BINARY HARDENING CHALLENGES: MODULARITY & IMMUTABILITY

Dr. Kevin Hamlen

Associate Professor

Computer Science Department

Cyber Security Research and Education Institute

The University of Texas at Dallas

Supported in part by:

ONR Awards N00014-14-1-0030 & N00014-17-1-2995,

NSF CAREER Award #1054629,

AFOSR YIP (Career) Award FA9550-08-1-0044,

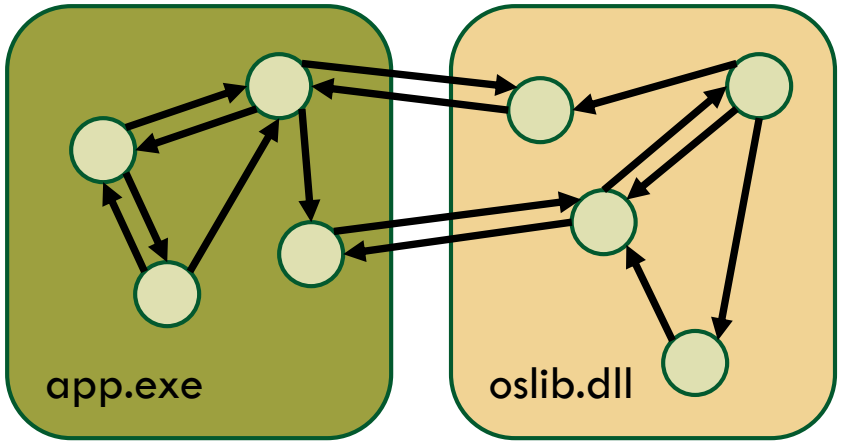
NSF Award 1513704

and an NSF I/UCRC Award from Raytheon Company

Modularity Challenge: Diverse, Incompatible Protections

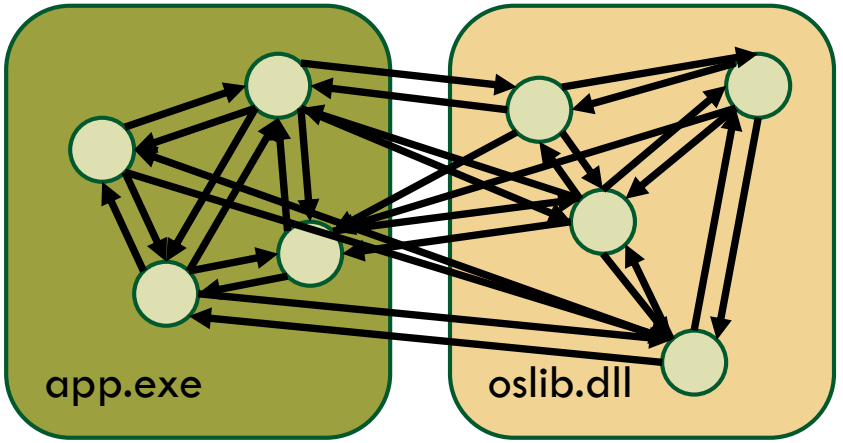
XFI [Erlingsson et al., OSDI'06]

- Instrumentation Strategy:
  - Insert labels at jump targets
  - Insert label-checking guards at control-flow transfer instructions
- Policy: a CFG



Microsoft Contol-Flow Guard

- Instrumentation Strategy:
  - Enumerate jump targets in a table
  - Insert table-checking guards at indirect calls
- Policy: jump target whitelist



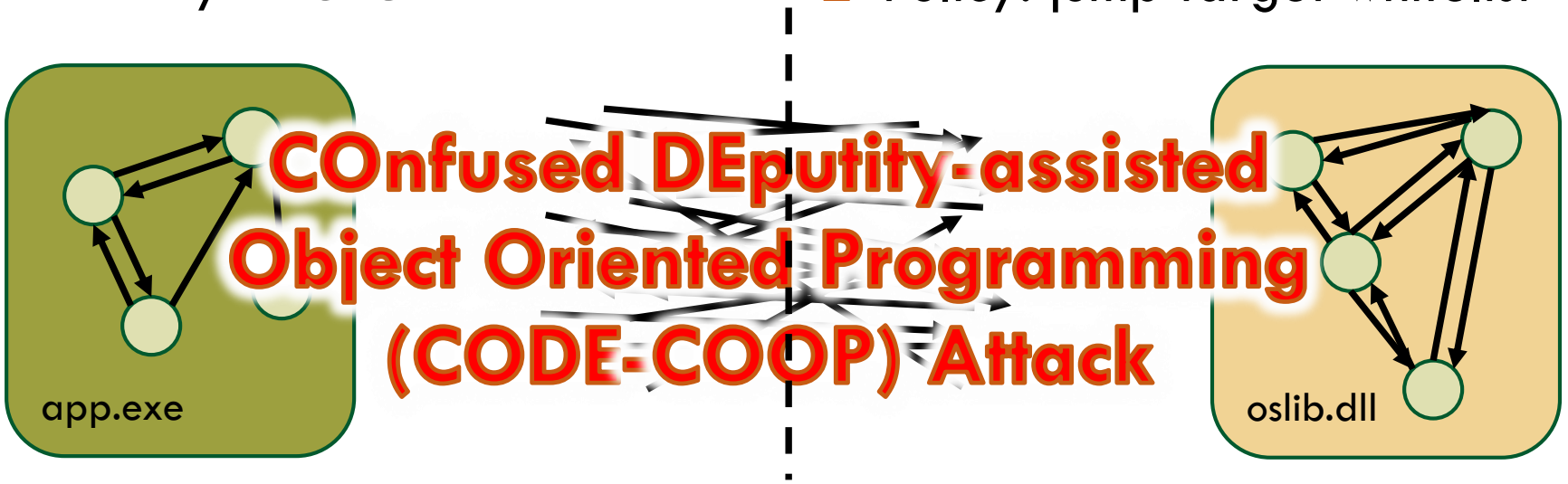
Modularity Challenge: Diverse, Incompatible Protections

XFI [Erlingsson et al., OSDI'06]

- Instrumentation Strategy:
  - Insert labels at jump targets
  - Insert label-checking guards at control-flow transfer instructions
- Policy: a CFG

Microsoft Contol-Flow Guard

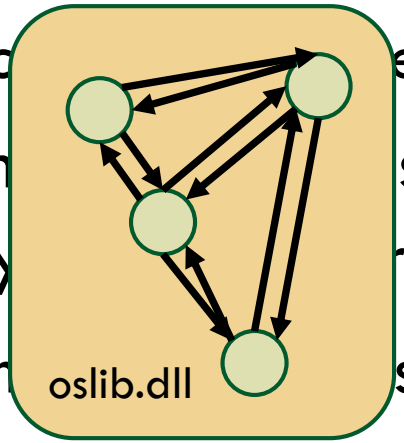
- Instrumentation Strategy:
  - Enumerate jump targets in a table
  - Insert table-checking guards at indirect calls
- Policy: jump target whitelist



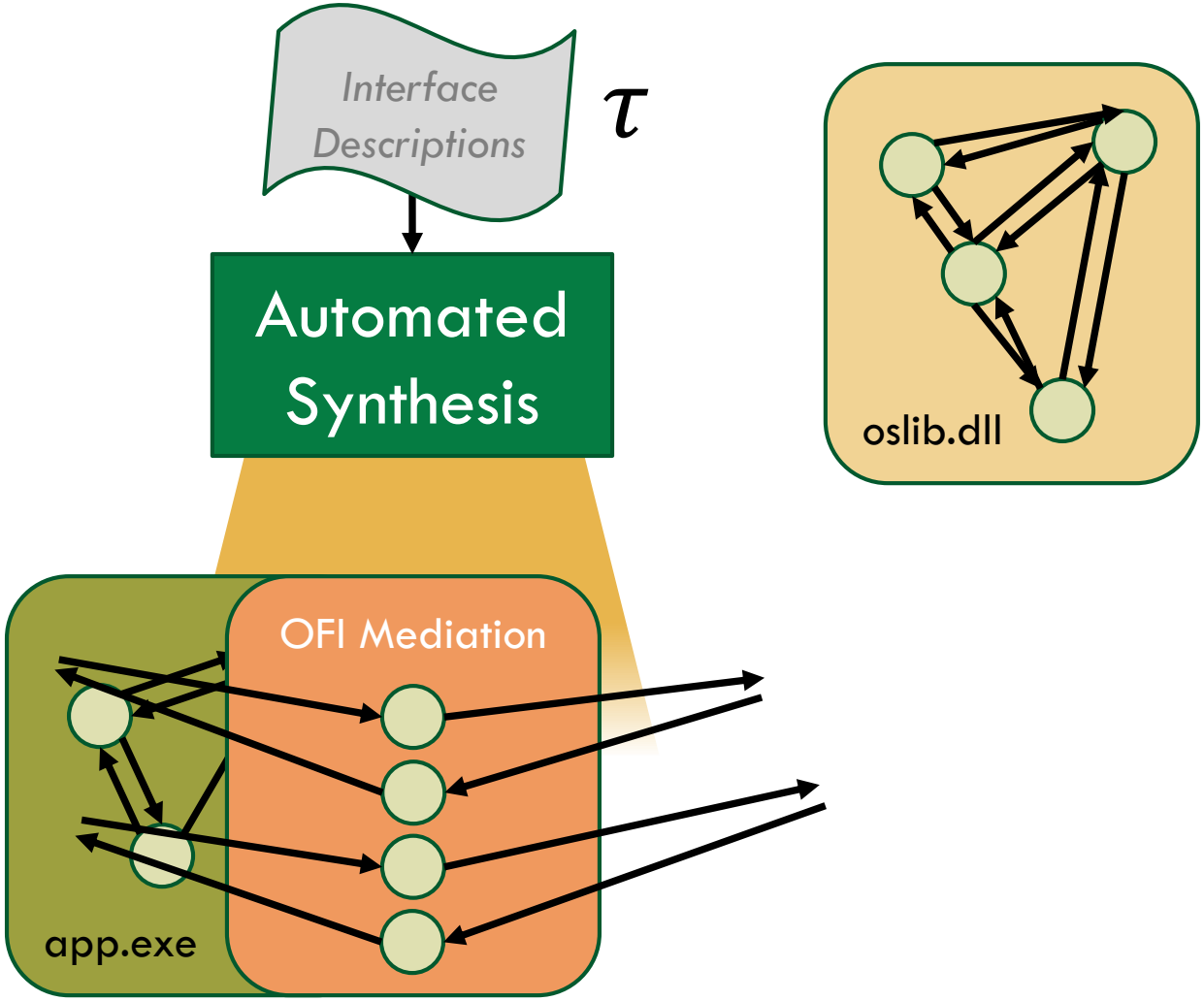
Immutability Challenge: System Modules and Runtime APIs

- Trusted but Immutable modules
  - Integrated into closed-source OS/VM
  - Digitally signed
  - Hard to disassemble (e.g., obfuscated)
  - Dynamically downloaded (e.g., clouds)
  - Anti-tampering / anti-piracy technology
  - Nevertheless "secure" (acc e policy)
- Modularity question: Can strong CFI policies if we can't modify re" modules?

  Our Answer: Yes! … som stly…



Object Flow Integrity [Wang, Xu, Hamlen, CCS'17]



OFI Outcomes

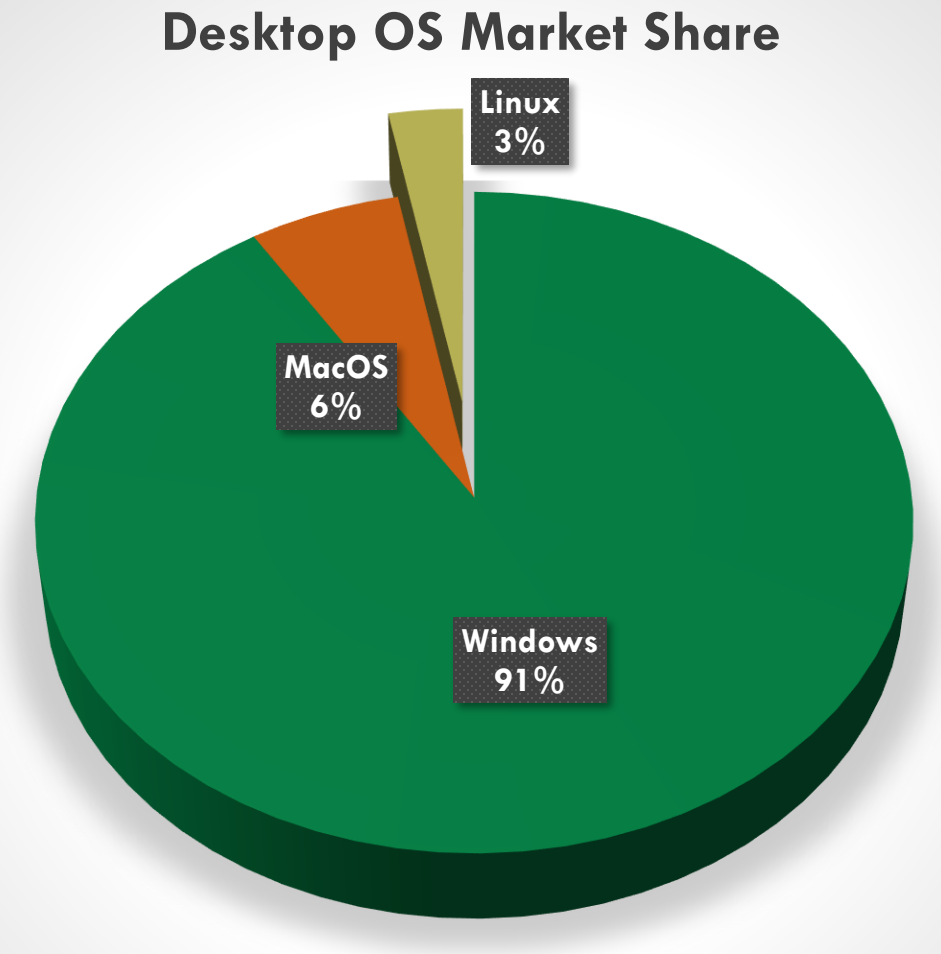
- First source-free CFI that can protect large-scale, commercial, event-driven Windows apps
  - finally support for Component Object Model (COM) apps!
- Low overhead (~1%)
- No modification of Windows system libraries
- Embeds app-enforced CFI protections into shared data (objects and code pointers)

Wenhao Wang, Xiaoyang Xu, and Kevin Hamlen. "**Object Flow Integrity.**" In *Proceedings of the 24th ACM Conference on Computer and Communications Security (CCS)*, 2017.

Research Challenges/Limitations

- How to know what security invariants trusted modules obey/enforce?
  - What memory safety policy? (stack? heap?)
  - What control-flow policy? (threading? indirect calls? returns?)
  - What API call policy? (needed API accesses? arguments?)
- Missing Research
  - Source-free analyses to answer such questions
  - Source-aware technologies for proving answers to such questions
  - More modular hardening algorithms that anticipate diversity of defenses

Beyond Linux



Thank you!

Wenhao Wang, Xiaoyang Xu, and Kevin Hamlen. "**Object Flow Integrity**." In *Proceedings of the 24th ACM Conference on Computer and Communications Security (CCS)*, 2017.