Embracing the new threat: towards automatically, self-diversifying malware

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Image (c) http://ucrtoday.ucr.edu/9768/assassin-bugs

Malware landscape is changing

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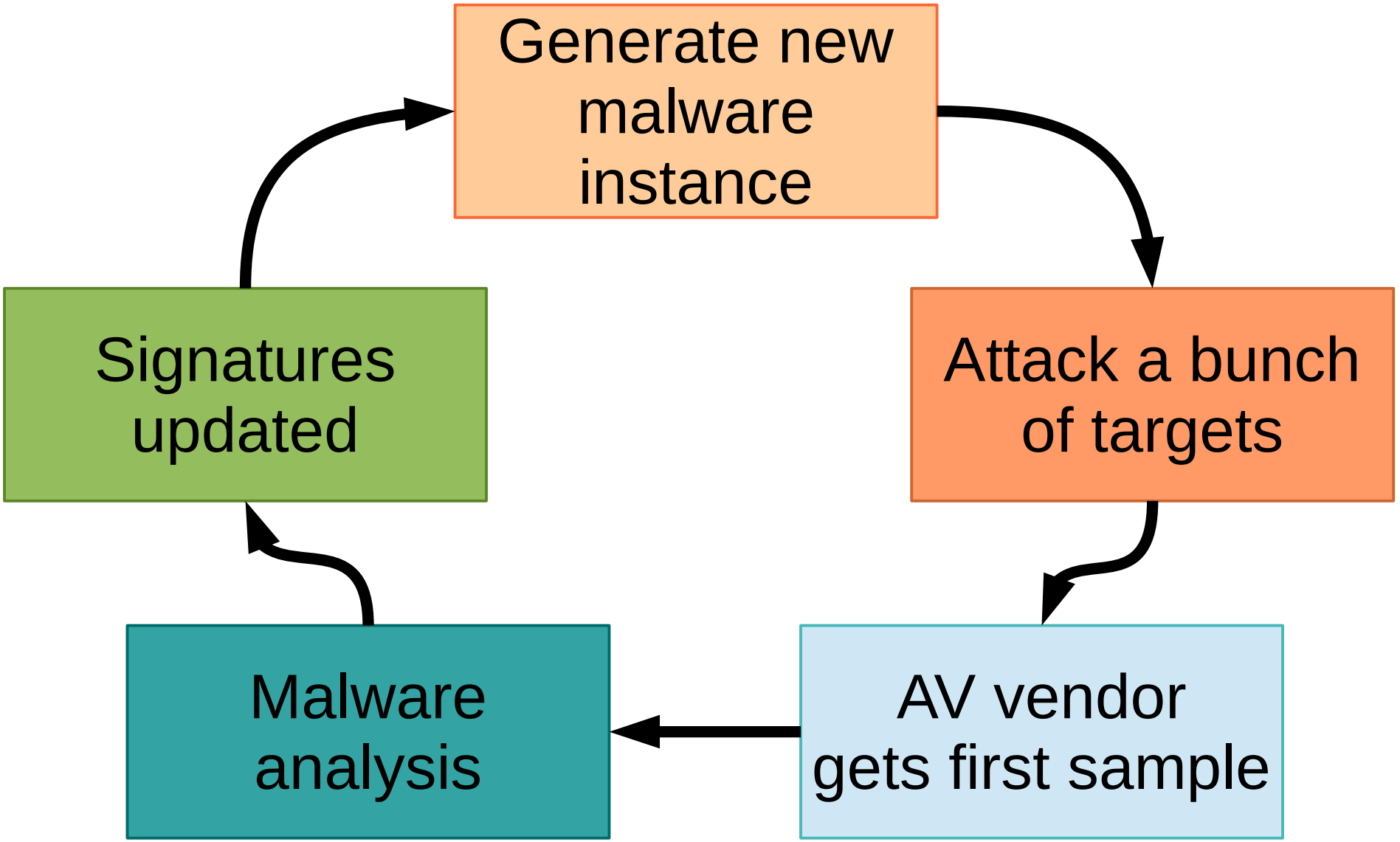
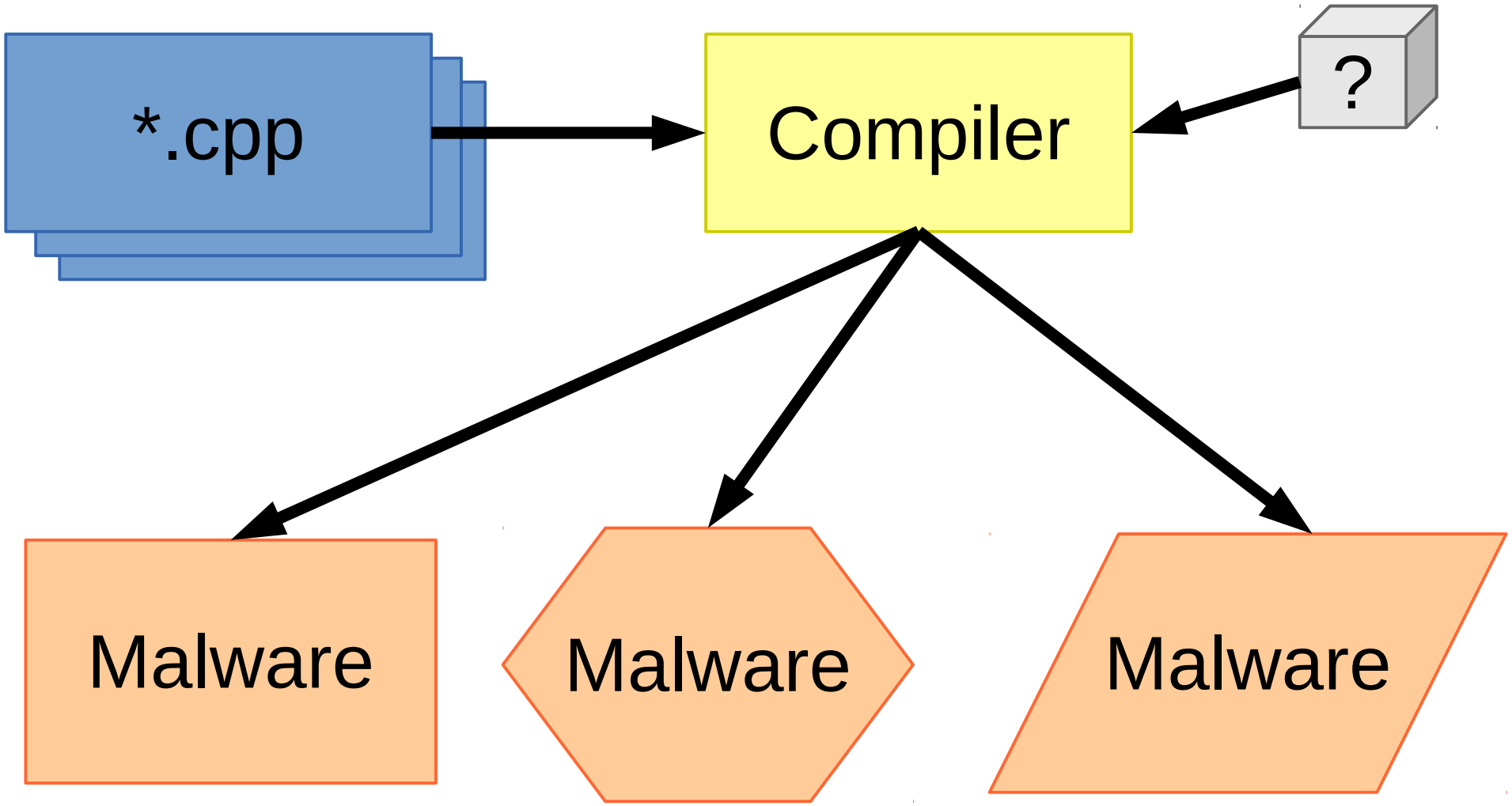
The ongoing malware arms race



Defense limitations

- Newly diversified samples are not detected
  - Basically a “new” attack
- New malware spreads fast
  - Time lag between analysis and updated signatures
- Can we automate this process?

Fully automatic diversity



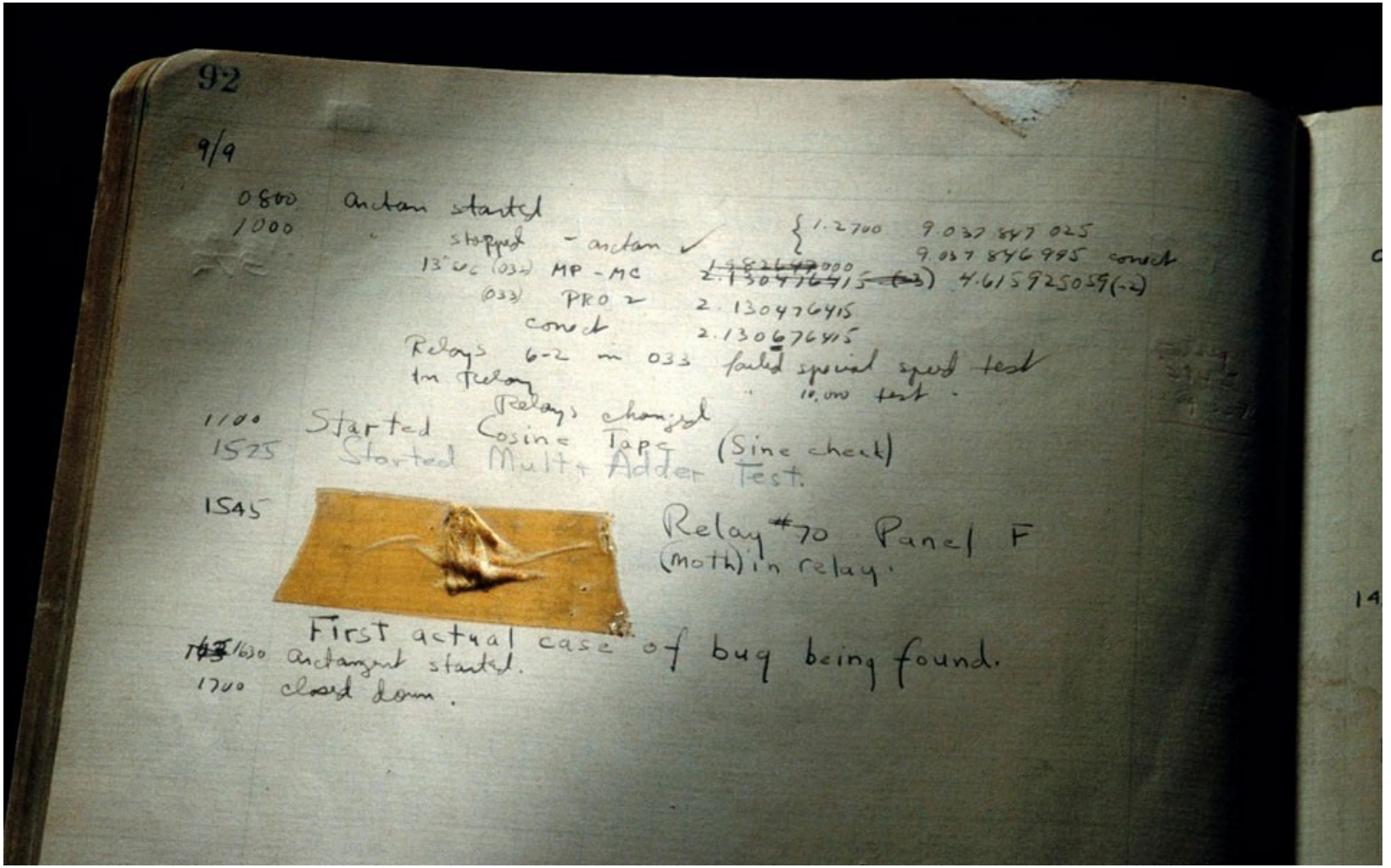
Outline

State of the art:
Malware detection

A new threat:
Malware diversification

Possible mitigation:
Better security practices

State of the art: Malware detection



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Malware detection is limited

- Performance
  - Don't slow down a user's machine (too much)
- Precision
  - Behavioral, generic matching
- Latency
  - Time lag between spread and protection

Detection mechanisms

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Signature-based detection

- Compare against database of known-bad
  - Extract pattern
  - Match sequence of bytes or regular expression
- Advantages
  - Fast
  - Low false positive rate
- Disadvantages
  - Precision limited to known-bad samples

Static analysis-based detection

- Search potentially bad patterns
  - API calls
  - System calls
- Advantages
  - Low overhead
- Disadvantages
  - False positives
  - Based on well-known heuristics

Behavioral-based detection

- Execute “file” in a virtual machine
  - Detect modifications
- Advantages
  - Most precise
- Disadvantages
  - High overhead
  - Precision limited due to emulation detection

Summary: Malware protection

- Arms race due to manual diversification
  - Signature-based techniques loose effectiveness
- Cope with limited resources
  - On the target machine, for the analysis, and to push new signatures/heuristics
- No perfect solution
  - Either false positives and/or negatives or huge performance impact

New threat: Malware diversification

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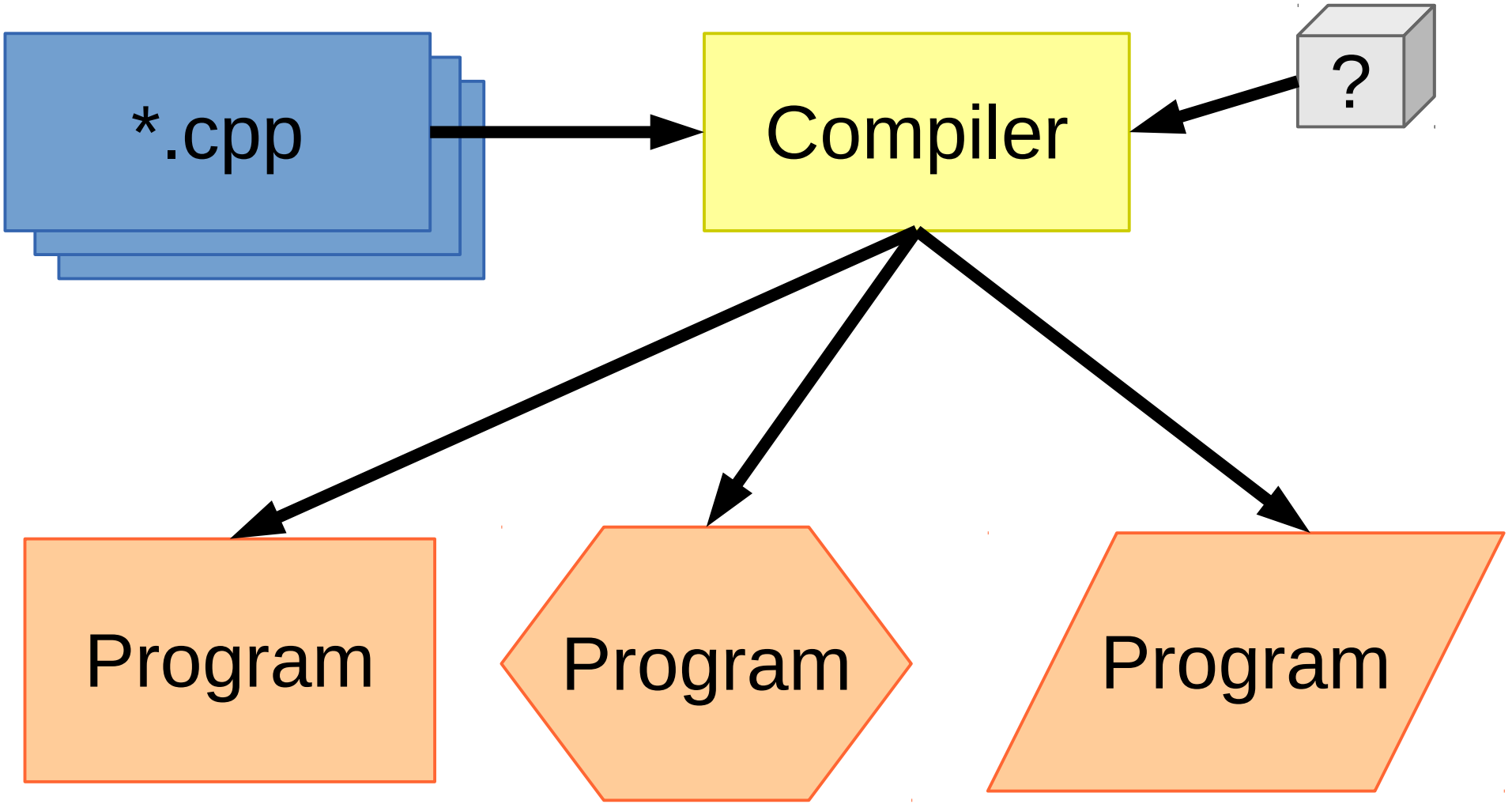
Software diversification



C/C++ liberties

- Data layout changes
  - Data structure layout on stack
  - Layout for heap objects (limited for structs)
- Code changes
  - Register allocation (shuffle or starve)
  - Instruction selection
  - Basic block splitting, merging, shuffling

Malware diversification

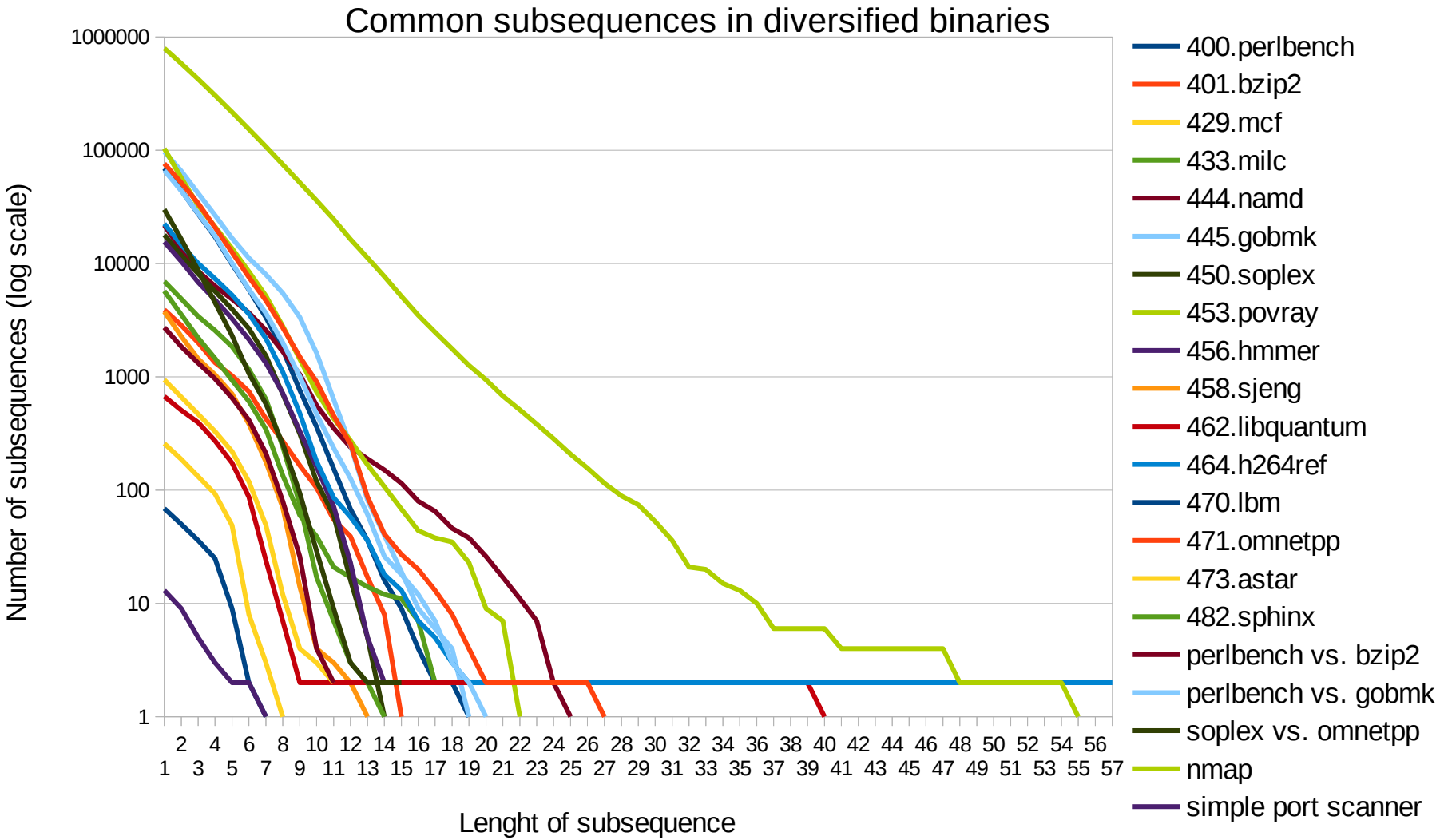
- Generate unique binaries
  - Minimize common substrings (code or data)
  - Performance overhead not an issue
- Diversify code and data layout
- Diversify static data as well

Implementation

- Prototype built on LLVM 3.4
  - Small changes in code generator, code layouter, register allocator, stack frame layouter, some data obfuscation passes
- Input: LLVM bitcode
- Output: diversified binary

- Source: http://github.com/gannimo/MalDiv

Similarity limitations

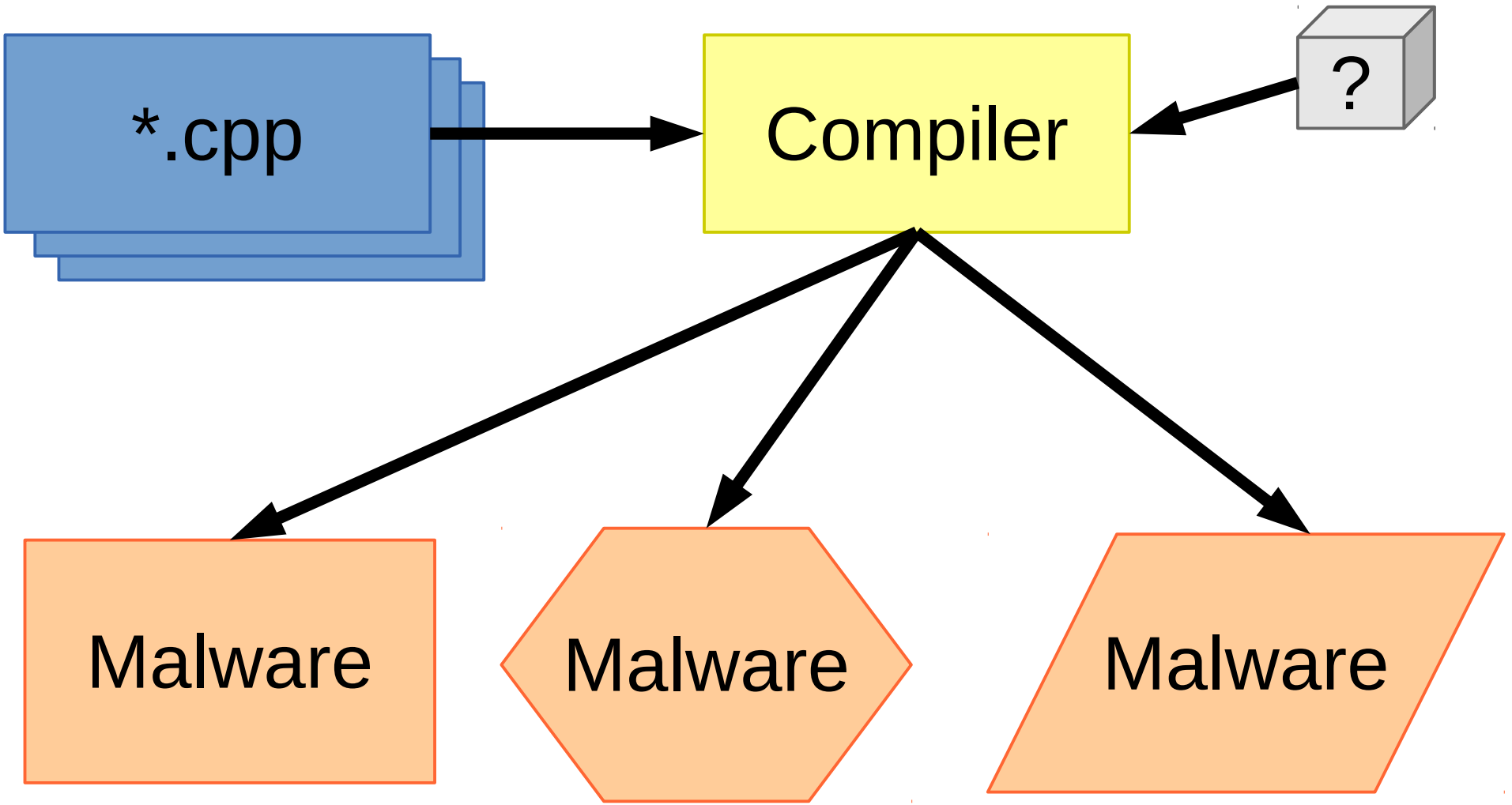


Demo

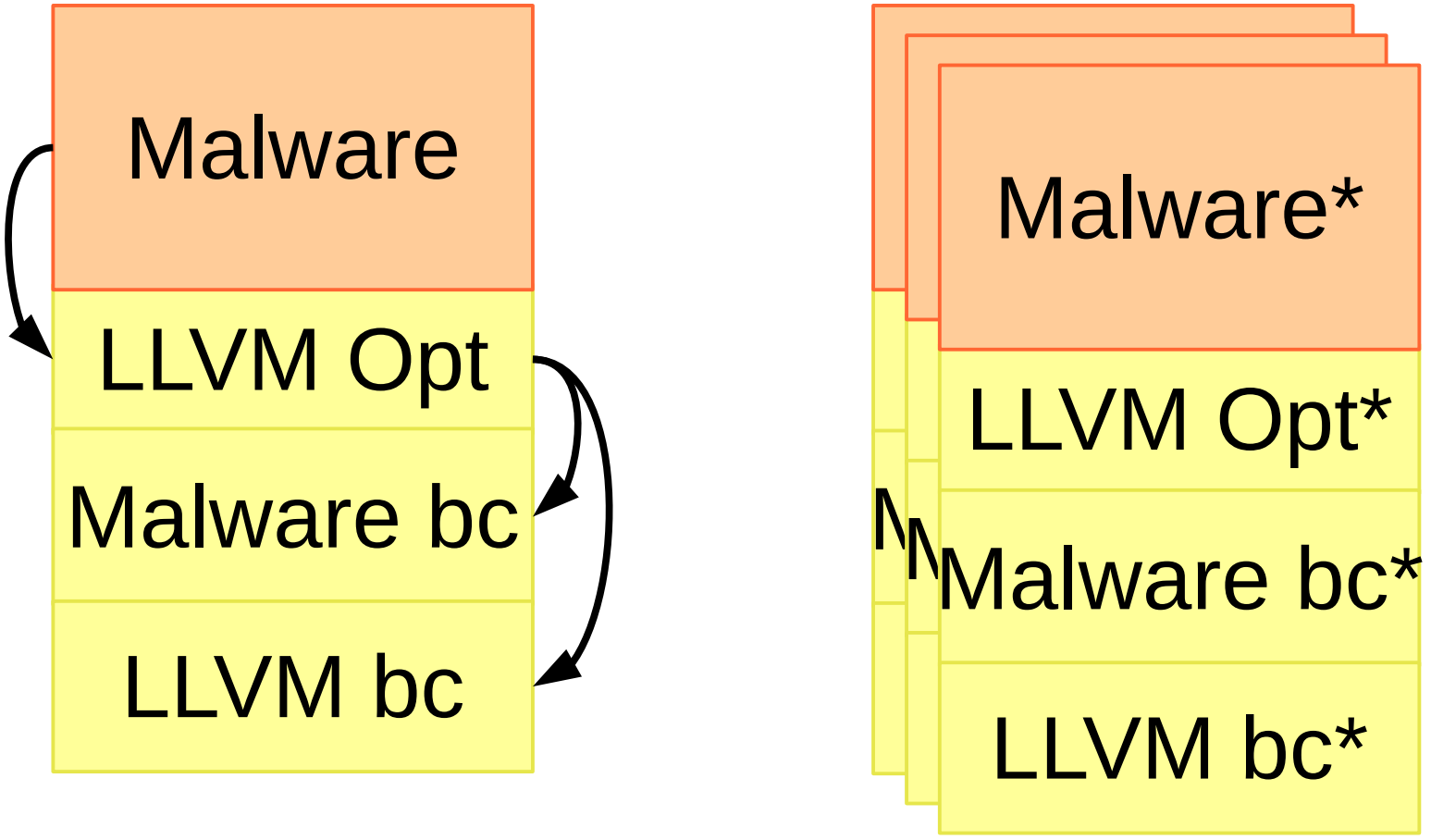
- Simple hello world
  - Let's see how far we can push this!

```
#include <stdio.h, string.h>

const char foo[] = "foobar";
char bar[7];

int main(int argc, char* argv[]) {
   strcpy(bar, "barfoo");
   printf("Hello World %s %s\n", foo, bar);
   printf("Arguments: %d, executable: %s\n",
             argc, argv[0]);
   return 0;
}
```

Scenario 1: malware generator



Scenario 2: self-diversifying MW



Possible mitigation:
Better security practices

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Mitigation

- Recover high-level semantics from code
  - Hard (and results in an arms race)
- Full behavioral analysis
  - Harder
- Prohibit initial intrusion
  - Fix broken software & educate users
  - Hardest

Conclusion

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Conclusion

- Diversity evades malware detection
  - Fully automatic, built into compiler
  - No need for packers anymore
- Adopts to new similarity metrics
- New arms race between defenders and compiler writers
- Don't rely on simple, static similarity!

Questions?

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