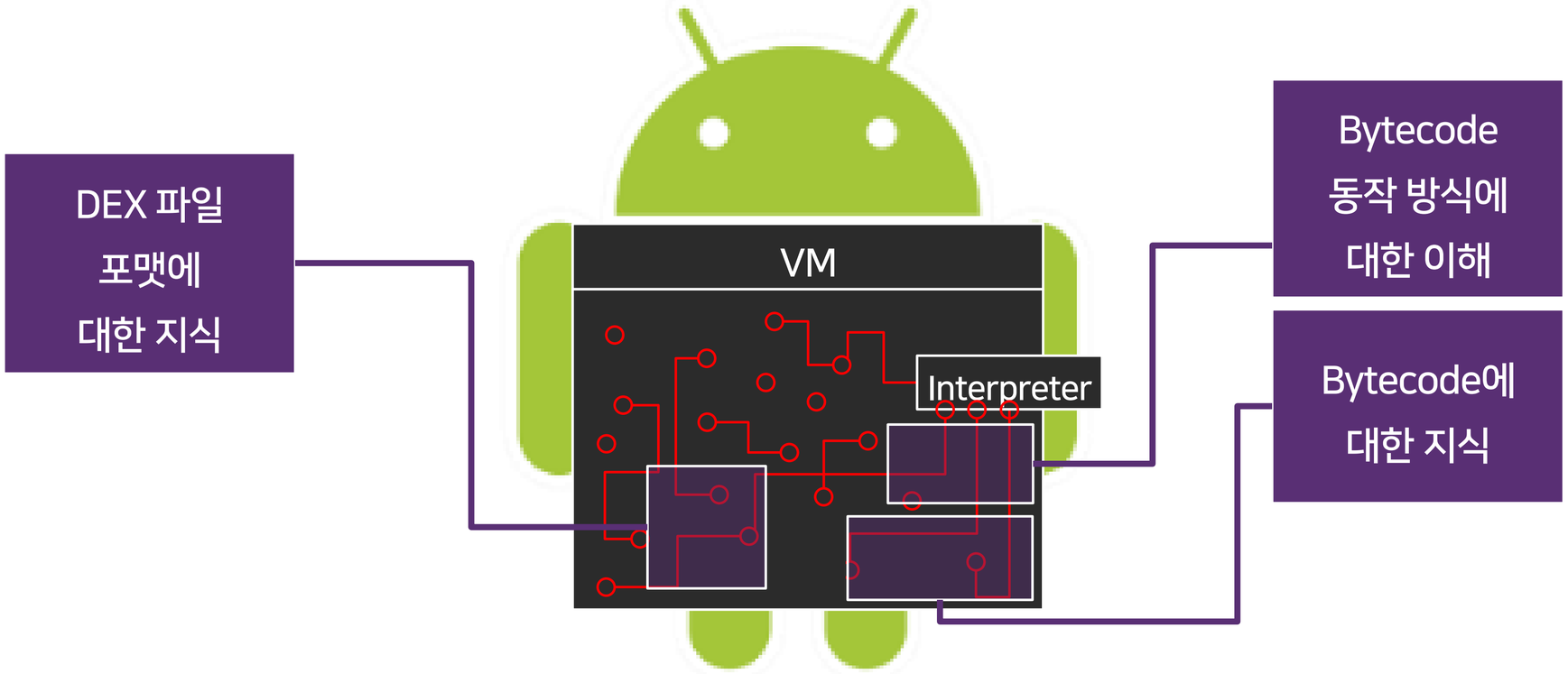
특정 오픈소스를 분석해야 하는 경우


```
public class Main {
    public static void main(String[] args) {
            System.out.println("Hello World!");
        }
}
```

```
$ javac Main.java
$ dx --dex --output=classes.dex Main.class
$ zip Main.apk classes.dex
$ uftrace record -a `which dalvikvm64` –cp Main.apk Main
```

Tracing 에 도움이 되는 요소들

거대 오픈소스를 분석할 때는 관련 배경지식이 매우 중요합니다



Tracing 에 도움이 되는 요소들

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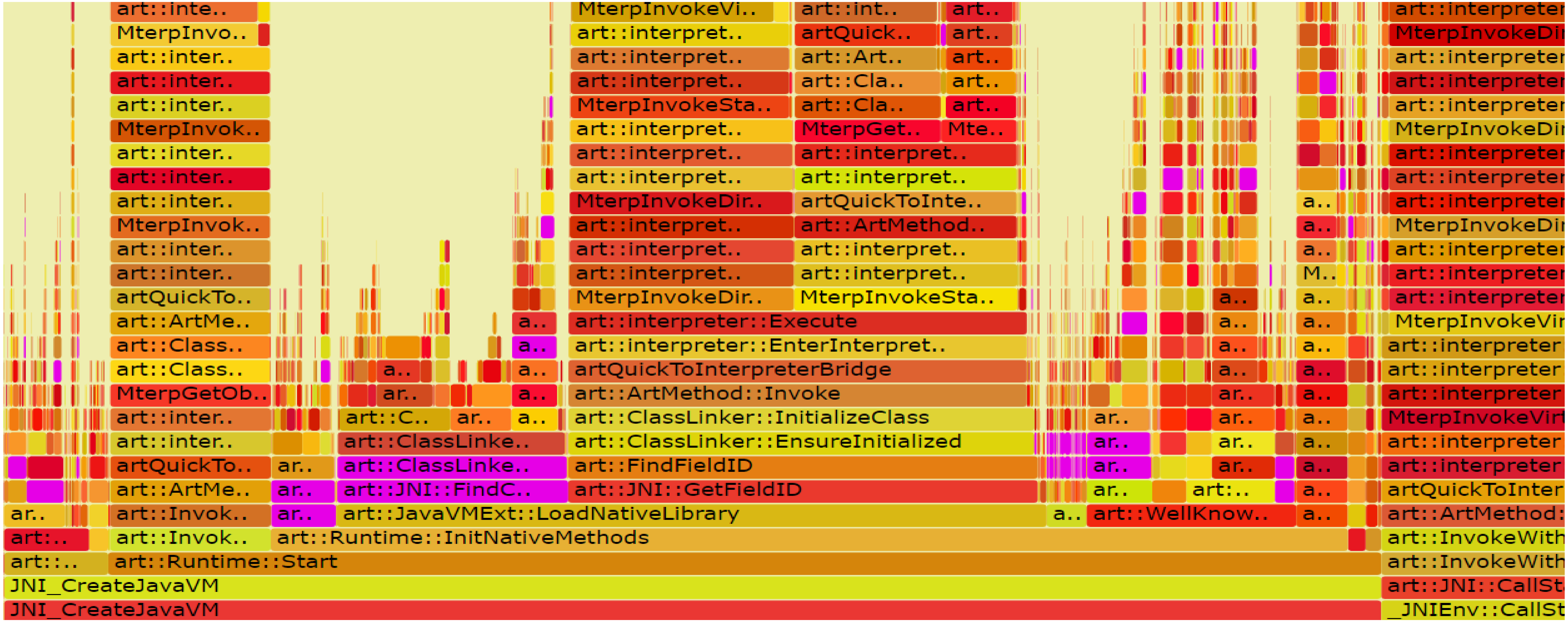
Tracing 시각화의 유용성



Tracing 에 도움이 되는 요소들

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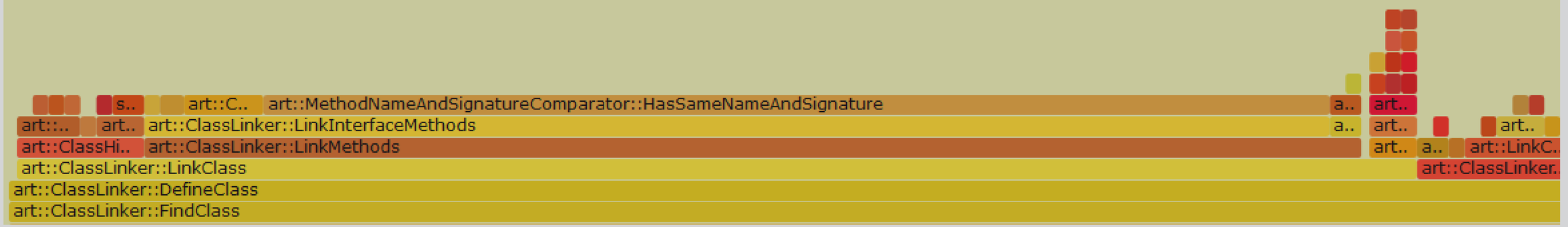
Tracing 시각화의 유용성

Class Path

art::ClassLinker::FindClass
└ art::ClassLinker::DefineClass
└ art::ClassLinker::LinkClass
└ art::ClassLinker::LinkMethods
└ art::ClassLinker::LinkInterfaceMethods



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Tracing
오픈소스 접근성을 올려주는 요소

개발자가 남긴 메시지는 매우 중요!!

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```
;; Function get_msg (get_msg, funcdef_no=0, decl_uid=1792, cgraph_uid=0, symbol_order=0)
Deleted dead store: str = "Hello world₩n";
__attribute__((always_inline))  get_msg ()
{
    char str[64];
    <bb 2> [0.00%]:
    str ={v} {CLOBBER};
    return &str;
}
```

코드는 접근성이 매우 떨어집니다.


```
;; Function get_msg (get_msg, funcdef_no=0, decl_uid=1792, cgraph_uid=0, symbol_order=0)
De
__
{
  str ={v} {CLOBBER};
  return &str;
}
```

```
(gdb) p *gsi->ptr
$4 = {code = GIMPLE_ASSIGN, no_warning = 0, visited = 0,
nontemporal_move = 0, plf = 1, modified = 0, has_volatile_ops
= 0, pad = 0, subcode = 32, uid = 0,
    location = 2147483655, num_ops = 2, bb = 0x7ffff6ede478,
next = 0x7ffff702d190, prev = 0x7ffff702d140}
```

Tracing에는 배경지식이 매우 중요합니다.

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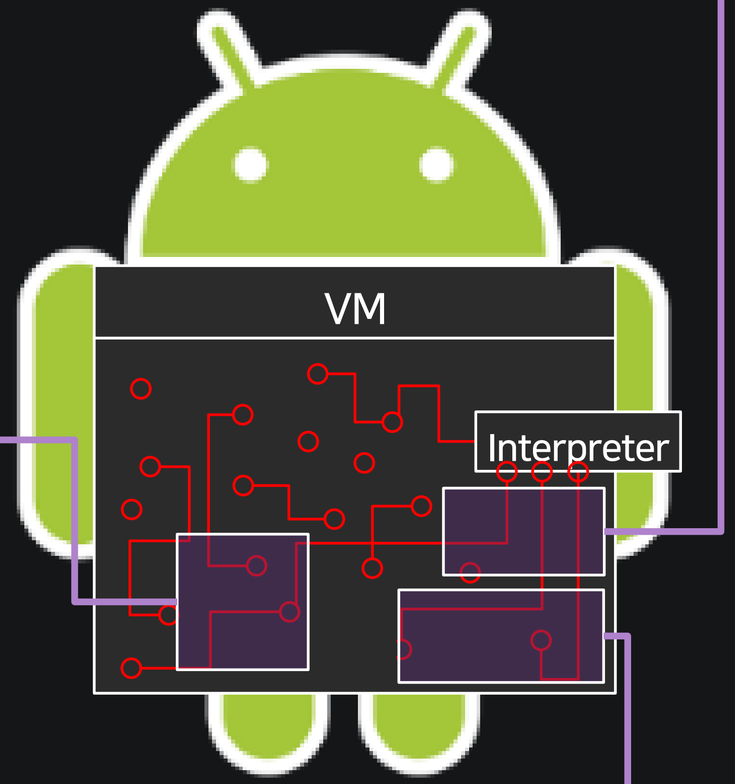
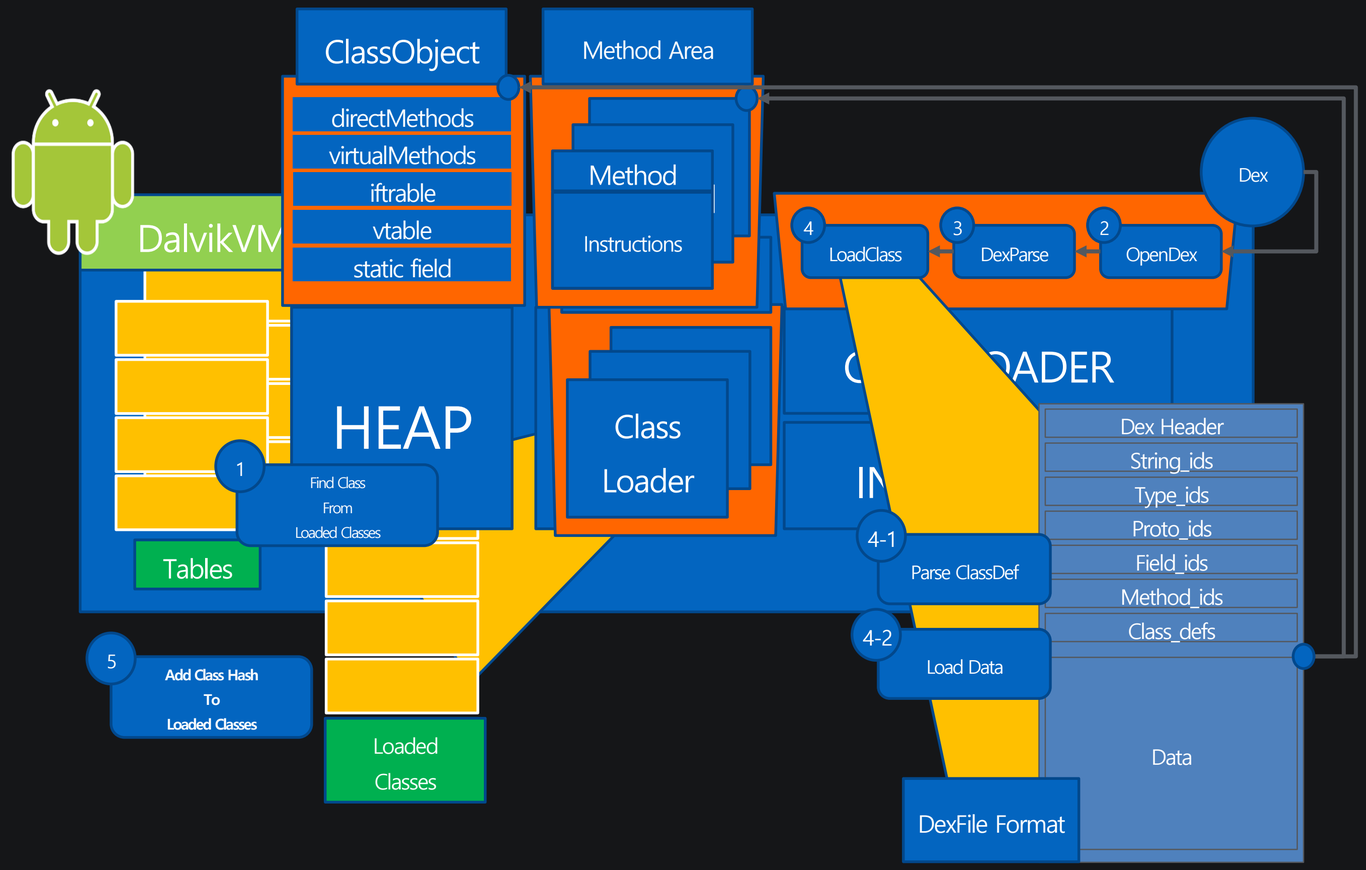
Bytecode
동작 방식에
대한 이해

DEX 파일
포맷에
대한 지식

Bytecode에
대한 지식





부족한 배경지식은 강제로 배우게 되니까요

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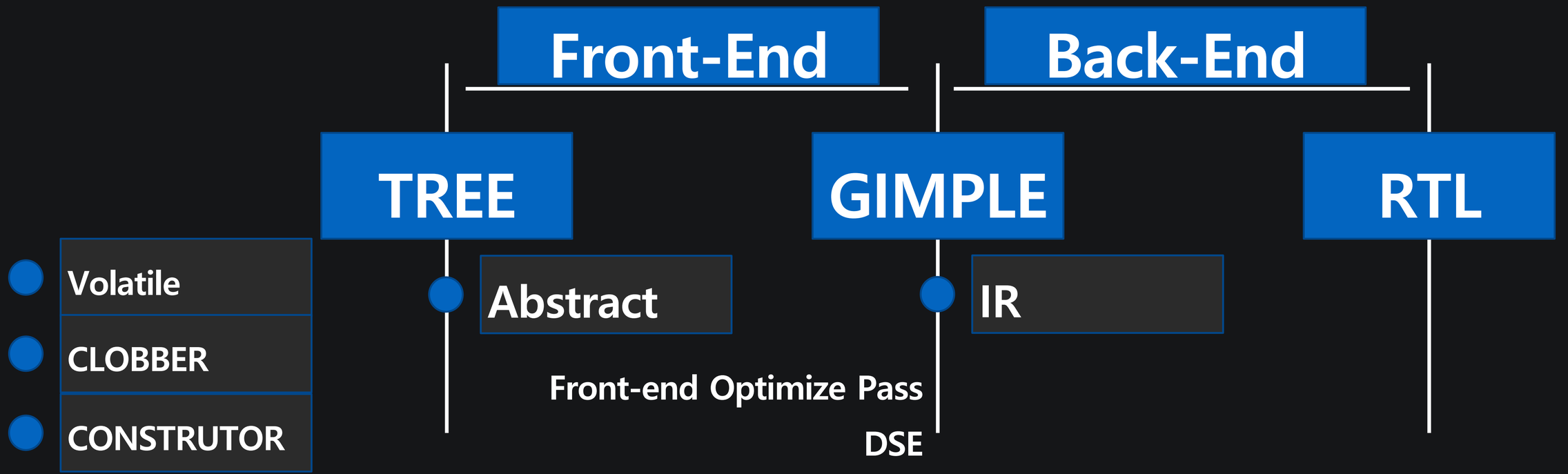
```
else if (DECL_DECLARED_INLINE_P(current_function_decl))
    inner->base.volatile_flag = true;
```



누군가 알려줬다면 훨씬 쉬웠을텐데…

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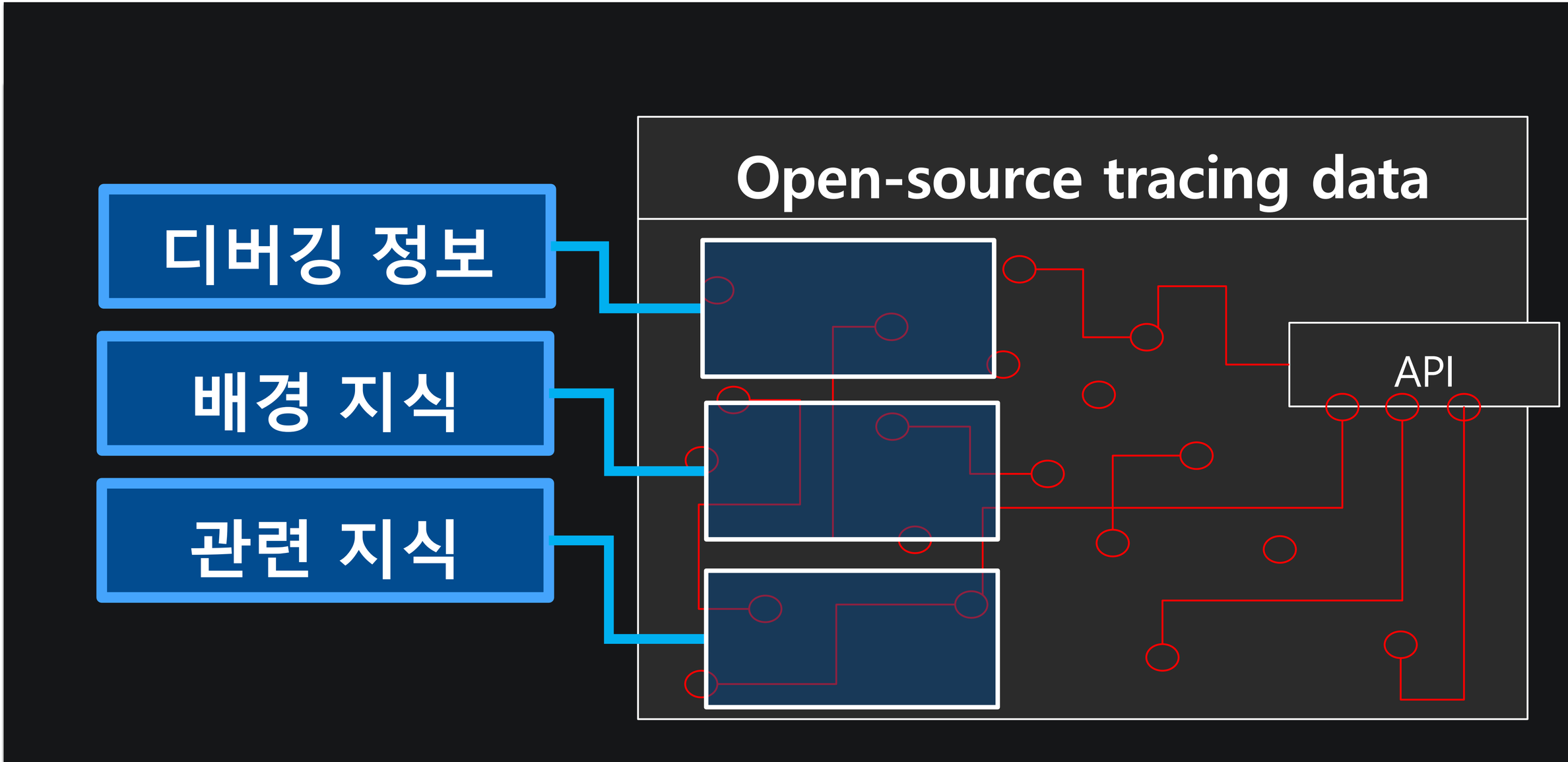

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Tracing

배경지식과 개발자 메시지 입히기

(feat, NodeJS/Pinpoint/v8)

NodeJS 개발자들이 남긴 메시지

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```
function find_me_a() {
  console.log("hellworld");
}
```

```
$ nodejs --trace hellworld.js
1: ~+0(this=0x355aaee01521 <JSGlobal Object>) {
2: ~find_me_a+0(this=0x355aaee01521 <JSGlobal Object>) {
hellworld
2: } -> 0x1aa1629004d1 <undefined>
1: } -> 0x1aa1629004d1 <undefined>
```

또 다른 메시지 —print-bytecode

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--trace 옵션 disable 시 생성되는 bytecode

```
[generated bytecode for function: find_me_a]
Parameter count 1
Register count 3
Frame size 24
   18 E> 0x1ce45b01eb1f @    5 : a5                StackCheck
   27 S> 0x1ce45b01eb20 @    6 : 13 00 00          LdaGlobal [0], [0]
         0x1ce45b01eb23 @    9 : 26 fa             Star r1
   35 E> 0x1ce45b01eb25 @   11 : 28 fa 01 02       LdaNamedProperty r1, [1], [2]
         0x1ce45b01eb29 @   15 : 26 fb             Star r0
         0x1ce45b01eb2b @   17 : 12 02             LdaConstant [2]
         0x1ce45b01eb2d @   19 : 26 f9             Star r2
   35 E> 0x1ce45b01eb2f @   21 : 59 fb fa f9 04    CallProperty1 r0, r1, r2, [4]
         0x1ce45b01eb34 @   26 : 0d                LdaUndefined
         0x1ce45b01eb35 @   27 : 26 fb             Star r0
   53 S> 0x1ce45b01eb3c @   34 : a9                Return
```

--trace 옵션 enable 시 생성되는 bytecode

```
[generated bytecode for function: find_me_a]
Parameter count 1
Register count 3
```

CallRuntime [TraceEnter], r0-r0

```
   18 E> 0x1ce45b01eb1f @    5 : a5                StackCheck
   27 S> 0x1ce45b01eb20 @    6 : 13 00 00          LdaGlobal [0], [0]
         0x1ce45b01eb23 @    9 : 26 fa             Star r1
   35 E> 0x1ce45b01eb25 @   11 : 28 fa 01 02       LdaNamedProperty r1, [1], [2]
         0x1ce45b01eb29 @   15 : 26 fb             Star r0
         0x1ce45b01eb2b @   17 : 12 02             LdaConstant [2]
         0x1ce45b01eb2d @   19 : 26 f9             Star r2
   35 E> 0x1ce45b01eb2f @   21 : 59 fb fa f9 04    CallProperty1 r0, r1, r2, [4]
         0x1ce45b01eb34 @   26 : 0d                LdaUndefined
```

CallRuntime [TraceExit], r0-r0

```
   53 S> 0x1ce45b01eb3c @   34 : a9                Return
```

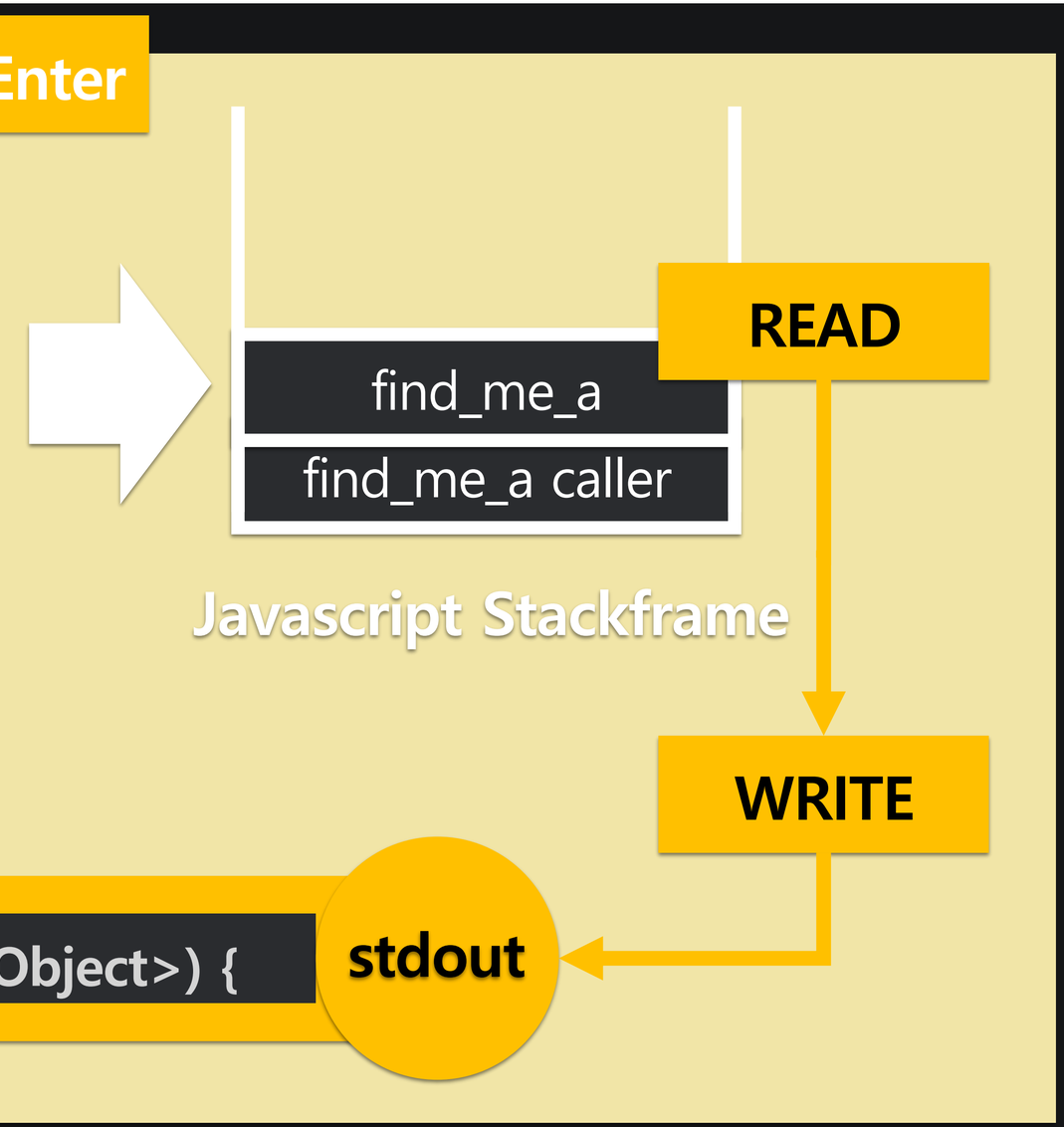
TraceEnter/Exit 가 추가되는 것을 확인


```
function find_me_a() {
    console.log("hellworld");
}
```

```
function find_me_a() {
    TraceEnter();
    console.log("hellworld");
    TraceExit();
}
```

TraceEnter 의도된 작업

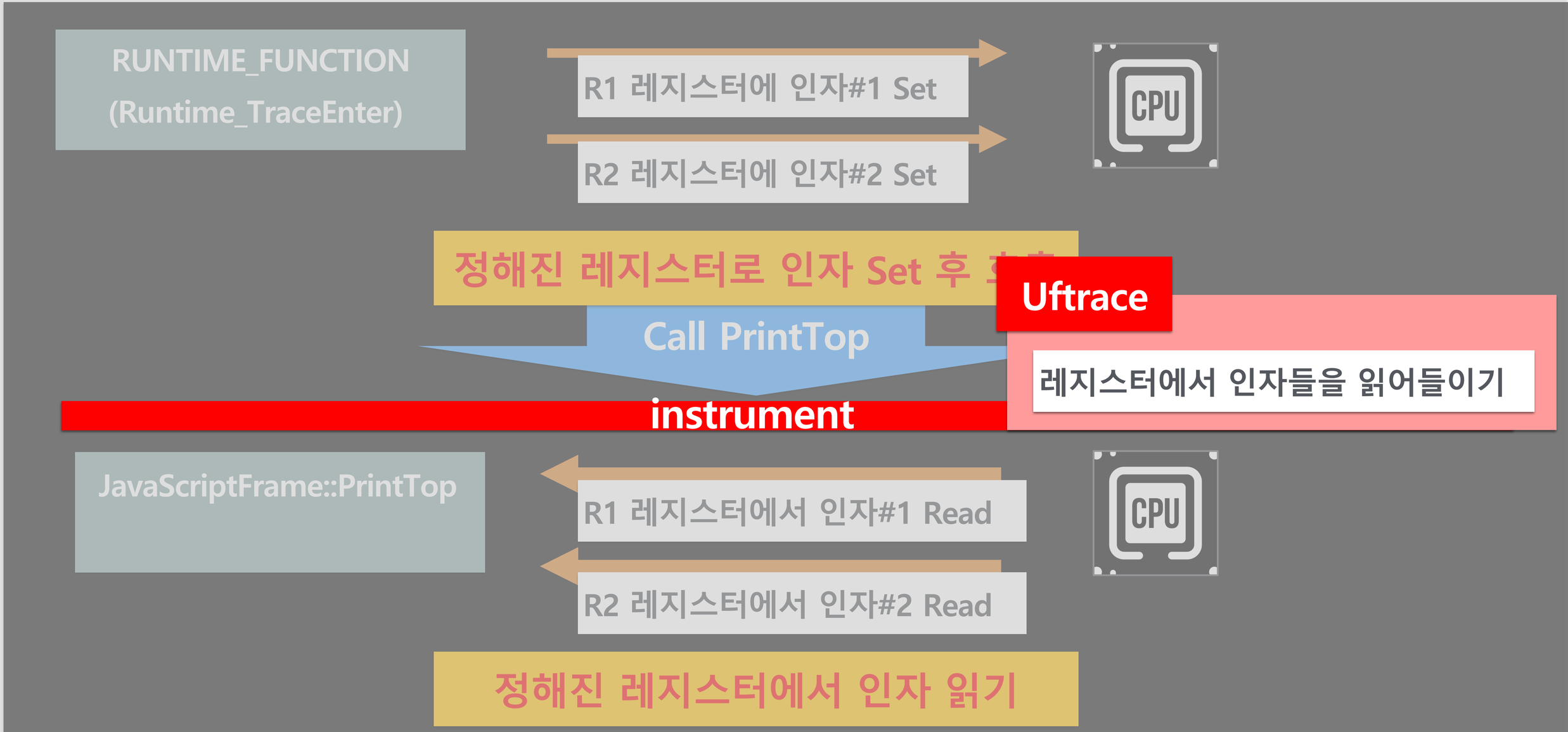

```
function find_me_a() {
    TraceEnter();
    console.log("hellworld");
    TraceExit();
}
```




```
2: ~find_me_a+0(this=0x355aaee01521 <JSGlobal Object>) {
```

Calling Convention – 인자 값 전달 방식

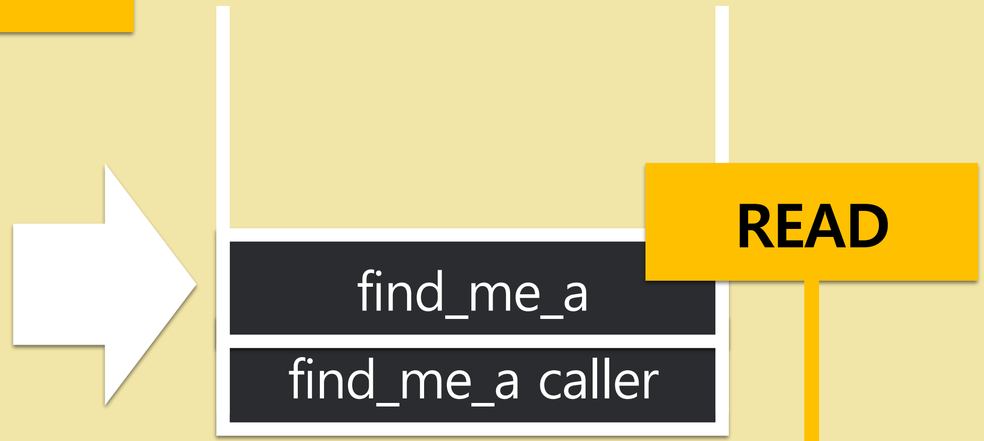
Uftrace에서 활용하는 방식



Uftrace로 출력 Stream 가로채기


```
function find_me_a() {
    TraceEnter();
    console.log("hellworld");
    TraceExit();
}
```

TraceEnter Enter



READ

Javascript Stackframe

WRITE

Uftrace

```
2: ~find_me_a+0(this=0x355aaee01521 <JSGlobal Object>) {
```

UFTRACE
Stream

Tracing Data에 기록한 결과

JavaScript 호출

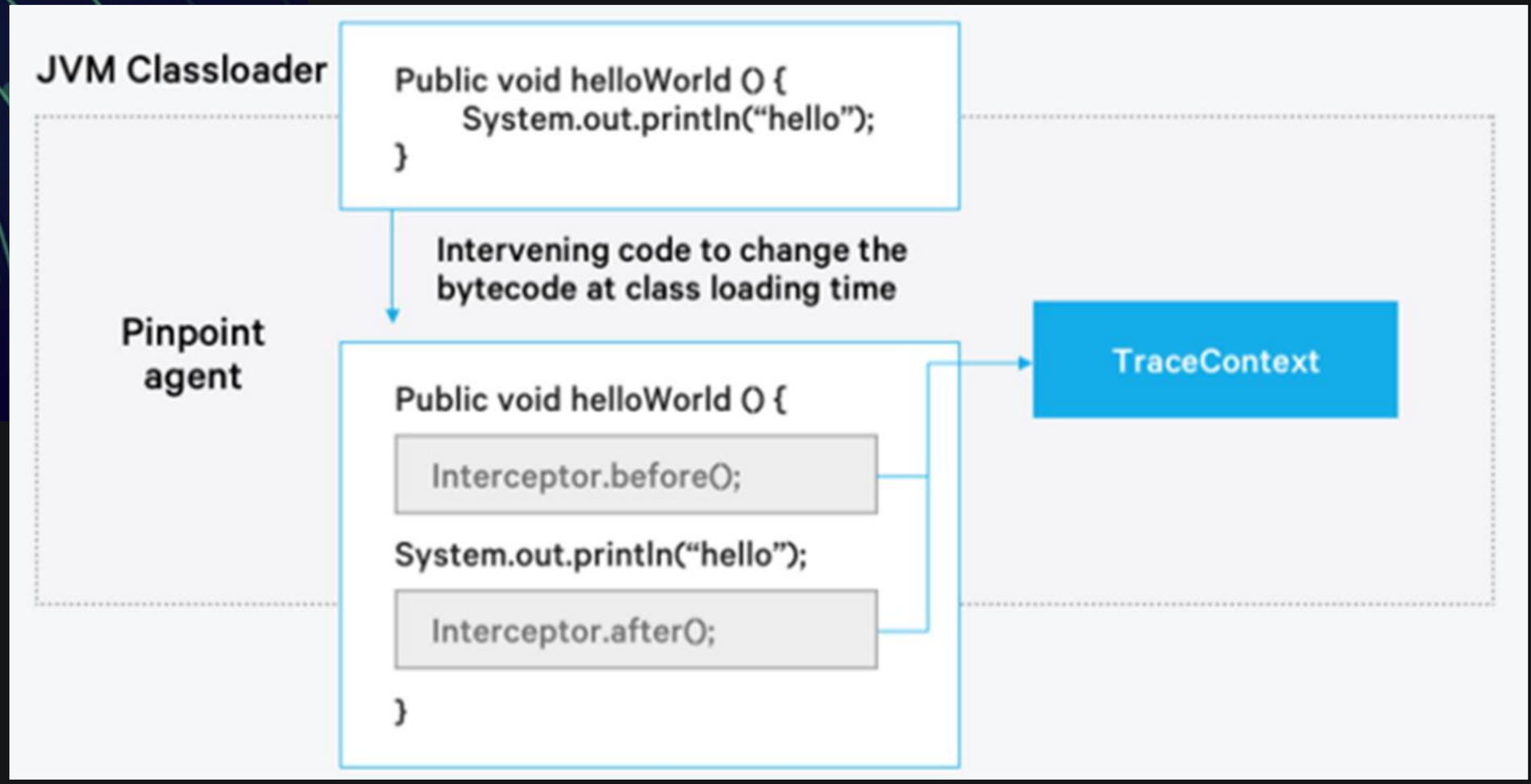
```
[ 30053] |  ~find_me_a+0(this=0x2c3bb9284de9 <JSGlobal Object>, 0x081d3615ead1 ...)
```

JavaScript 호출
처리 동작

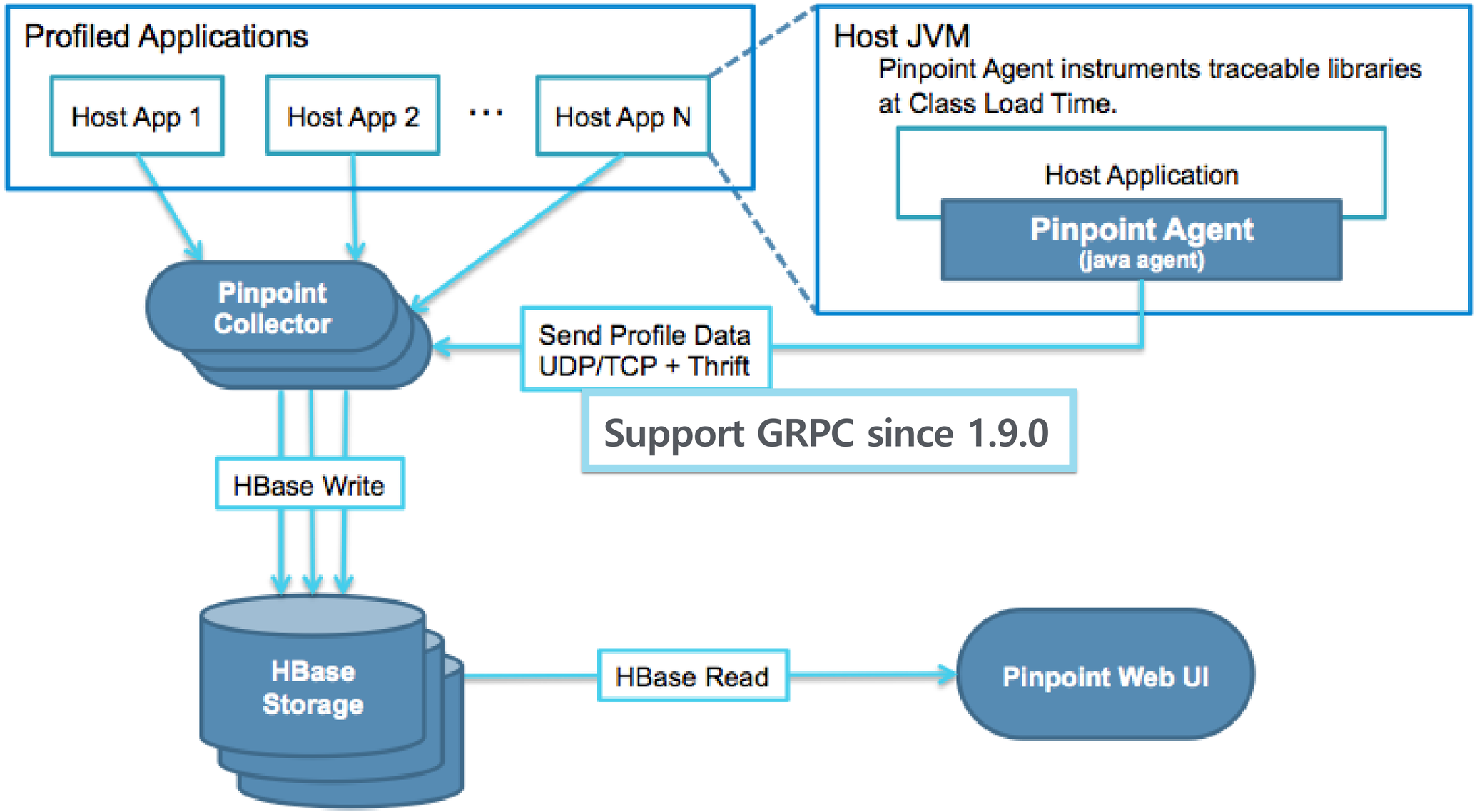
```
[ 30053] |      v8::internal::Runtime_CompileLazy() {
[ 30053] |        v8::internal::StackLimitCheck::JsHasOverflowed() {
0.145 us [ 30053] |          v8::internal::GetCurrentStackPosition();
1.453 us [ 30053] |        } /* v8::internal::StackLimitCheck::JsHasOverflowed */
[ 30053] |        v8::internal::Compiler::Compile() {
[ 30053] |          v8::internal::Compiler::Compile() {
```

Pinpoint 의 instrument

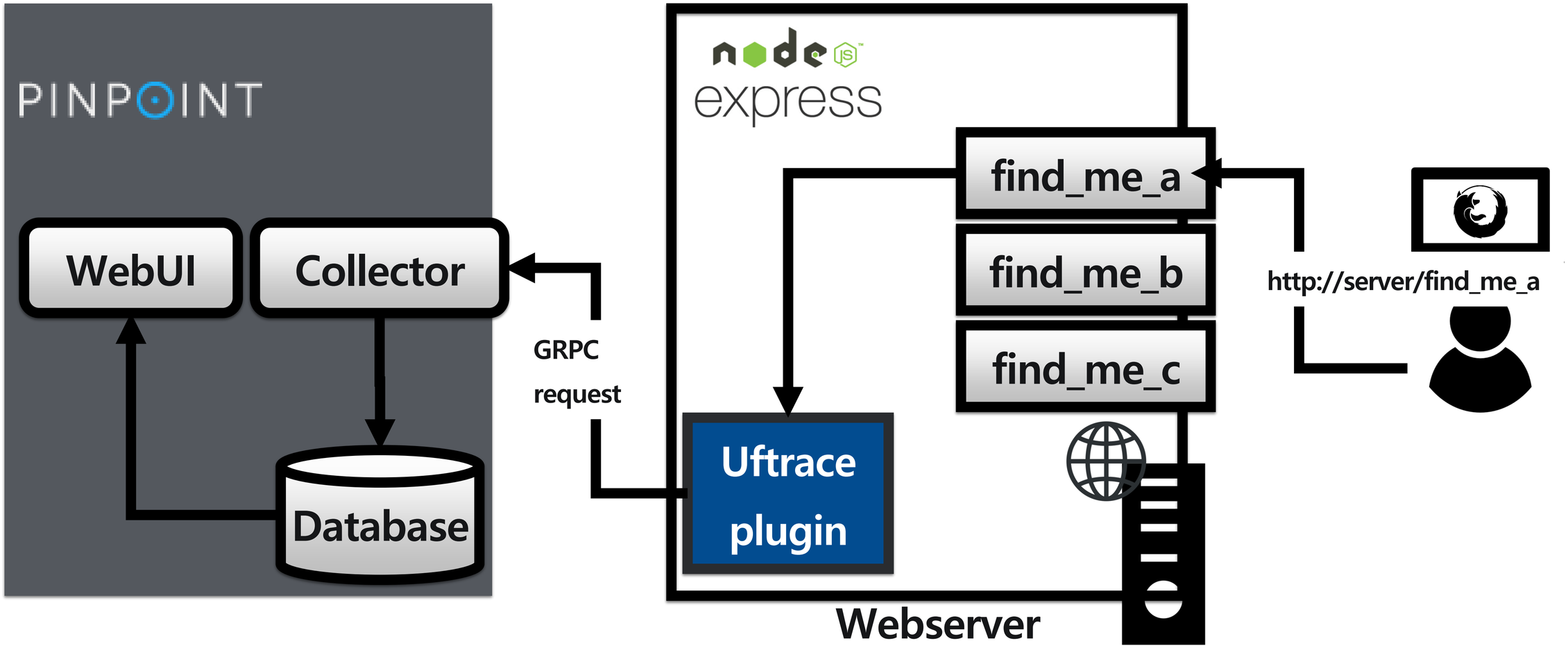
애플리케이션
성능 모니터링
Pinpoint



Pinpoint APM



Simple NodeJS APM



too much information

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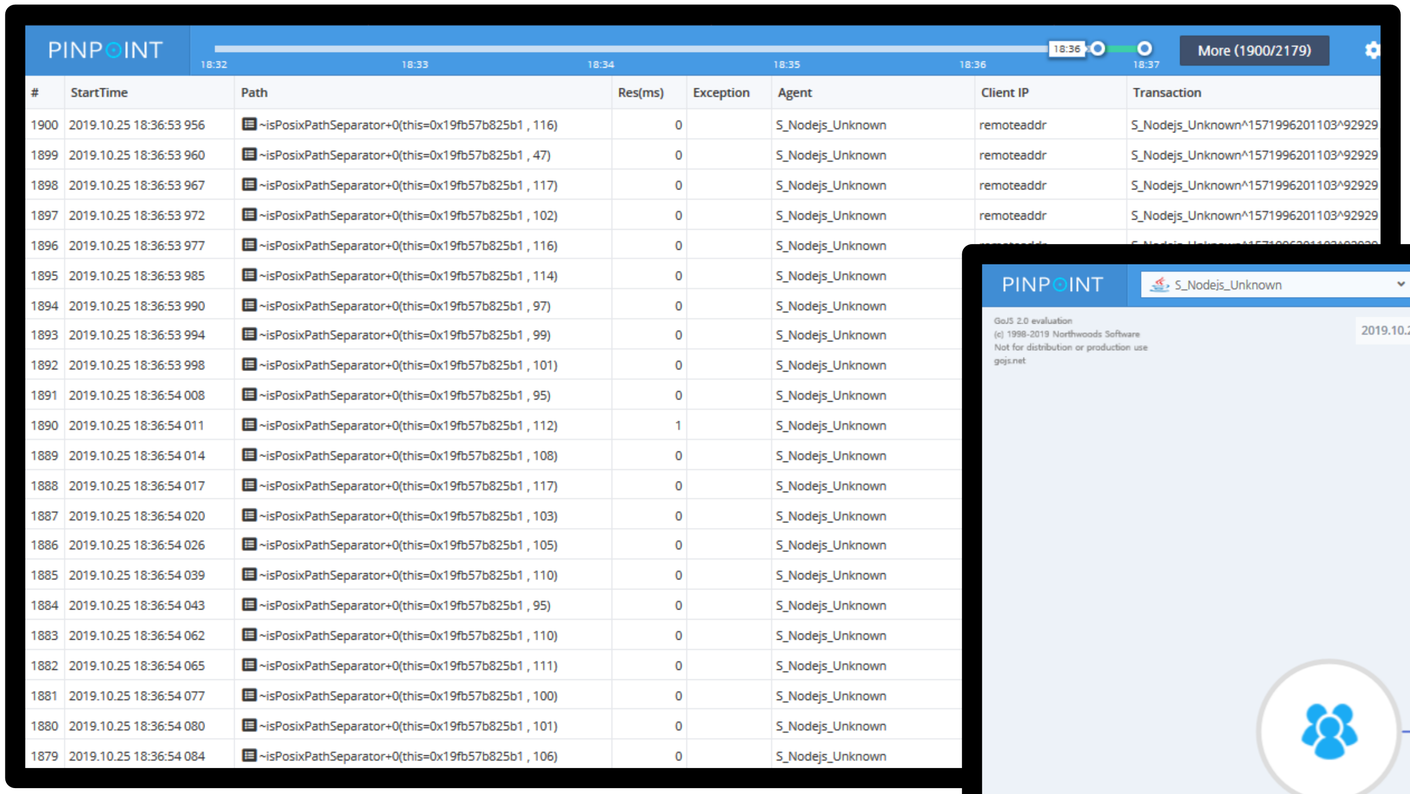
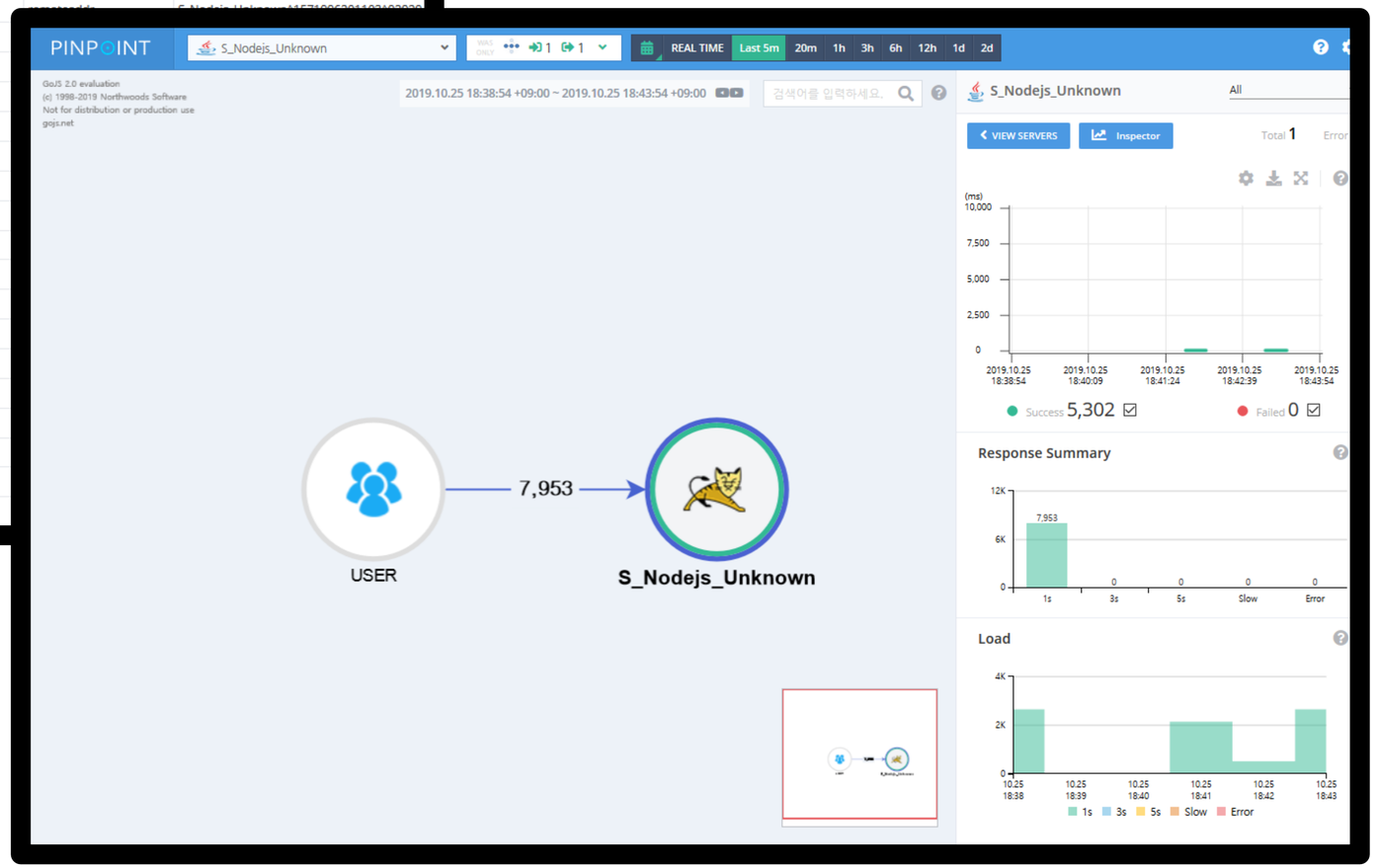


#	StartTime	Path	Res(ms)	Exception	Agent	Client IP	Transaction
1900	2019.10.25 18:36:53 956	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 116)	0		S_Nodejs_Unknown	remoteaddr	S_Nodejs_Unknown^1571996201103^92929
1899	2019.10.25 18:36:53 960	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 47)	0		S_Nodejs_Unknown	remoteaddr	S_Nodejs_Unknown^1571996201103^92929
1898	2019.10.25 18:36:53 967	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 117)	0		S_Nodejs_Unknown	remoteaddr	S_Nodejs_Unknown^1571996201103^92929
1897	2019.10.25 18:36:53 972	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 102)	0		S_Nodejs_Unknown	remoteaddr	S_Nodejs_Unknown^1571996201103^92929
1896	2019.10.25 18:36:53 977	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 116)	0		S_Nodejs_Unknown		
1895	2019.10.25 18:36:53 985	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 114)	0		S_Nodejs_Unknown		
1894	2019.10.25 18:36:53 990	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 97)	0		S_Nodejs_Unknown		
1893	2019.10.25 18:36:53 994	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 99)	0		S_Nodejs_Unknown		
1892	2019.10.25 18:36:53 998	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 101)	0		S_Nodejs_Unknown		
1891	2019.10.25 18:36:54 008	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 95)	0		S_Nodejs_Unknown		
1890	2019.10.25 18:36:54 011	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 112)	1		S_Nodejs_Unknown		
1889	2019.10.25 18:36:54 014	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 108)	0		S_Nodejs_Unknown		
1888	2019.10.25 18:36:54 017	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 117)	0		S_Nodejs_Unknown		
1887	2019.10.25 18:36:54 020	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 103)	0		S_Nodejs_Unknown		
1886	2019.10.25 18:36:54 026	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 105)	0		S_Nodejs_Unknown		
1885	2019.10.25 18:36:54 039	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 110)	0		S_Nodejs_Unknown		
1884	2019.10.25 18:36:54 043	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 95)	0		S_Nodejs_Unknown		
1883	2019.10.25 18:36:54 062	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 110)	0		S_Nodejs_Unknown		
1882	2019.10.25 18:36:54 065	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 111)	0		S_Nodejs_Unknown		
1881	2019.10.25 18:36:54 077	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 100)	0		S_Nodejs_Unknown		
1880	2019.10.25 18:36:54 080	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 101)	0		S_Nodejs_Unknown		
1879	2019.10.25 18:36:54 084	~isPosixPathSeparator+0(this=0x19fb57b825b1 , 106)	0		S_Nodejs_Unknown		



Javascript 함수의 Parsing


```
function find_me_a() {
  return find_me_b();
}
function find_me_b() {
  return find_me_c();
}
function find_me_c() {
  return 1;
}
find_me_a();
```

Javascript 코드의 실행 과정

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START v8::internal::_GLOBAL__N_1::CompileToplevel()

Enter Func 0

Call find_me_a()

v8::internal::Execution::Call

v8::internal::Execution::(anonymous

v8::internal::Runtime_CompileLazy

v8::internal:__RT_imple_Runtime_Co

v8::internal::Compiler::Compile

Enter find_me_a

Call find_me_b()

v8::internal::Execution::Call

v8::internal::Execution::(anonymous

v8::internal::Runtime_CompileLazy

v8::internal:__RT_imple_Runtime_Co

v8::internal::Compiler::Compile

Enter find_me_b

Call find_me_c()

v8::internal::Execution::Call

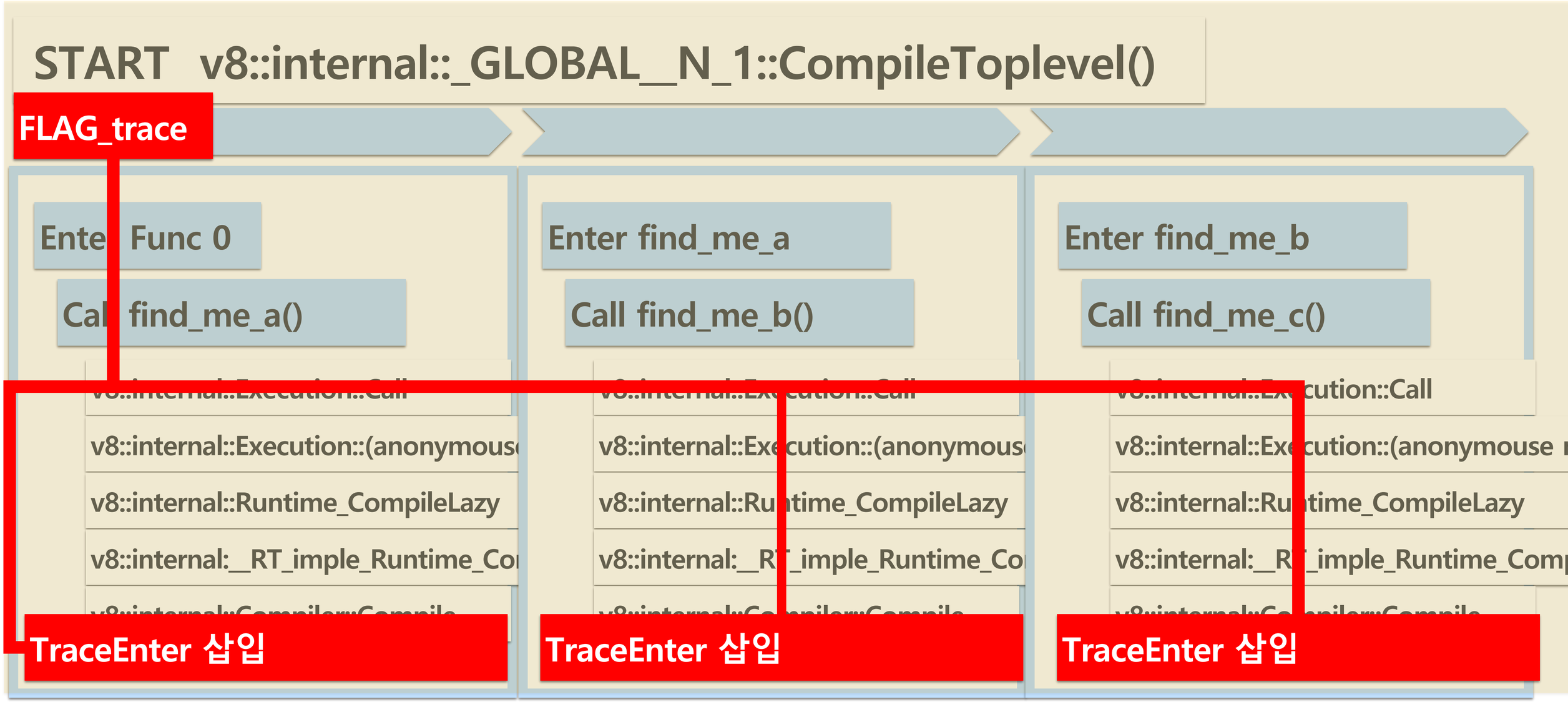
v8::internal::Execution::(anonymouse na

v8::internal::Runtime_CompileLazy

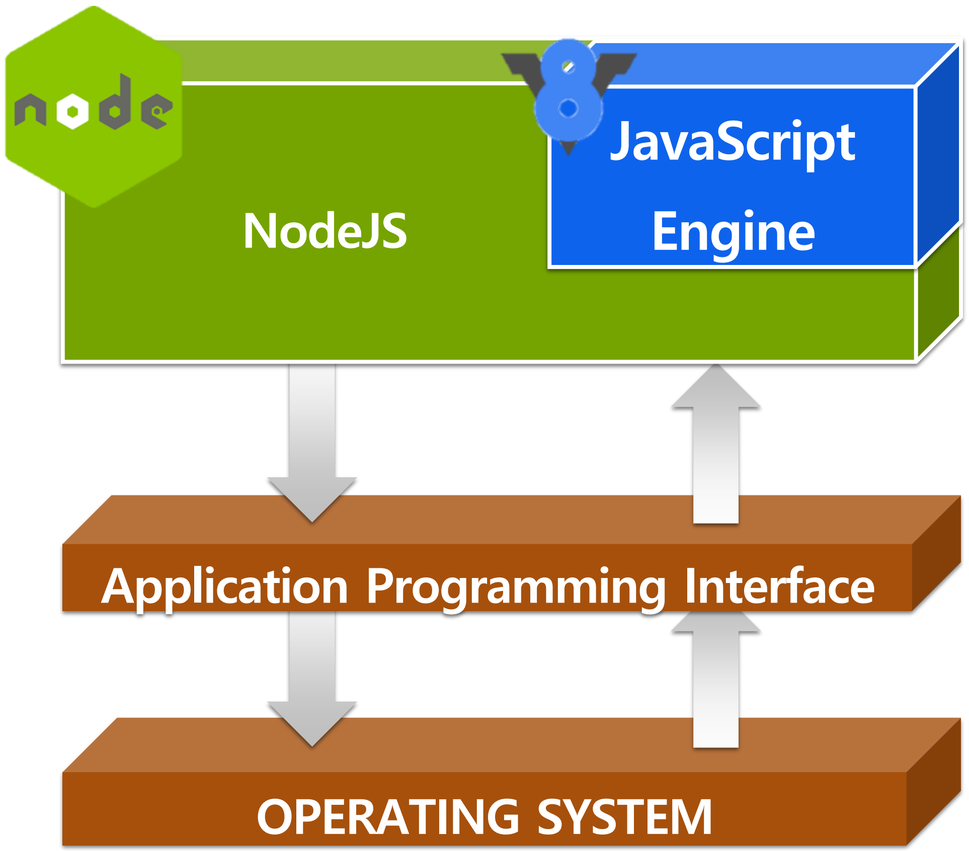
v8::internal:__RT_imple_Runtime_Compi

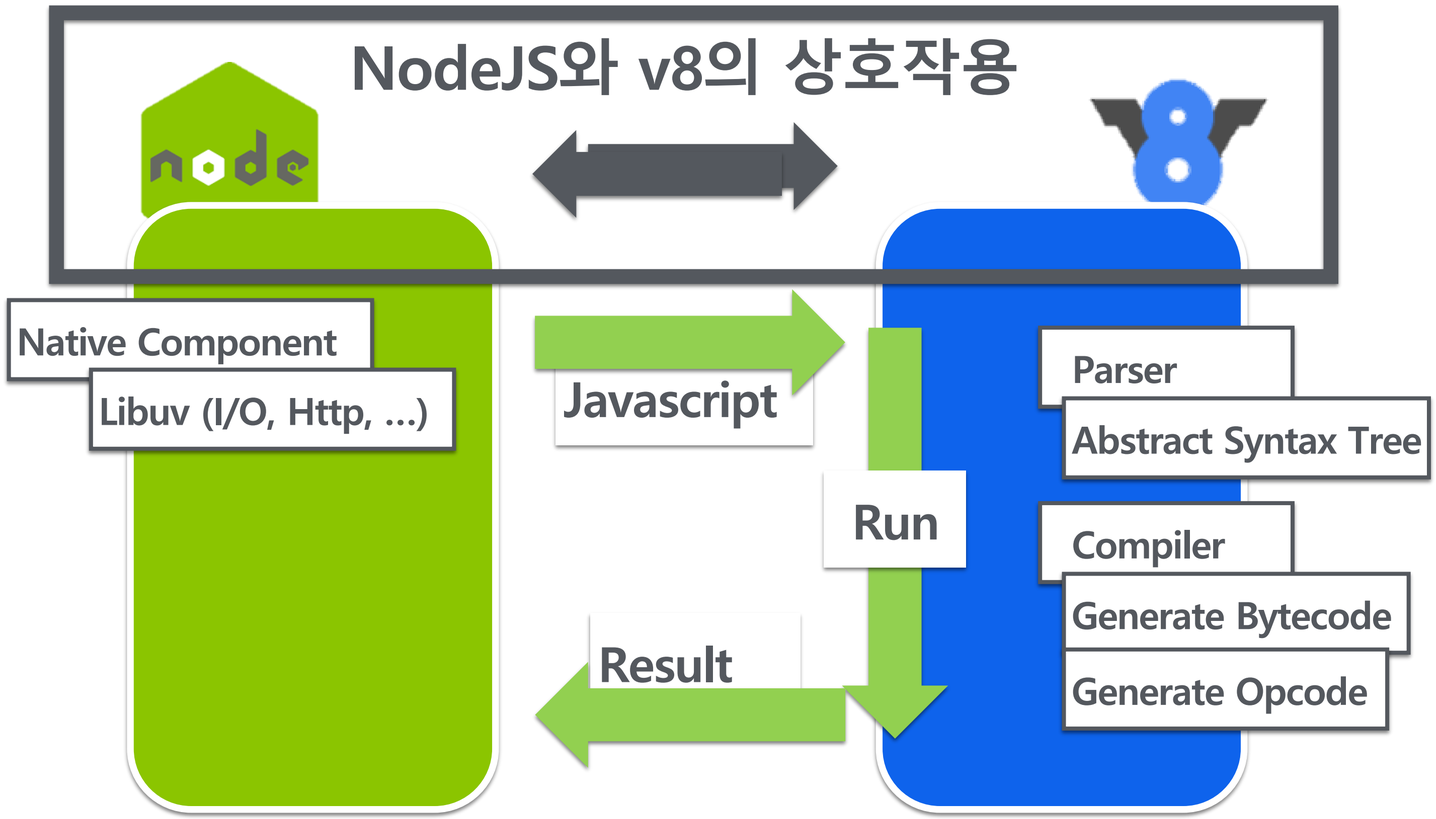
v8::internal::Compiler::Compile

TraceEnter 삽입 지점



NodeJS에 대한 배경지식

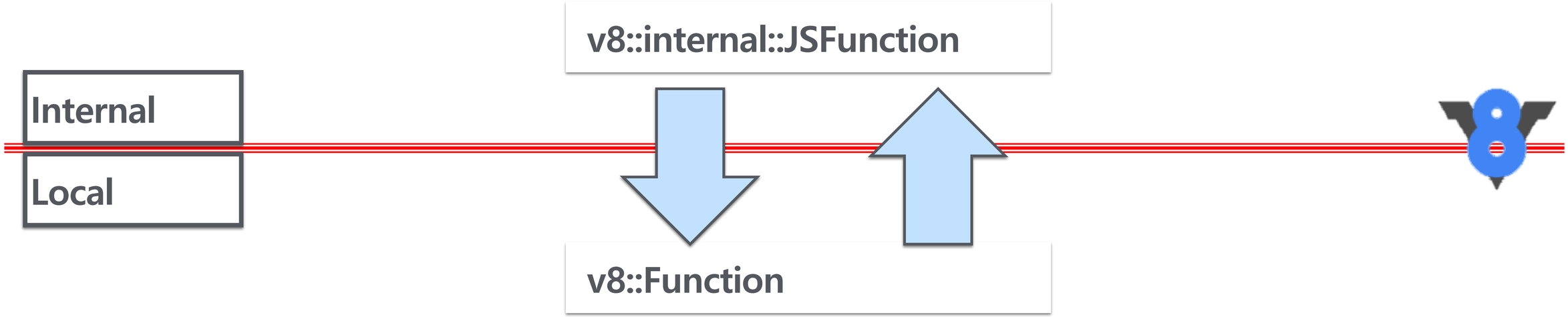





```
v8::Local<v8::Script> script = v8::Script::Compile(context, source);
v8::Local<v8::Value> result = script->Run(context);
```

Javascript Compile 함수

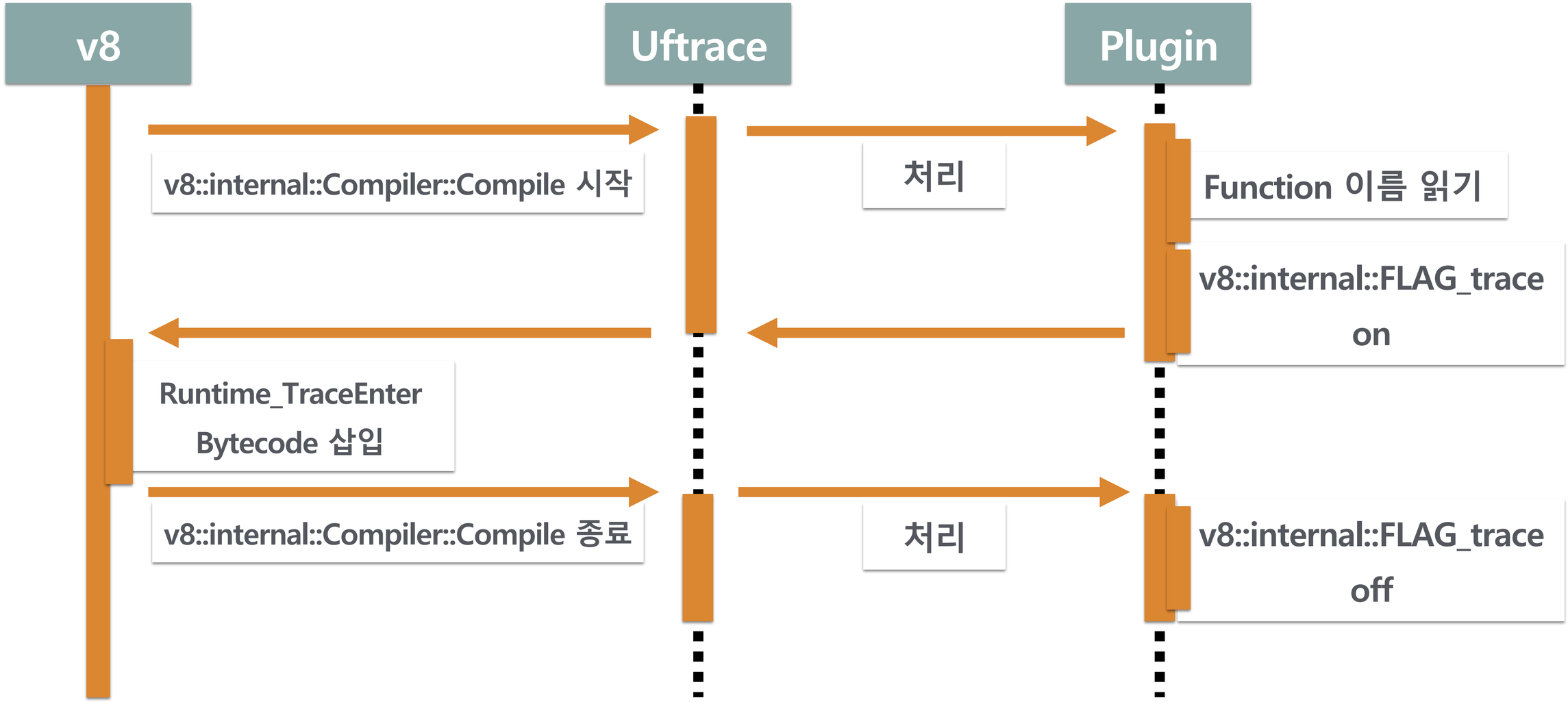

```
v8::internal::Compiler::Compile(Handle<JSFunction> function, ClearExceptionFlag, IsCompiledScope*)
```




```
v8::Function *func = reinterpret_cast<v8::Function*>(ARG1(regs));
v8::String::Utf8Value name(func->CreationContext()->GetIsolate(), func->GetDebugName());
```

배경지식 입히기

특정 JavaScript Function만 기록되게 만드는 로직



필요 함수만을 선별 기록

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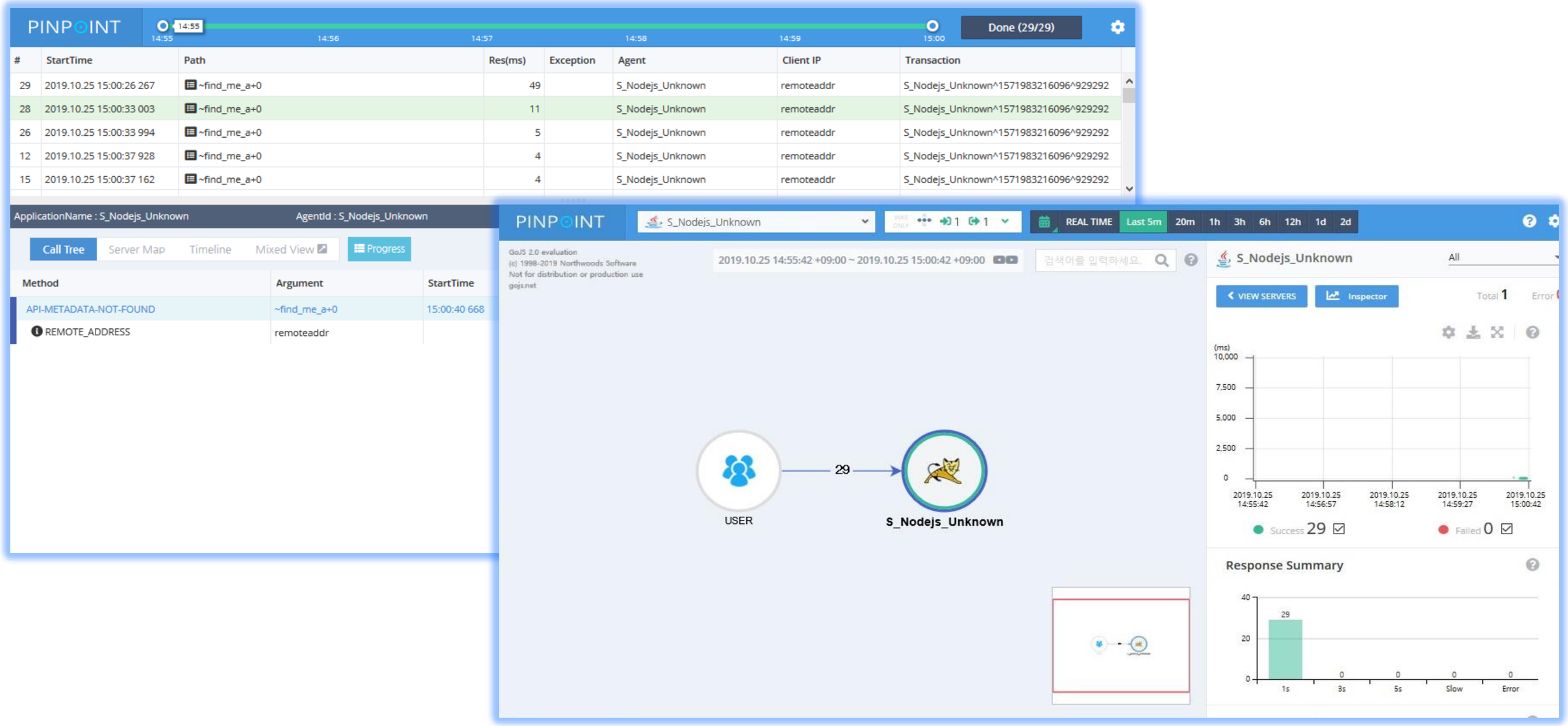

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눈발자국

뒷사람의 이정표가 된다


KBS 광주(뉴)
'눈 발자국'으로 20대 강도 검거

Plugin 제작을 통한 소기 목적 달성

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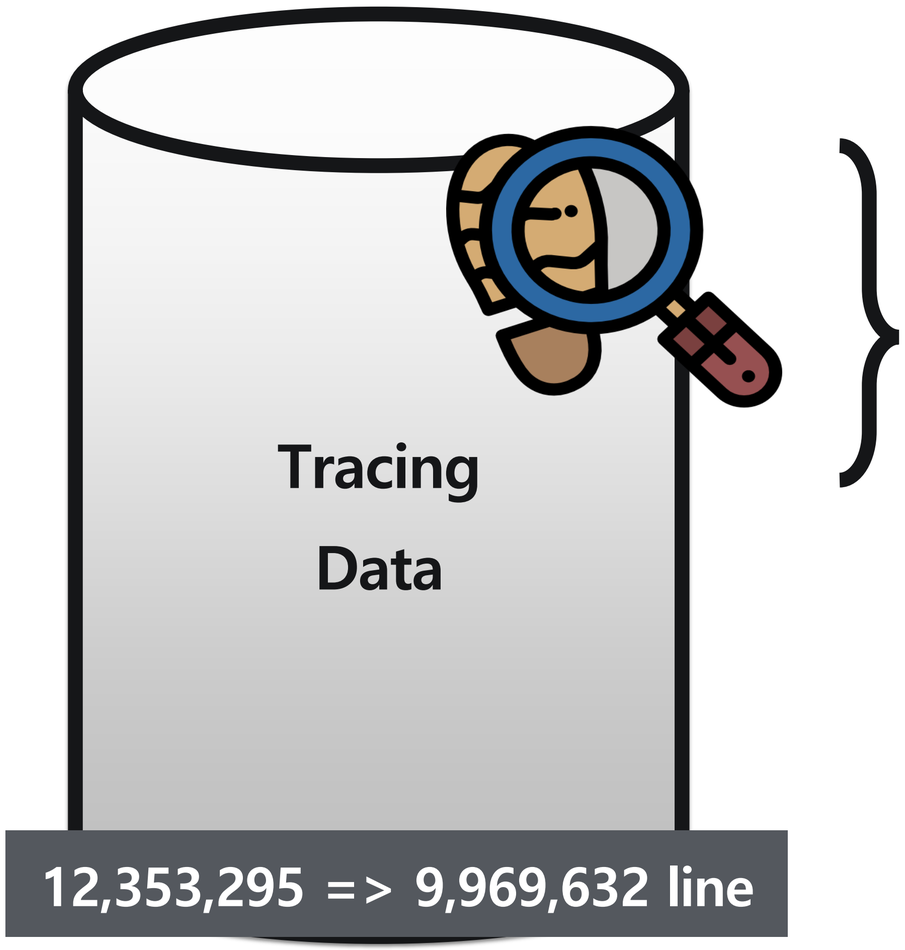


Javascript 함수를 컴파일하는 CallTree

v8::internal::Runtime_CompileLazy

v8::internal:__RT_imple_Runtime_CompileLazy

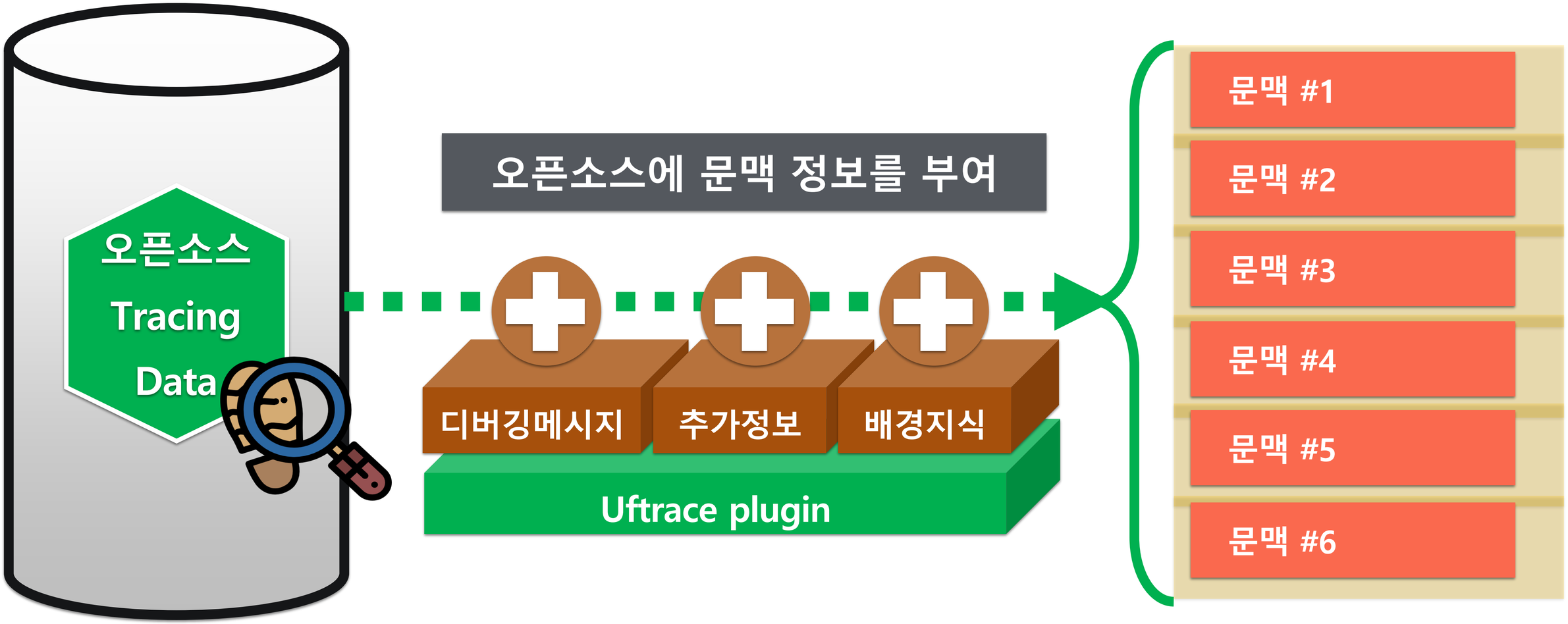
v8::internal::Compiler::Compile

치환

Javascript 함수가 컴파일된다는 문맥

<Function name> Lazy Compile

오픈소스 접근성 높히기


오픈소스
Tracing
Data
오픈소스에 문맥 정보를 부여
디버깅메시지
추가정보
배경지식
Uftrace plugin
문맥 #1
문맥 #2
문맥 #3
문맥 #4
문맥 #5
문맥 #6

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Q & A

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Thank You