An API For API Hookers
Taking A Closer At Malware

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Outline

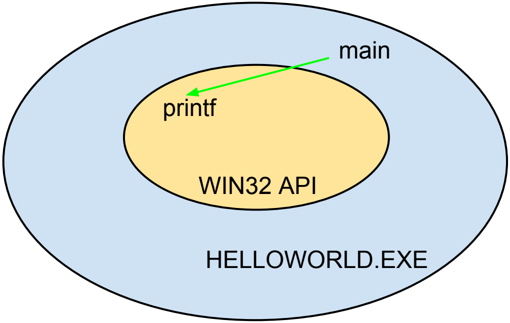
Motivation

Want to answer the question: what does `randomBinary.exe` do?

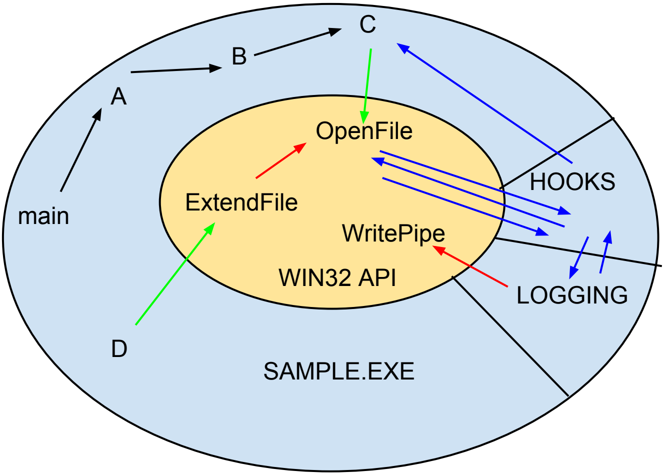
- We could stare at the assembler and/or run it.
- We shall run it and observe its behaviour, via API hooking.
- We want to know about *all* its behaviour, not just some of it.
- We want to know not only what it does, but also *how* it was composed.

Programs Use System Libraries To Get Work Done

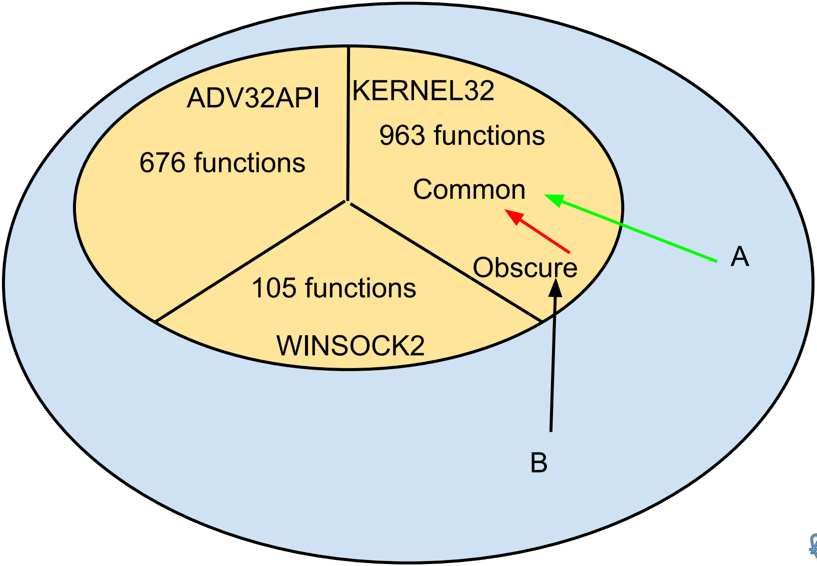
Even HelloWorld uses a system API...



API Hooking Overview



API Hooking Obstacles



API Hooking Obstacles

- Huge number of entry points into the Win32 API.
- Hook *coverage* is ratio of all hooked calls to all possible calls.
- Unhooked calls allow the malware to fly under the radar of the hooking system.
- Goal is to maximise hook coverage and hence monitoring power.

Hooking Calls To A Windows Function — Socket

```
SOCKET socket( int af, int type, int protocol );
```

To monitor this function being called, a hook function might then be

```
SOCKET socketHOOK( int af, int type, int protocol ) {
 SOCKET result = socketREAL( af, type, protocol );
 logThisCall( "socket", result, af, type, protocol );
 return result;
}
```

An example hook enabling system is Microsoft Detours:

```
SOCKET (*socketREAL)( int, int, int ) = socket;
DetoursAttach( &socketREAL, socketHOOK );
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Hook Function Code Generation Strategies

Each function to be hooked requires its own hook. No re-use possible.

Options for writing a hook for each, every call into the WinAPI:

- Inspect the header files or web docs (MSDN) and transcribe.
  - What the original developer did, for however many calls used.
  - 10 mins to code each hook times 2000+ functions = long time!
- Transcribe entire API to a database and auto-generate from there. Moves the problem rather than solves it.
- Consider the header files to *be* the database, generate the hooking code from these directly.

Introducing WinC (as in wink, not wince)

WinC is a combination of Java and Windows C:

- A Windows header file parser.
  - Turns C source code in to Java objects.
  - Extracts all function declarations and typedefs.
  - Based on Antlr and a contributed C grammar (adapted!)
- A Java API (3 main classes) for hook function code generation.
- A C API (10 functions) for runtime call logging, distribution.

WinC API Hooking Workflow

- Turn the Windows header files into a data structure (parsing).
- Interrogate this data structure to mass produce hook function source code (code generation)
- Instrument the hooks with precise logging of each call (logging).
- Build and deploy the hooks via e.g. DLL injection.
- Collect the logging messages and analyze.

WinC Header File Parser In Action

First, create a one line C file, e.g. `winsock.c`:

```
#include <Winsock2.h>
```

Next, compile this file on Windows (VizStudio/cygwin/mingw):

```
cl /P winsock.c  // produces winsock2.i, over 1MB!
```

With #defines and #includes now gone, `winsock2.i` contains just

- Function declarations.
- New types (structs,unions,enums) and typedefs.

Finally, run WinC's header file parser on `winsock2.i`:

```
winCParser winsock2.i winsock2.tu
```

WinC Header File Parser Result

```
winCParser winsock2.i winsock2.tu

Located FunctionDeclarations = 2775
Located Typedefs             = 2613
```

- Each C function declaration in the source becomes a Java object.
- Each typedef also becomes a Java object.
- The output object is a *TranslationUnit* (from the C grammar)
- A TranslationUnit is a pair: `List<FunctionDeclaration>, TypedefSystem`
- Save the TU for later use, using e.g. Java serialization.

Hook Function Generation API — TranslationUnit

After the parse phase, we load the saved TU and move on to hook function code auto-generation:

```
class TranslationUnit {
  static TranslationUnit load( File serializedTU );
  // all function declarations
  List<FunctionDeclaration> funcDecls;
  // all typedefs
  TypedefSystem typedefs;
}

TranslationUnit tu = TranslationUnit.load(
  new File( "winsock2.tu" ) );
for( FunctionDeclaration fd : tu.funcDecls ) {
  autoGenerateHook( fd );
}
```

Hook Generation API — Functions and Parameters

```
class FunctionDeclaration {
  String  getName();
  void    setName( String newName );
  boolean returnsVoid();
  String  returnType();
  String  declaration();
  String  callExpression();
  List<ParameterDeclaration> getParameters();
  String  assignableVariable( String name );
}

class ParameterDeclaration {
  String  getName();
  boolean isValue();
  boolean isString();
}
```

Hook Generation API In Action

```
SOCKET socket( int af, int type, int );
```

Interrogate the FunctionDeclaration object `fd` created by the parser:

```
String s = fd.getName();
fd.setName( s + "HOOK" );
print( fd.declaration() );
print( fd.returnType() );
fd.setName( s + "REAL" );
print( fd.callExpression() );
```

```
SOCKET socketHOOK( int af, int type, int poppy3 ){
 SOCKET result;
 result = socketREAL( af, type, poppy3 );
 return result;
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Hook Function Generation Results

```
winCHookGen winsock2.tu hooks.c

Located FunctionDeclarations = 2775
Printed Source Line Count    = 17523
```

I use Detours for testing, so the code generator produces

- All the hook functions.
- All the assignable variables.
- A hooks table for table-driven hook insertion.

Finally, take `hooks.c` back to Windows to build the DLL.

Instrumenting The Hooked Call

The whole purpose of API hooking is to watch the program in action.

- Want to record the parameters passed in.
- Want to record the call result.
- Also would like to characterize the call site.

```
SOCKET socketHOOK( int af, int type, int poppy3 ) {
 SOCKET result = socketREAL( af, type, poppy3 );

 // Need to record/transmit parameters, result

 return result;
}
```

Logging The Function Call

```
print( "int retAddr;" );
print( "__asm  mov eax,[ebp+4]; mov retAddr,eax" );
print( "LogSite(" + retAddr + ")" );
print( "LogName(" + fd.getName() + ")" );

SOCKET socketHOOK( int af, int type, int poppy3 ) {
 SOCKET result = socketREAL( af, type, poppy3 );

 int retAddr;
 __asm { mov eax, [ebp+4]; mov retAddr, eax }
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Can further use the return address value to *not* log within-API calls (earlier red arrows).

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Logging The Function Parameters

```
int arity3( DWORD p1, char* p2, struct S* p3 );

void logParam( ParameterDeclaration pd ) {
 String s = pd.getName();
 if( pd.isValue() )
  print( "LogValue( sizeof( "+ s + "),&" + s + ")");
 else if( pd.isString() )
  print( "LogString(" + s + ")" );
 else
  print( "LogPointer( sizeof(" + s + "," + s + ")");
}

LogValue( sizeof( p1 ), &p1 );   // int, void*
LogString( p2 );                 // char*
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Resolving Typedef Declarations

```
void DeleteRegistryEntry( LPSTR key );
```

The parameter appears to be a simple value, and we might log it incorrectly. But following its typedef chain reveals it to be a string:

```
typedef char  CHAR;
typedef CHAR* LPSTR;

void DeleteRegistryEntry( char* key );
```

Correct logging of each parameter is thus:

```
for( ParameterDeclaration pd:fd.getParameters() ) {
 ParameterDeclaration pd2 = tu.typedefs.resolve(pd);
 logParam( pd2 );
}
```

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```

Completed Hook Function

```
int arity3( DWORD p1, char* p2, struct S* p3 );

int arity3HOOK( DWORD p1, char* p2, struct S* p3 ) {
 int result = arity3REAL( p1, p2, p3 );
 LogValue( sizeof( p1 ), &p1 );
 LogString( p2 );
 LogPointer( sizeof( *p3 ), p3 );
 LogResult( sizeof( result ), &result );
 return result;
}
```

Enriching The Logger

```
int arity3( DWORD p1, char* p2, struct S* p3 );

void LogPointer( int dataSize, void* ptr2Data ) {
 // dereference ptr2Data, grab dataSize bytes...
}
```

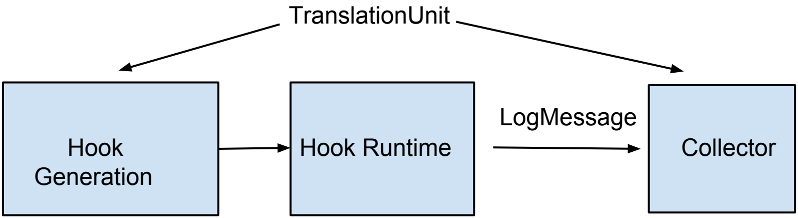
Should also grab the *value* of the pointer, it tells us something about the calling program:

- Structure allocated globally.
- Structure allocated on the heap.
- Structure allocated on the stack (avenue for overflow?).

With info from a memory map (Ollydbg), can then fingerprint the coding style, in addition to the runtime behaviour.

Collecting the Logged Information

- Run an agent to harvest hook/log outputs (NamedPipe)
- Forward to central collector (UDP), oversees a whole network?
- Collector archives the log messages. Visualizations too.
- Collector uses same TranslationUnit information to decode the log messages.
- Knowledge about the hooked calls at both sender and receiver mean the log message format is general (and terse), needs no markup.



Conclusions, Future Work

- To maximize API hooking effectiveness, need automated hook generation.
- Once have such automation, easy to experiment with different logging strategies.
- Rich, precise logging can fingerprint original coding styles.
- But don't forget, API hooking is easy to combat, decoy.

Plan to release to github. Looking for testers!