Hardware, Languages, and Architectures for Defense Against Hostile Operating Systems

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My Goals for Today

- Brief you on our planned approach
- Solicit your feedback on our plans
- Understand your needs, problem domain, and threat model better
- Build personal connections

Agenda

9:00- 9:30	Welcome + Overview (Wagner)
9:30- 9:45	Secure Virtual Architecture (Adve)
9:45-10:00	Architectures for secure systems (Evans)
10:00-10:15	Binary analysis (McCamant)
10:45-11:00	Binary translation (Sekar)
11:00-11:15	Formal verification (Chlipala)
11:15-11:30	Secure browsers, hardware (King)
11:30-11:45	Secure hardware (Asanović)
11:45-12:15	Discussion and feedback
12:15- 1:15	Lunch

Problem Statement

Defend against a compromised, hostile, or malicious operating system.

Today: If the OS is malicious, all is lost.

Desired end state: We can survive a malicious OS, perhaps with degraded functionality or availability.

Problem Statement

Defend against a compromised, hostile, or malicious operating system.

We want to:

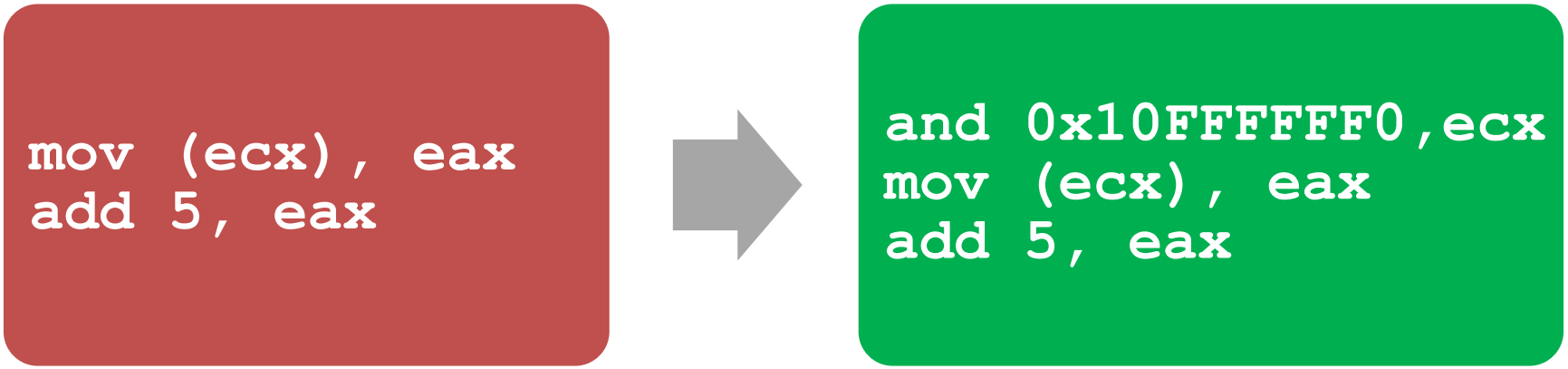
- Protect legacy software
- Facilitate building secure systems of the future

Theme 1: Restrict the OS

We'll enforce end-to-end security policies by instrumenting the OS, using:

- Binary translation:
  when we only have code in binary form
- Secure Virtual Architecture:
  when we have source code

Binary Translation

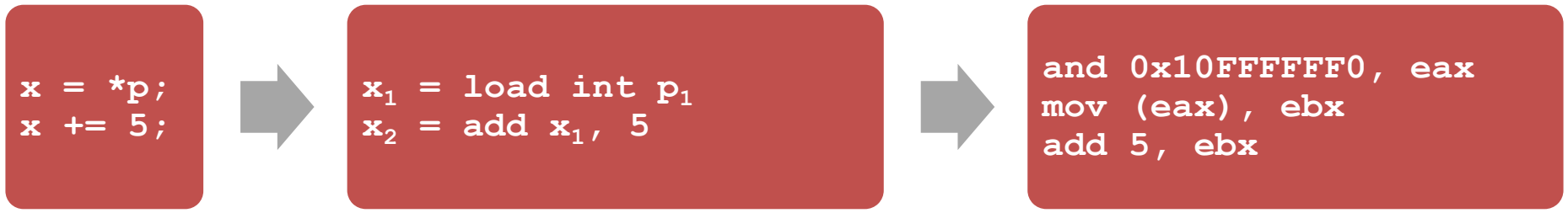


x86 code
(potentially hostile)

x86 code
(neutered)

Instrument binary OS code to enforce security policies (e.g., end-to-end information flow properties; memory safety; isolation).

Secure Virtual Architecture (SVA)

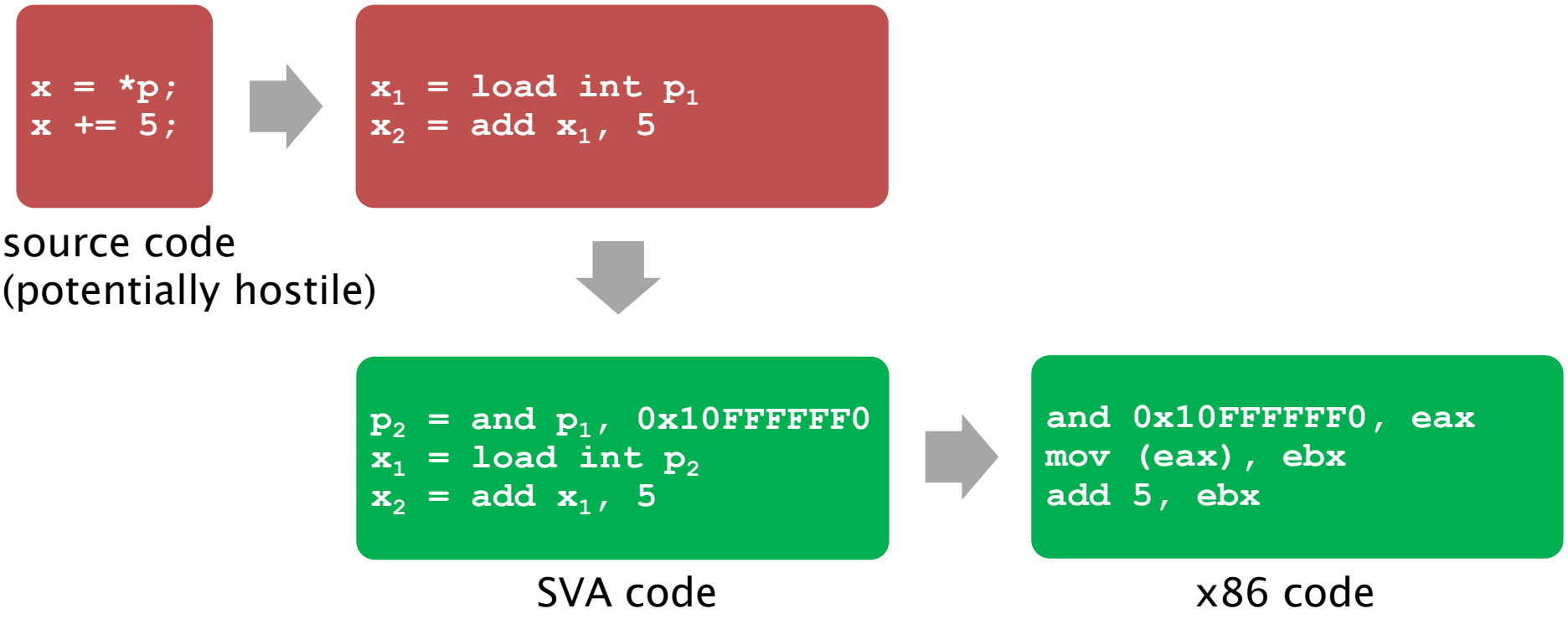


source code
(potentially hostile)

SVA code
(potentially hostile)

x86 code
(potentially hostile)

Secure Virtual Architecture (SVA)

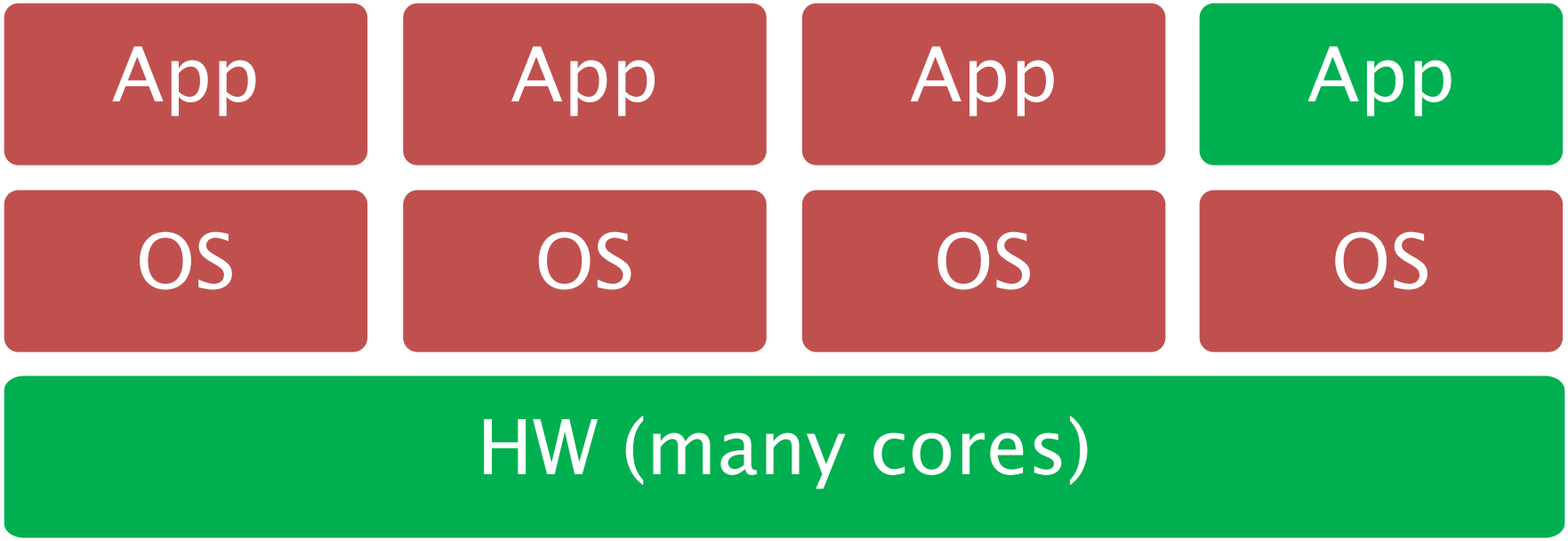


SVA facilitates instrumentation, static analysis , rewriting, virtualization, memory safety, …

Theme 2: Minimize Reliance upon the OS

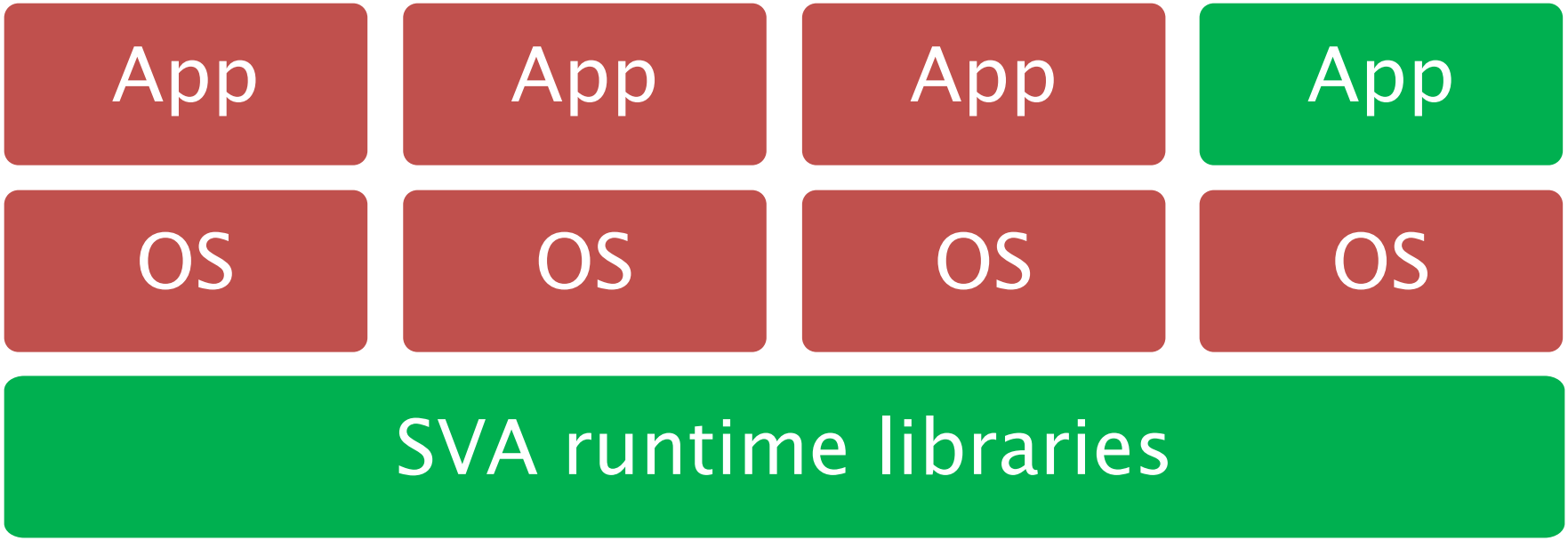
- Isolate OS instances to contain the impact of OS compromise, using:
  - Secure hardware, or
  - Virtualization (Secure Virtual Architecture)
- Build single-purpose "appliances"
  - Don't need a general-purpose OS
    $\Rightarrow$ eliminates a class of risks

Secure Hardware



Partition untrusted OS instances across multiple cores, with hardware isolation.

Virtualization

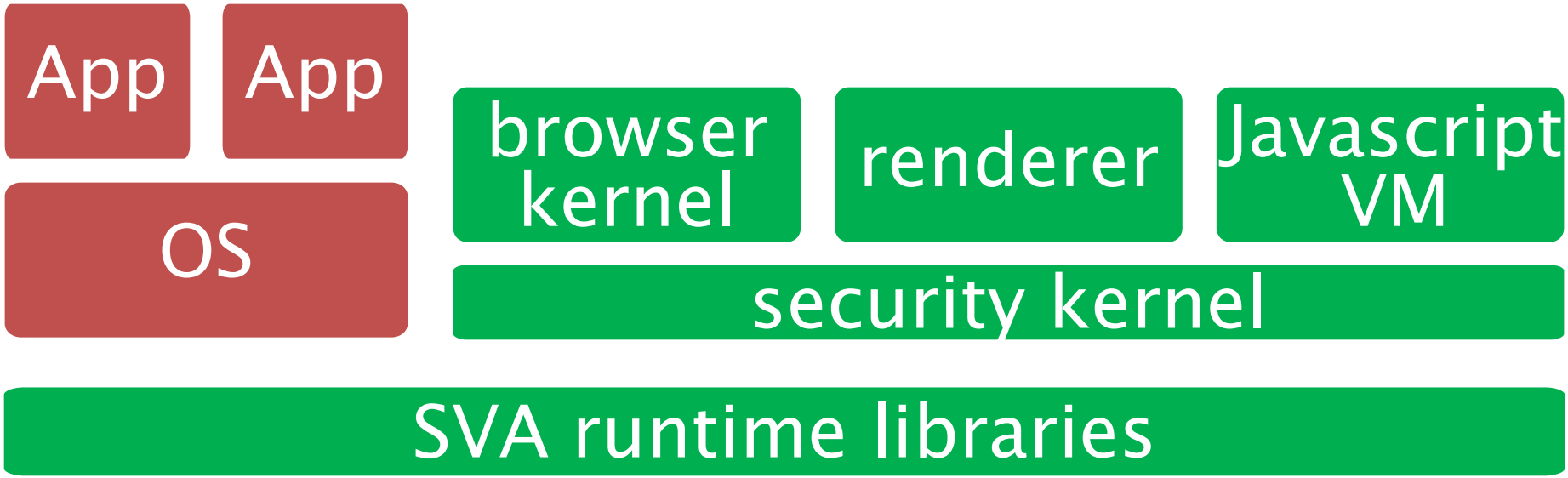


Use SVA to virtualize and isolate multiple OS instances.

Secure Browser Appliance

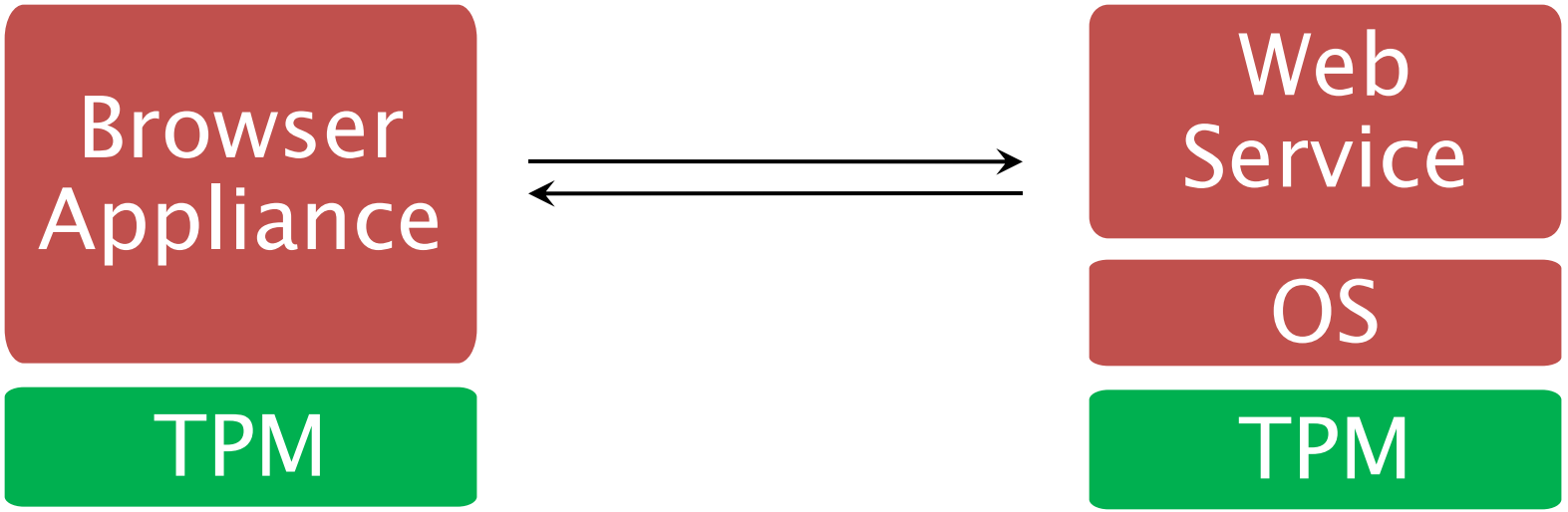
Build a single-purpose appliance, for secure web browsing, with no OS.

Secure Browser Appliance



"Virtual browser appliance" can co-exist securely with insecure OS environment.

Secure Web Systems



New security architecture:

- UI code runs on client (HTML/CSS/Javascript).
- Application logic runs on server, protected with SVA/hardware/safe languages.

Data-Oriented Computing

A new security architecture:

- Users may attach a security policy to each discrete piece of data.
- Goal: Ensure that entire system respects this policy, and that policy is inseparable from data.
  - Mechanism: binary translation, SVA, or other tools

Be Aware

- We are exploring many approaches to the problem. We do not know which will prove most effective. Some may fail.
- We hope some of our ideas will have applications to other security problems outside of the hostile OS problem.

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