MILS and the Central Role of Policy Architecture In High Assurance Security

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MILS

- Is a **security architecture** adopted for
  - F22, F35, FCS, JTRS, DDG-1000, CDS
  among others
- Those are military embedded systems
- **But I want to persuade you** the approach will work for enterprise and commercial systems, too
- **MILS is also a business model and a business opportunity**
- **And I want to persuade you** that it’s worth some attention

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MILS Policy Architecture: 2
Compositional Assurance

- We are talking about security as a critical property
- So need to provide strong assurance that it is achieved
  - DoD: Medium and High Robustness
  - Common Criteria: EAL 4 to 7+
- We build systems from components
- And we’d like critical properties and assurance to compose
- Seldom happens: assurance dives into everything
- The system assurance argument may not decompose on architectural lines
  - So what is architecture?
  - A good one simplifies the assurance case
The MILS Idea

- Construct an architecture so that assurance does decompose along structural lines

- Two issues in security:
  - Enforce the security policy
  - Manage shared resources securely

- The MILS idea is to handle these separately

- The policy architecture is the interface between them
Policy Architecture

- **Boxes and arrows diagram**
- **Boxes** encapsulate data, information, control
  - Access only local state, incoming communications
  - i.e., they are state machines
- **Arrows** are channels for information flow
  - Strictly unidirectional
  - Absence of arrows is often crucial
- Some boxes are trusted to enforce local security policies
- Want the trusted boxes to be as simple as possible
- Decompose the policy architecture to achieve this
- Assume boxes and arrows are free

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MILS Policy Architecture: 5
Crypto Controller Example: Step 1

Policy: no plaintext on black network

No architecture, everything trusted
Crypto Controller Example: Step 2

Good policy architecture: fewer things trusted

Local policies:

**Header bypass**: low bandwidth, data looks like headers

**Crypto**: all output encrypted
Policy Architecture: Compositional Assurance

- Provide an argument that the local policies
  - In the context of the policy architecture
  - Achieve the overall system policy

- EAL4: this is done informally

- EAL7: this is done formally (compositional verification)
Resource Sharing

- Next, we need to implement the logical components and the communications of the policy architecture in an affordable manner

- Allow different components and communications to share resources

- Need to be sure the sharing does not violate the policy architecture
  - Flaws might add new communications paths
  - Might blur the separation between components
Uncontrolled Resource Sharing

Naive sharing could allow direct red to black information flow, or could blur the integrity of the components.

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MILS Policy Architecture: 10
Blurred Separation Between Components

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MILS Policy Architecture: 12
Secure Resource Sharing

- For broadly useful classes of resources
  - e.g., file systems, networks, consoles, processors
- Provide implementations that can be shared securely
- Start by defining what it means to partition specific kinds of resource into separate logical components
- Definition in the form of a protection profile (PP)
  - e.g. separation kernel protection profile (SKPP)
  - or network subsystem PP, filesystem PP, etc.
Crypto Controller Example: Step 3

Separation kernel securely partitions the processor resource

The integrity of the policy architecture is preserved
A Generic MILS System

Care and skill needed to determine which logical components share physical resources (performance, faults)

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MILS Business Model

- DoD moves things forward by supporting development of protection profiles
  - Separation kernels, partitioning communications systems, TCP/IP network stacks, file systems, consoles, publish-subscribe

- Then vendors create a COTS marketplace of compliant components

- Currently they are all resource sharing components; should be some policy components, too
  - e.g., filters, downgraders for CDS
MILS In The Enterprise

- **Separation kernels are like minimal hypervisors** (cf. Xen)
  - MILS separation kernel (4 KSLOC), EAL7
  - Avionics partitioning kernel (20 KSLOC), DO-178B Level A (∼EAL4)
  - Hypervisor (60 KSLOC), EAL?

- Can expect some convergence of APIs (cf. ARINC 653)

- **Different vendors will offer different functionality/assurance tradeoffs**

- Can extend use of hypervisors from providing isolated virtual hosts to supporting the policy architecture of a secure service
Recent Progress

- Initial development of mathematical theory for compositional assurance of MILS systems
- Initial development (by Rance DeLong) of a Common Criteria Authoring Environment to assist construction of coherent PPs
- PPs for several MILS components at different levels of completion
  - SKPP done, PCSPP nearly done
  - Console, network, filesystem, under way
- High and medium robustness separation kernels from several RTOS vendors
Summary

- Key idea of MILS is to align the architecture with the assurance case
- Enabler for this is separation of concerns
  - Enforcing policy
  - Sharing resources
- The policy architecture is the interface between these
- Efficient and secure resource sharing allows the policy architecture to have many logically separate components and communications
  - Use this to simplify the trusted components
  - Which eases their assurance
- Assured resource sharing components are COTS
- Assurance for the system is composed from that of the components
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