Memory Forensics
Pattern-Oriented

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Inter-Regional Inter-University Open Computer Security Contest
www.volgactf.ru

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Forensics

> A discipline studying past structure and behavior.

Memory Forensics

> A discipline studying past structure and behavior in acquired computer memory.

We Have A Problem

- Proliferation of computer architectures, operating systems, and tools
- Different memory analysis narratives
- Need to measure analysis quality

Solution

- Empirical patterns
- A pattern language
- Pattern orientation

Forensic Pattern

> A common recurrent identifiable set of indicators (signs) together with a set of recommendations to apply in a specific context.

Memory Forensics revised

> A discipline studying past structure and behavior of software in acquired memory using pattern-oriented analysis methodology.

Software Forensics

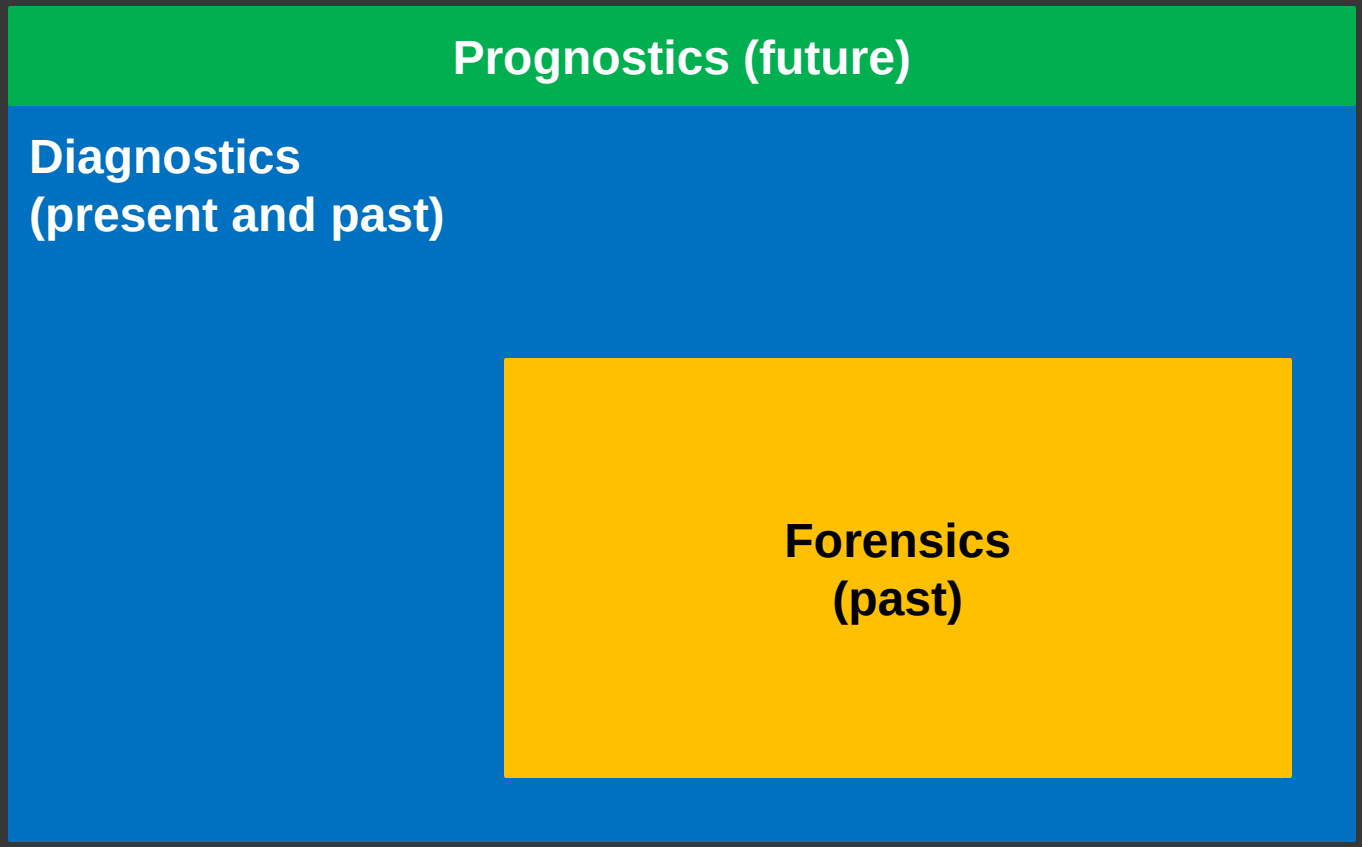
Software Forensics

> A discipline studying past structure and behavior of software in execution artifacts using systemic and pattern-oriented analysis methodologies.

Structure and Behavior

- Memory snapshots (dumps)
- Traces and logs
- Source code
- Digital data (media)

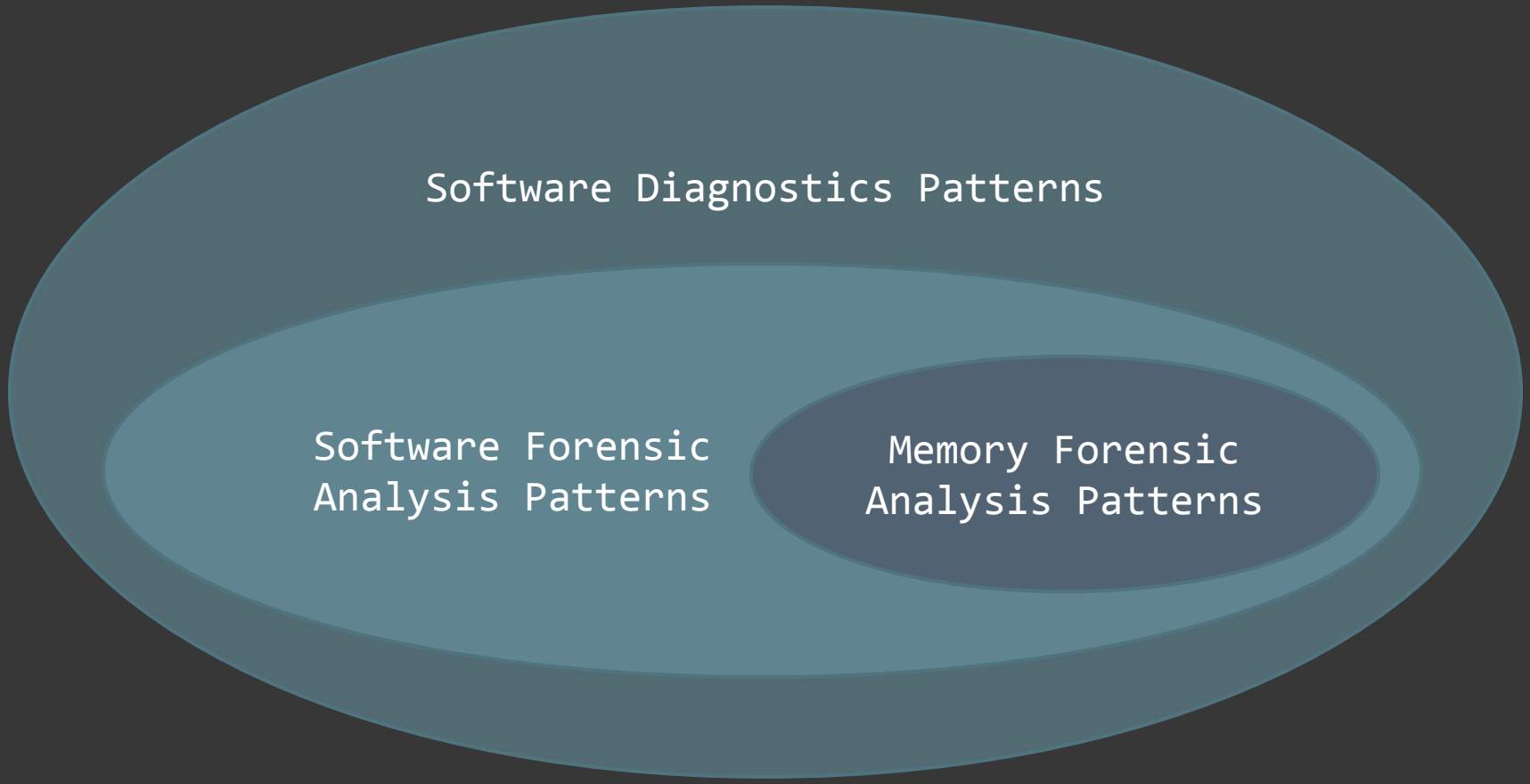
Diagnostics and Forensics



Software Diagnostics

> A discipline studying signs of software structure and behavior in software execution artifacts (such as memory dumps, software and network traces and logs) using systemic and pattern-oriented analysis methodologies.

Forensic Analysis Patterns



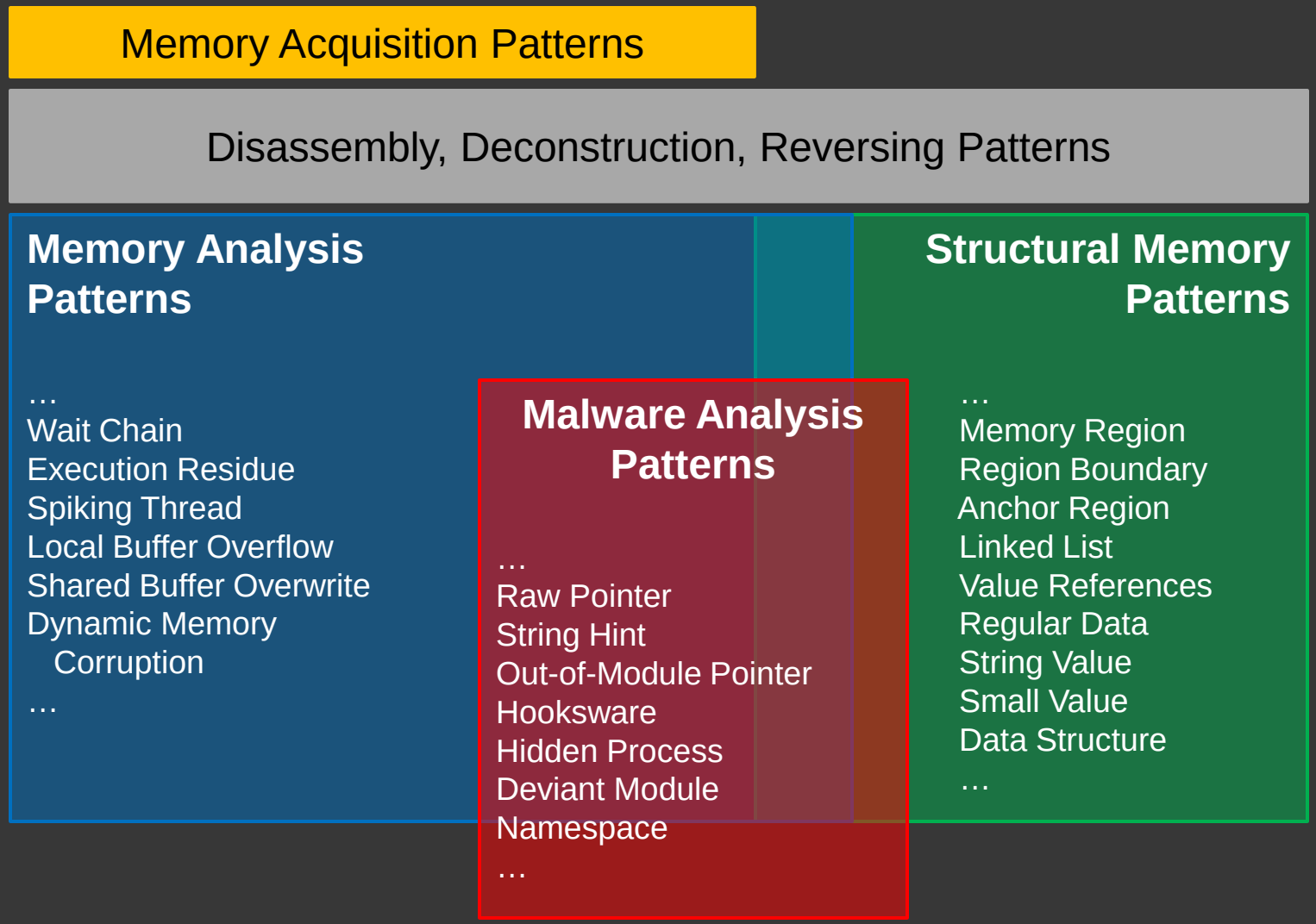
A Pattern Language

- The same detection and analysis language for different computer architectures, operating systems, and tools
- The same memory analysis narratives
- Measured analysis quality
- Predicting unknown

Pattern Orientation

1. Pattern-driven
   - Finding patterns in memory
   - Using checklists and pattern catalogs
2. Pattern-based
   - Pattern catalogue evolution
   - Catalog packaging and delivery

Main Pattern Catalogues



Pattern Classification

…

Dynamic Memory Corruption Patterns

Stack Overflow Patterns

Stack Trace Patterns

Symbol Patterns

Exception Patterns

Meta-Memory Dump Patterns

Module Patterns

Optimization Patterns

Thread Patterns

Process Patterns

…

Memory Acquisition Patterns

http://www.dumpanalysis.org/memory-acquisition-patterns

Structural space patterns

…
Process Memory Dump
Kernel memory Dump
Physical Memory Dump
Fiber Bundle Dump
…

Acquisition strategy patterns

…
External Dump
Self Dump
Conditional Dump
Dump Sequence
…

ADDR Patterns

http://www.dumpanalysis.org/addr-patterns

…

Potential Functionality
Function Skeleton
Function Call
Call Path
Local Variable
Static Variable
Pointer Dereference
Function Prologue
Function Epilogue
Variable Initialization

Memory Copy
Call Prologue
Call Parameter
Call Epilogue
Call Result
Control Path
Function Parameter
Structure Field
Last Call
…

Pattern Implementation

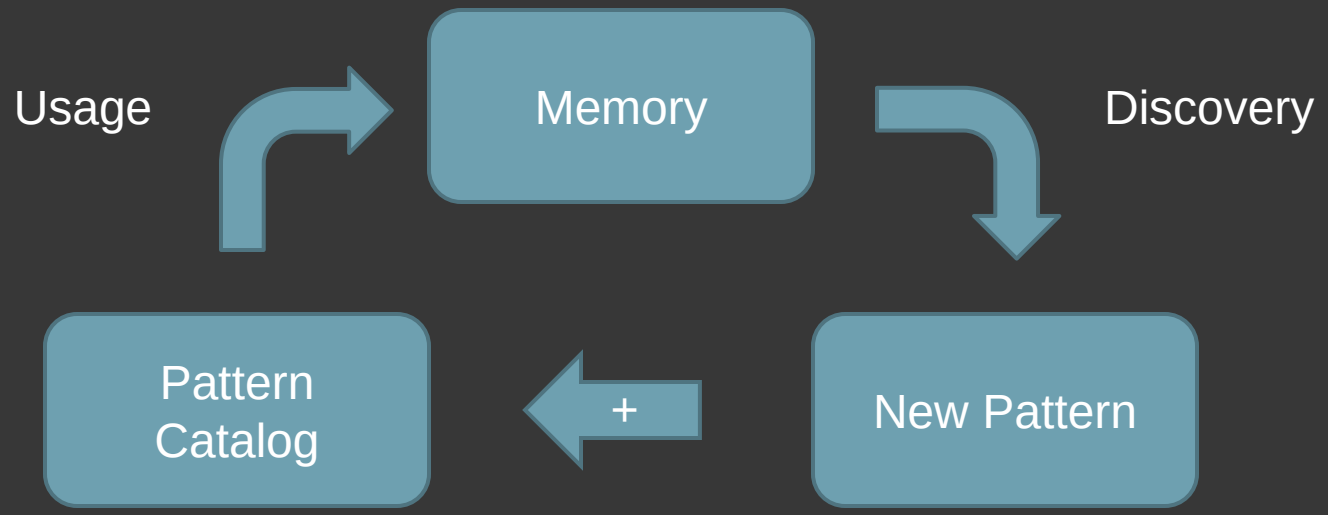
- By OS vendor (Windows, Mac OS X, Linux, …)
- By tool (WinDbg, Volatility, IDA, GDB, LLDB, …)
- By CPU architecture (x86, x64, ARM, …)
- By digital media (memory, volume, file, blob, …)

Pattern-Driven Analysis

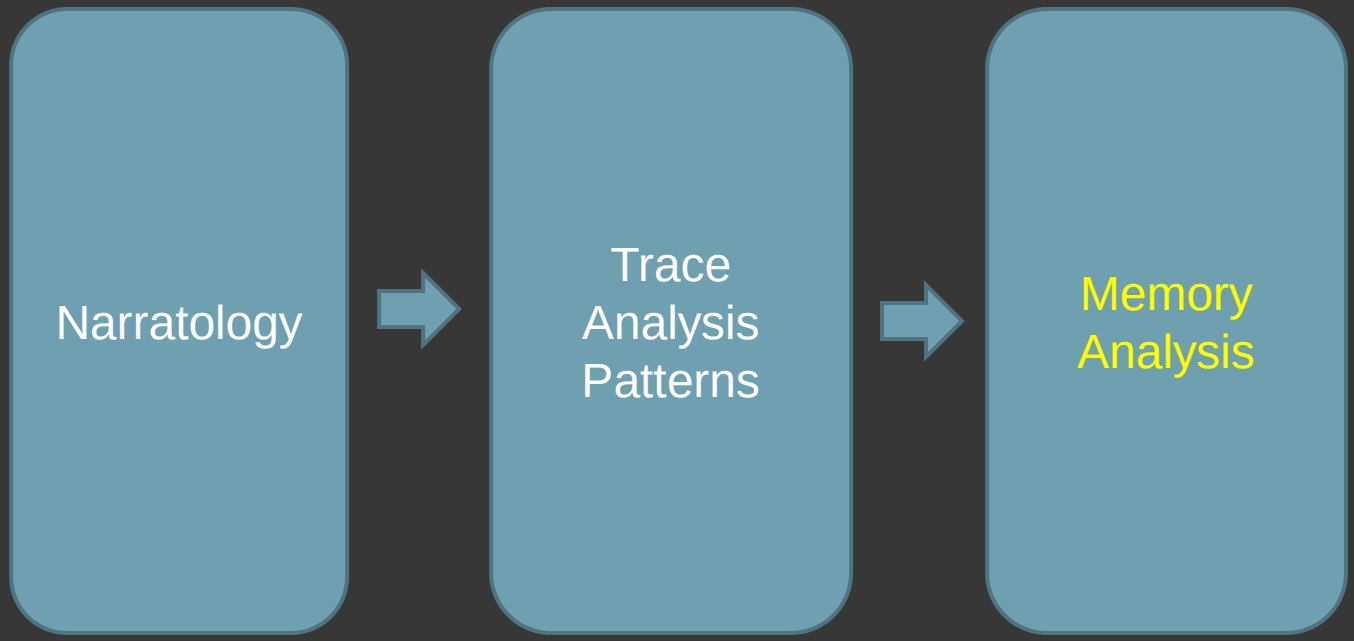
- ✓ Pattern
- Pattern
- Pattern
- ✓ Pattern
- ✓ Pattern

1. Tool-specific checklist: http://www.dumpanalysis.org/windows-memory-analysis-checklist
2. Pattern catalogue checklists: http://dumpanalysis.org

Pattern-Based Analysis



Systems Approach



Native Memory Forensics

Using native OS debuggers such as WinDbg from Debugging Tools for Windows or GDB (Linux) or GDB/LLDB (Mac OS X).

Practical Examples

WinDbg session…

Patterns for Example A

- Tampered Dump
- Exception Stack Trace
- Stored Exception
- Lateral Damage
- Execution Residue
- Hidden Exception
- NULL Data Pointer

Patterns for Example B

- Heap Corruption
- Stack Trace Collection
- RIP Stack Trace
- Hooksware
- Patched Code
- Hidden Module
- Deviant Module
- String Hint
- Fake Module
- No Component Symbols
- Namespace

Example C

Pattern correspondence

- Process Dump
- Physical (Complete) Dump
- Kernel Dump

Further Reading (Patterns)

- The Timeless Way of Building (by Christopher Alexander)
- A Pattern Language: Towns, Buildings, Construction (by Christopher Alexander, et al.)

Further Reading (MDA)

- Cloud Memory Dump Analysis
- Fundamentals of Physical Memory Analysis
- Victimware
- Pattern-Oriented Software Forensics
- Debugging TV

Further Reading (SD)

- Software Diagnostics Institute
- Pattern-Driven Software Diagnostics
- Systemic Software Diagnostics
- Pattern-Based Software Diagnostics
- Philosophy of Software Diagnostics

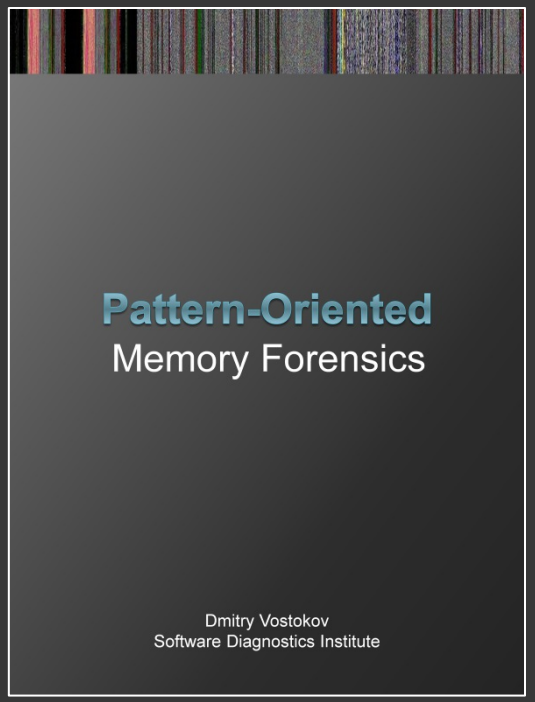
Current Reference

Memory Dump Analysis Anthology: 7 volumes + 3 colour volumes

Volume 8 is planned for 2015/2016

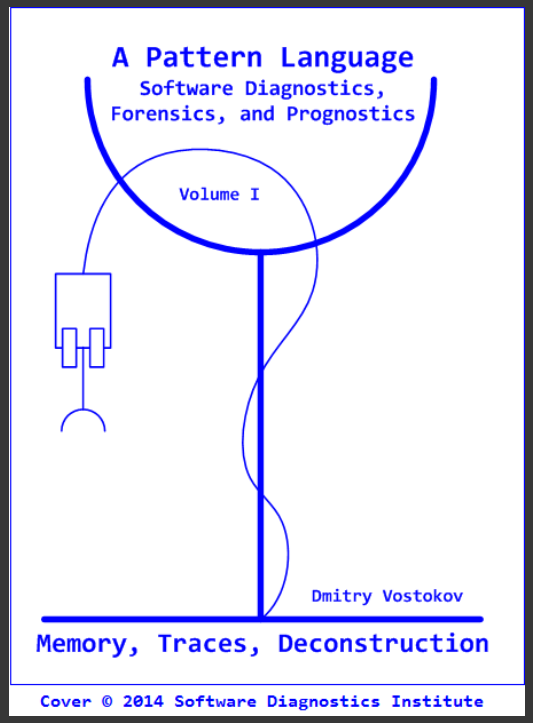
Forthcoming Transcript

Pattern-Oriented Memory Forensics: A Pattern Language Approach
(ISBN: 9781908043764)



Forthcoming Reference

A Pattern Language for Software Diagnostics, Forensics, and Prognostics: Memory, Traces, Deconstruction (10 volumes)



Q&A

Please send your feedback using the contact form on DumpAnalysis.org

Thank you for attendance!

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