Current Status of the Xenon Secure Hypervisor

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Project Goals

* investigate higher-assurance open source
* investigate run-time security of VMMs

Increasing Run-Time Security of a VMM

* add external run-time integrity verification
* add internal run-time integrity verification
* additional self-protection mechanisms, to increase tamper-resistance
* refactor the software, to decrease the number of residual security flaws
* use formal methods to decrease the number of residual security flaws

Issues 1

* ceteris paribus, adding software adds flaws and increases attack volume
* integrity verification challenged by sampling rate, coverage, assurance, and tamper resistance
* segment register rant (self-protection mechanisms)

Issues 2

* new self-protection mechanisms challenged by performance, restrictions on system programming, and reference monitor properties
* refactoring challenged by complexity of hardware and guests, performance, commodity, and lack of bling
* formal methods challenged by complexity of hardware and guests, performance, commodity, and size of target system

Related Work

* NoHype (Princeton)
* HyperSafe (NC State)
* NOVA (Tech. U. Dresden)
* CloudVisor (Fudan U.)
* Xoar (UBC, NSA)
* L4.verified (UNSW NICTA)
* embedded device separation kernel (NRL)

Refactoring

* simplification
* code base reduction
* subsetting
* must be able to run unmodified Windows7 guests

Simplification Patterns

* use complexity as a guide not a rule
* apply special patterns for Xen code
* replace/remove gotos
* static always_inline functions
* replace complex logic with simple state machines

Maximum Complexity

* Order of magnitude reduction from
  * 2954 (Xen) to
  * 112 (Xenon)
* Will be lower as work progresses

Code Base Reduction

* avoid high-security-risk features
* reduce cost and scope of 3rd party assessment
* reduce number of residual flaws

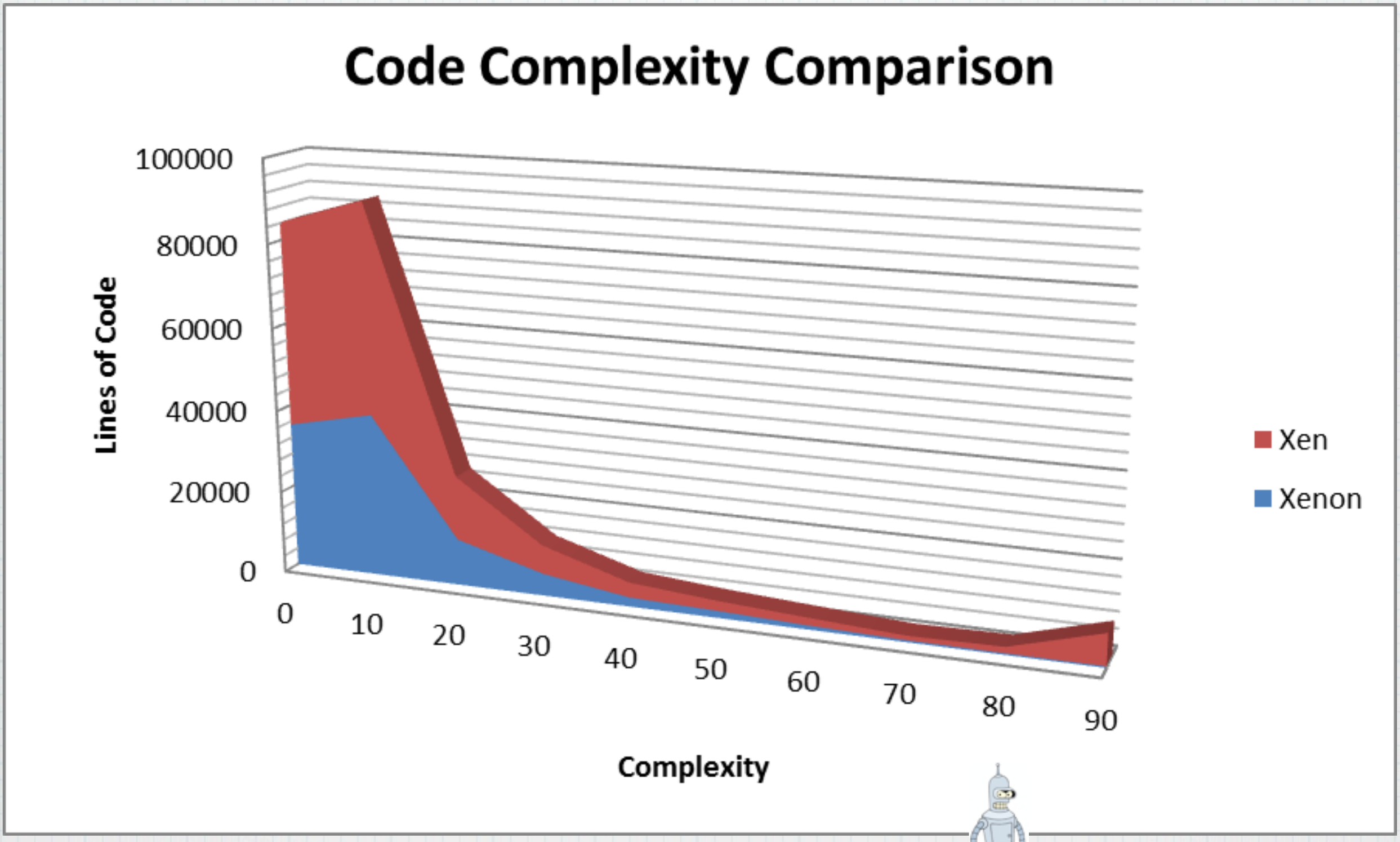
Significant Reductions

* dropped all CPU but x86_64
* dropped Intel HTT
* dropped transcendent memory
* dropped NUMA
* removed miscellaneous chunks of code
* dropping 32-bit VMM
* replacing XSM with MSM

Progress

* Xen - 181,174 SLOC
* Xenon - 128,082 SLOC
* measured by SciTools Understand

Size vs Complexity



Performance

* no apparent penalty (slight gain)
* kcbench -j 2 -n 10 # HAP enabled HVM Fedora 14 * 3
* Xeon E31270 3.4 GHz, 16 GiB memory
* Xenon/Xen 258 sec / 270 sec
* similar results for Windows 7 guests

Keeping Pace

* Xenon is based on Xen 4.0
* need to keep pace with Xen community
  * Xen development benefits
    * keep up with hardware evolution
  * adapted 194 patches from 13 April 2011 to 27 July 2011

Tools Are Important

* vi, emacs, cscope, hg, dot, bash, benchmarking tools
* mini-OS
* Understand (SciTools)
* CodeSurfer, CodeSonar (GrammaTech)
* CZT, Circus (formal methods)

Questions?