Xenon: High-Assurance Xen

John McDermott

John.McDermott@NRL.Navy.Mil

Naval Research Laboratory

Center for High-Assurance Computer Systems

http://chacs.nrl.navy.mil

Beyond Buffer Overflows

- Policy flaws
  - Use the wrong product
  - Mis-configure the right product
- Design flaws
  - Majority of flaws are design flaws
  - Can be interface or architecture problems
- Coding flaws
  - e.g. buffer overflows

Beyond Assurance: Robustness

- NSA originated this useful concept
- Robustness = (strength of feature, implementation assurance)
- **Assurance** = how well did we build it?
- **Strength** = what flaws would be present, even if we had a perfect implementation?

it is pointless to build a high-assurance implementation of a low-strength feature

Common Criteria

1. Define the **security problem** your product will solve.
2. By selecting from a framework of security requirements, define a **security solution**.
3. Choose a pre-defined **assurance level**.
4. Undergo **independent evaluation** to show that your product solves the problem, at the claimed level of assurance.

Independent Evaluation

- Actual evaluation is a contact sport.
  - Lots of communication needed.
  - Evaluator-developer relationship management.
- Following high-assurance practices without evaluation is beneficial, with much less pain.
- Actual evaluation is still possible.

Assurance Levels (EALs)

- Low (1-4):
  - Accepted internationally.
  - Does not review all source code.
  - No special security practices.

Assurance Levels (EALs)

- High (5-7):
  - Not accepted internationally.
  - Few examples.
  - Requires special high-assurance security development practices.

What is Suited to High-Assurance?

- Products that do not evolve rapidly.
- Products with a relatively small implementation.
- Products that are effective at key points in a larger architecture.
- Products that are strong mechanisms.

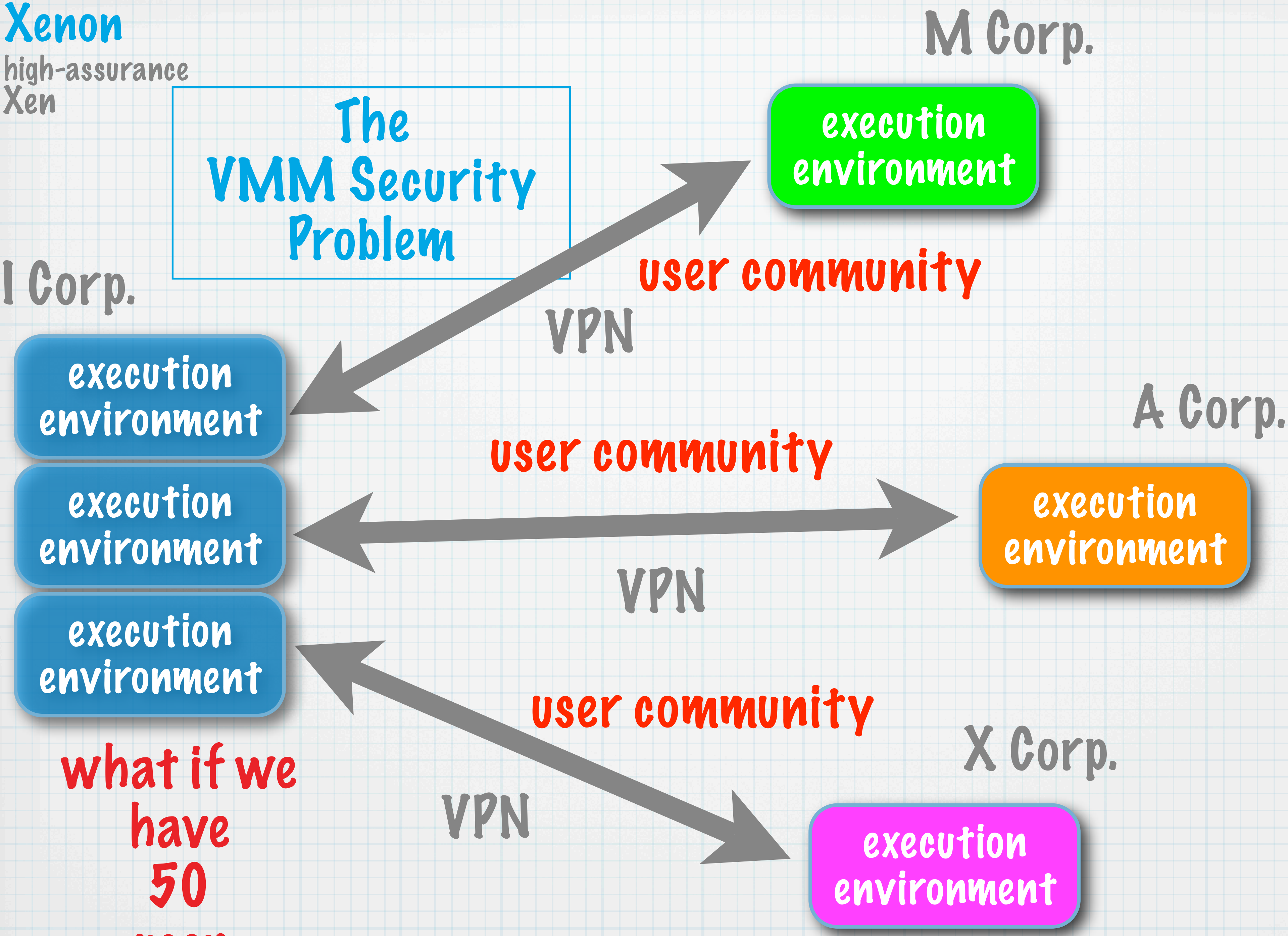
VMM Security

- What security problem does a VMM solve ...
- ... that cannot be solved by another technology?
- Strong separation of execution environments, per user community.

don't separate on a per-application basis

VMM's are a strong mechanism for this problem

The VMM Security Problem



M Corp.

execution environment

user community

VPN

I Corp.

execution environment

execution environment

execution environment

user community

A Corp.

execution environment

VPN

user community

X Corp.

VPN

execution environment

what if we have 50 user communities?

Threat Model

- A threat is the goal of some threat actor.
- Four threat actors for Xenon:
  - T1 - malicious developer
  - T2 - malicious guest
  - T3 - network intruder
  - T4 - problematic operator

T2 - Malicious Guest

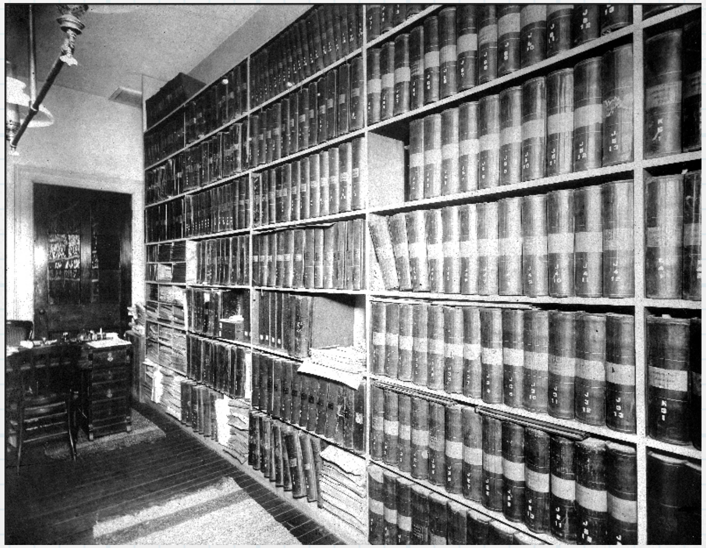
- We don't care how it got to be malicious.
- Initial access - guest boot time access to platform (no human assistance at guest boot time).
- Initial knowledge - own configuration data, human sponsor has full source of guests and Xen.
- Capabilities - arbitrary sequences of instructions and hypercalls

Actor T2 Threats

- **T2.1 Unauthorized access:** access or cause another guest to access a resource contrary to configured policy.
- **T2.2 Service Denial:** degrade a resource or its availability to another guest
- **T2.3 Information Leak:** leak information to another domain contrary to configured policy (may use residual data or covert storage channel).

High-Assurance Work Products

- Security problem definition
- Assurance argument
- Security factored code base
- Policy-to-code modeling
- Model-based vulnerability analysis
- Evidence package for third-party evaluation.



Assurance Argument

- Shows why the final product should be trusted.
- Documented organization of evidence: (factoring, modeling, analysis, etc.)
- Allows planning and trade-offs in allocating resources to assurance tasks.

Security Problem Definition

- Threats
- Regulations
- Assumptions about usage & environment
- Security policy that solves the problem
- Security features that enforce the policy
- Assurance plan
- Rationale connecting all of the parts

Security Factored Code Base

- Refactor to meet **complexity** goals.
  - A lot of Xen code is already there
- Refactor to meet **modularity** goals.
- Refactor to **separate** policy-enforcing code from other code.
  - A lot of Xen code is already there
- Remove code/features to **reduce overall size.**

Policy-to-Code Modeling

- Security policy model (formal)
- Interface model (semi-formal)
- Design model (semi-formal)
- Must model all code that runs in the same address space
- Backward correspondence demonstration

Things Xen May Want to Do

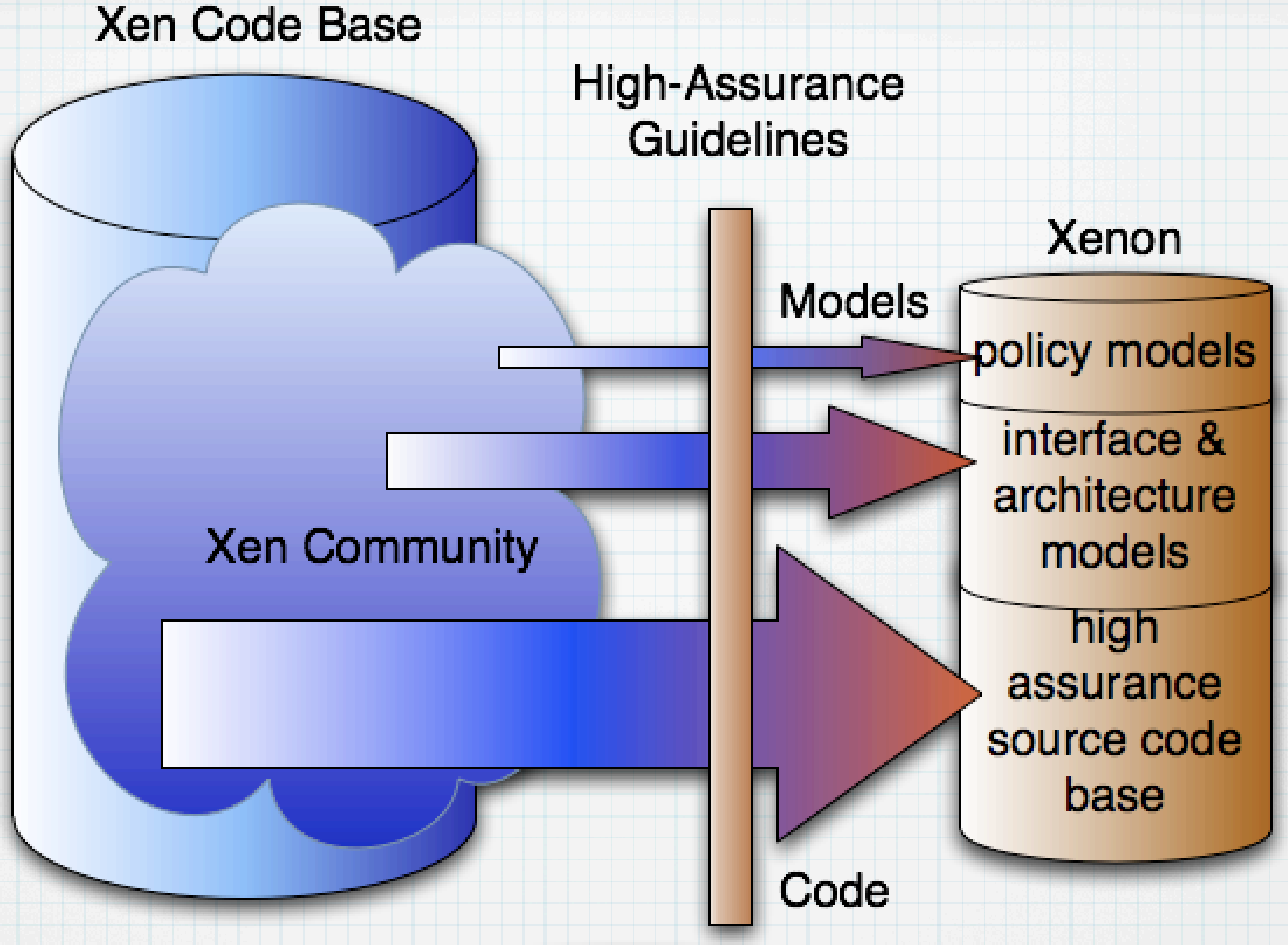
- Keep writing small cohesive low-complexity functions.
- Maintain good high-level design.
- Strive for smaller files with simpler includes.
- Don't spread concerns across multiple files.
- Don't optimize just because you can.
- Never use goto when break or continue will do; never use break when return will do.

Things We Do for High Assurance

- Break up big modules into smaller modules.
- Apply secrets-oriented design rules.
- Change macros to inlines.
- Modify logic for case completeness.
- Remove optimization where it is not needed.
- Only support one kind of hardware
- Sacrifice features to get security
- Sacrifice features to get assurance

Possible Open Community Process?

- Separate code & evidence base for high-assurance Xen?
  - What will be the minimal requirement for such code and evidence base?
  - Who will approve code & evidence?
  - How to keep up with main stream Xen?



Policy-to-Code Modeling

Build for Independent Review

Security Factoring

Model-Based Vulnerability Analysis

Family Approach?

- Design Xen to have two family members:
- Strong-security Xen with a simpler hypervisor.
- Feature-rich Xen that adds/replaces modules of strong-security Xen

Thank You