Applications of Formal Methods in Building High-Assurance Secure Systems

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Credits

The work described is being performed in the author's capacity as Staff Scientist for Security and Assurance at LynuxWorks in conjunction with SRI International.

Principal sponsors/promoters of the MILS effort are: the Air Force Research Laboratory, and the National Security Agency.

Product and tool vendor partners in the MILS effort are: LynuxWorks, OIS, GHS, University of Idaho, SRI International, and others.

MILS Testbed partners are:
SRI International, Naval Postgraduate School, and others.

* Mr. DeLong is also President and CEO of Trusted Systems Laboratories.

Consumers

MILS target programs and contractors:

Weapons Platforms

F-22, C-130, UCAV, **F35 (JSF), LW, Virginia Class, ...** — **Lockheed-Martin, Boeing, General Dynamics, Raytheon, . . .**

Communications Platforms

JTRS, Crypto MOD, **AIM, PEIP, JANIS, . . .** — **Boeing, BAE, GDDS, L-3, NRL, Rockwell Collins, Harris, ...**

Command and Control

DDX, AEGIS, FCS — **Boeing, Lockheed, Raytheon**

What We Need

- Complete and coherent IDE's
  – Programming, specification, analysis and verification
  – Programming & design "in the large", delegation, interfaces
- Design methodologies that support verification
  – Visser: "programming moving from coding toward design"
  – eliminate manual "coding"
- Modular verification for modular evaluations
- Assurance preservation throughout maintenance
- Verified composability and compositionality
  – Theory and frameworks to support component model
- Shift in perspective
  – "Engineers don't see the benefit"
  – "All that really matters is the code"
- Education to elevate the 90% of programmers
  – But we have to teach them *something specific and usable*

Now, a little history (1)

- The construction of secure operating systems and "security kernels" dates back to the '70's.
  - Multics, MITRE Security Kernel, UCLA Data Secure Unix, Kernelized Secure Operating System (KSOS), Provably Secure Operating System (PSOS)
  - Many computer vendors built security kernel-based operating systems during the '80's and '90's.
- Security kernel (traditional)
  - A general purpose OS, plus enforcement of a security policy
  - ***mandatory access control*** (MAC) such as Bell-LaPadula ***multilevel security*** (MLS), Biba ***multilevel integrity*** (MLI), as well as ***discretionary access control*** (DAC) policies.
- Security Kernel and associated ***trusted software*** constitutes the ***Trusted Computing Base*** (TCB)
- TCB must be ***verified*** to correctly implement policy and be ***evaluated*** by independent body of experts

Now, a little history (2)

- TCBs grew as more and more “trusted software” was added, becoming too large and complex to be verified to a high level of assurance (max EAL 4).
- In a seminal 1981 paper John Rushby observed:
  - Complications result when a security kernel is used to impose a single system-wide security policy
  - Applications requiring guaranteed security often perform simple functions
  - Distributed systems achieve security while avoiding difficulties arising from the security kernel approach
  - A conceptually distributed system may be supported on a single processor by a ***separation kernel***
  - A separation kernel can be verified w/ high-assurance
  - Decouple verification of SK from other components

Today

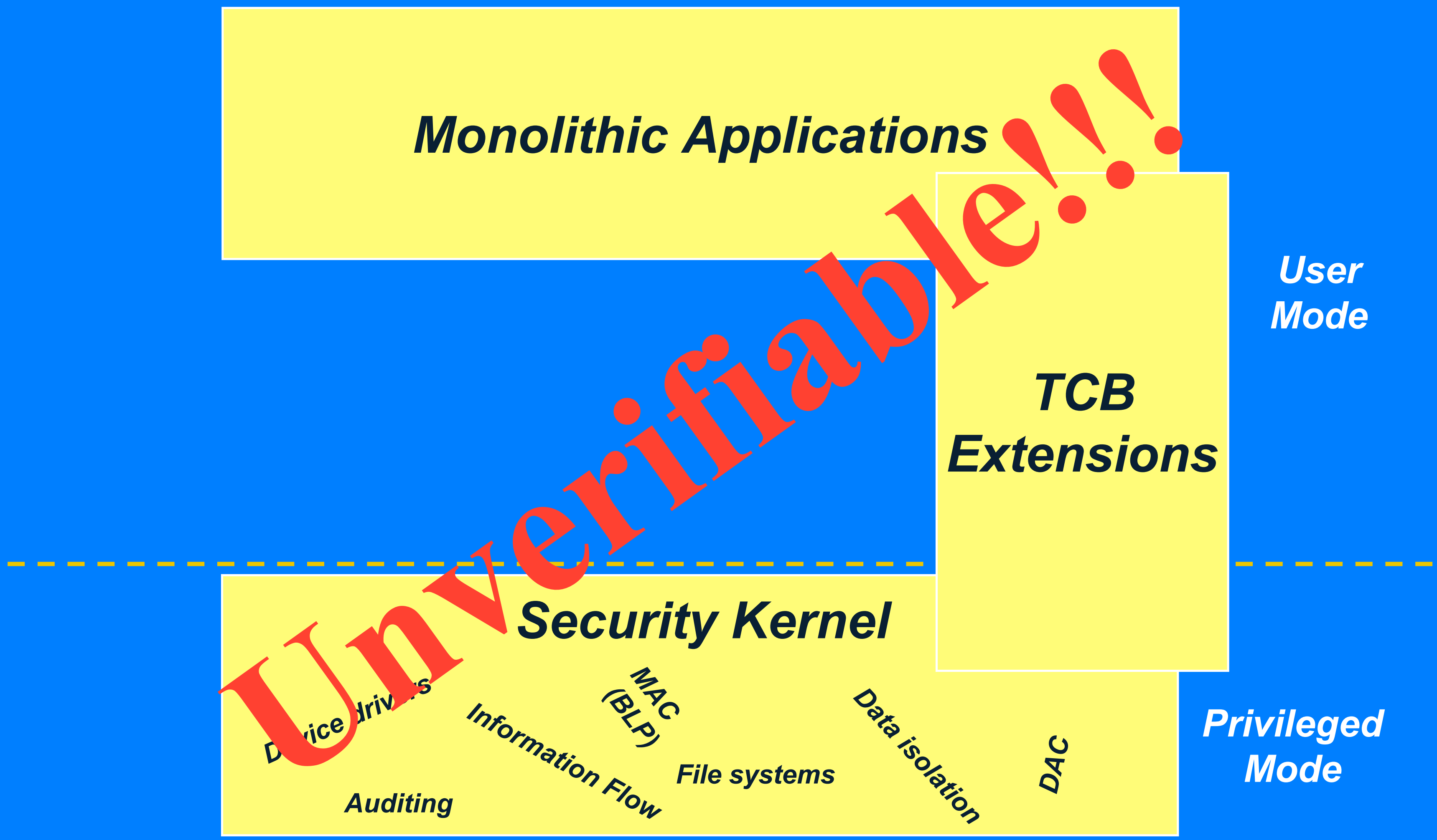
- Interest in the separation kernel concept has been renewed by advancements in processor performance.
  - Needed for safety- and security-critical apps & critical infrastructure
- The Separation Kernel is the foundation for the MILS architecture and must meet the highest standards in:
  - FAA DO-178B Level A Safety Technology (conservative)
  - Common Criteria EAL 7 Security Technology (progressive)
- SK's security policy is ***data isolation*** and ***information flow***
  - Small: ~ 4K LOC
  - SK simple enough to analyze, non-bypassable, tamper-proof
- All other OS and Middleware services and applications to reside in user mode
  - Leverage SK guarantees to enable "application" layers to enforce, manage & control their own policies
  - Implement reference monitors for higher level policies that are simple enough to analyze, non-bypassable, tamper-proof

MILS Assurance in a Nutshell

Dramatically decrease the amount of security critical code.

Dramatically increase the scrutiny of security critical code.

Security Kernel / TCB Approach



MILS Architecture Approach