# A Translationally Inspired Model for Autonomous Device Self-Regulation

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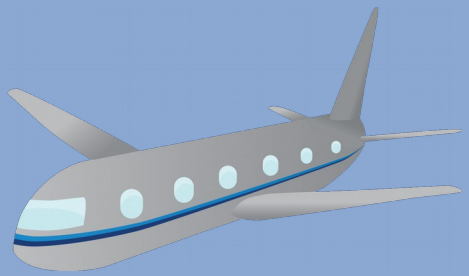
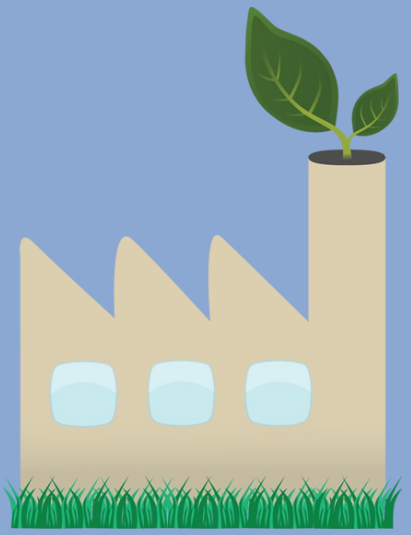
# Autonomous Self-Regulation

## Brought to you by:



$$Y = mx + b$$

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# Contrasting the Disciplines

- **Software Assurance**

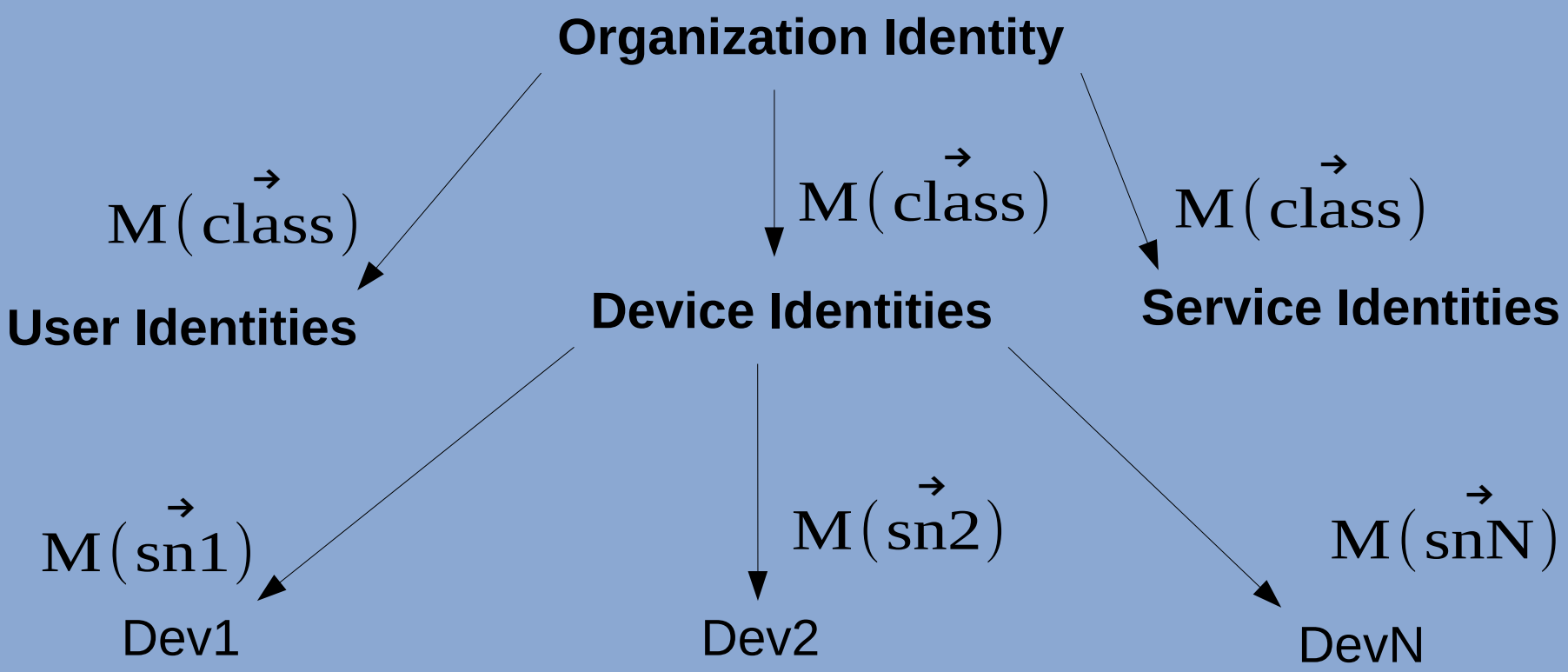
  The development of a formal definition of the desired behavior of a software platform and the mathematical proof of its correctness including the binary implementation of the software.

- **Behavioral Assurance**

  The development of a formal definition of the desired information exchange events for a computing platform and the mathematical verification of the hardware specific implementation of that behavior.

# Our Inspiration - Identity Modeling

## Genetic Hash Chaining – Identity Arborescence




Process yields device identities which are linked by a 'measurement path' to an organizational identity.

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# Our Initial Motivation - NHIN

***"These efforts will coordinate patient care with The stroke of a key or pull up life saving health information instantly in an emergency."***

Vice-President Biden and Secretary Sebelius
05/04/2010

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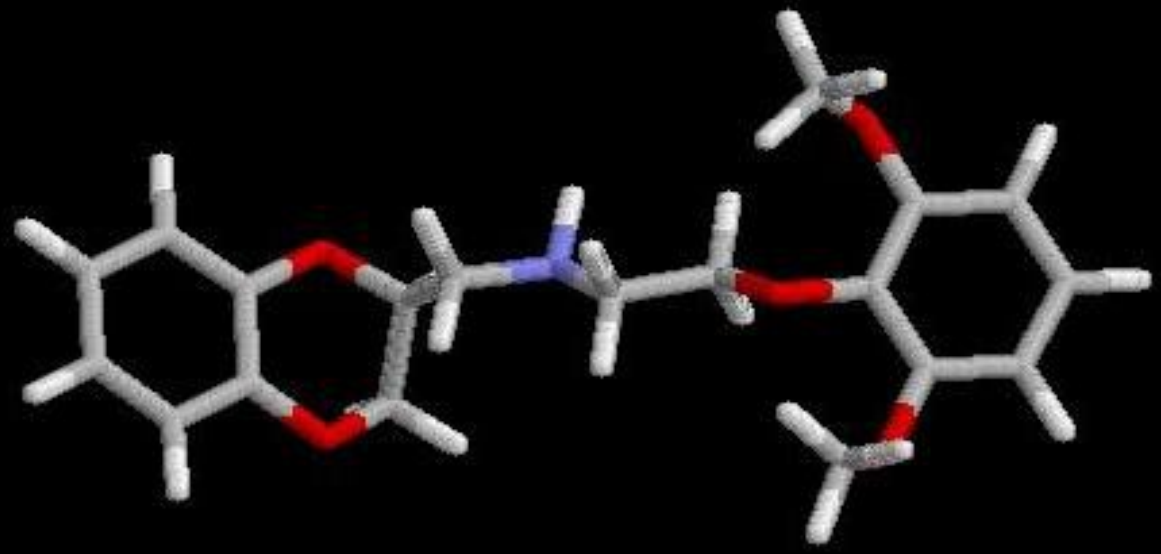
# Where Things Started



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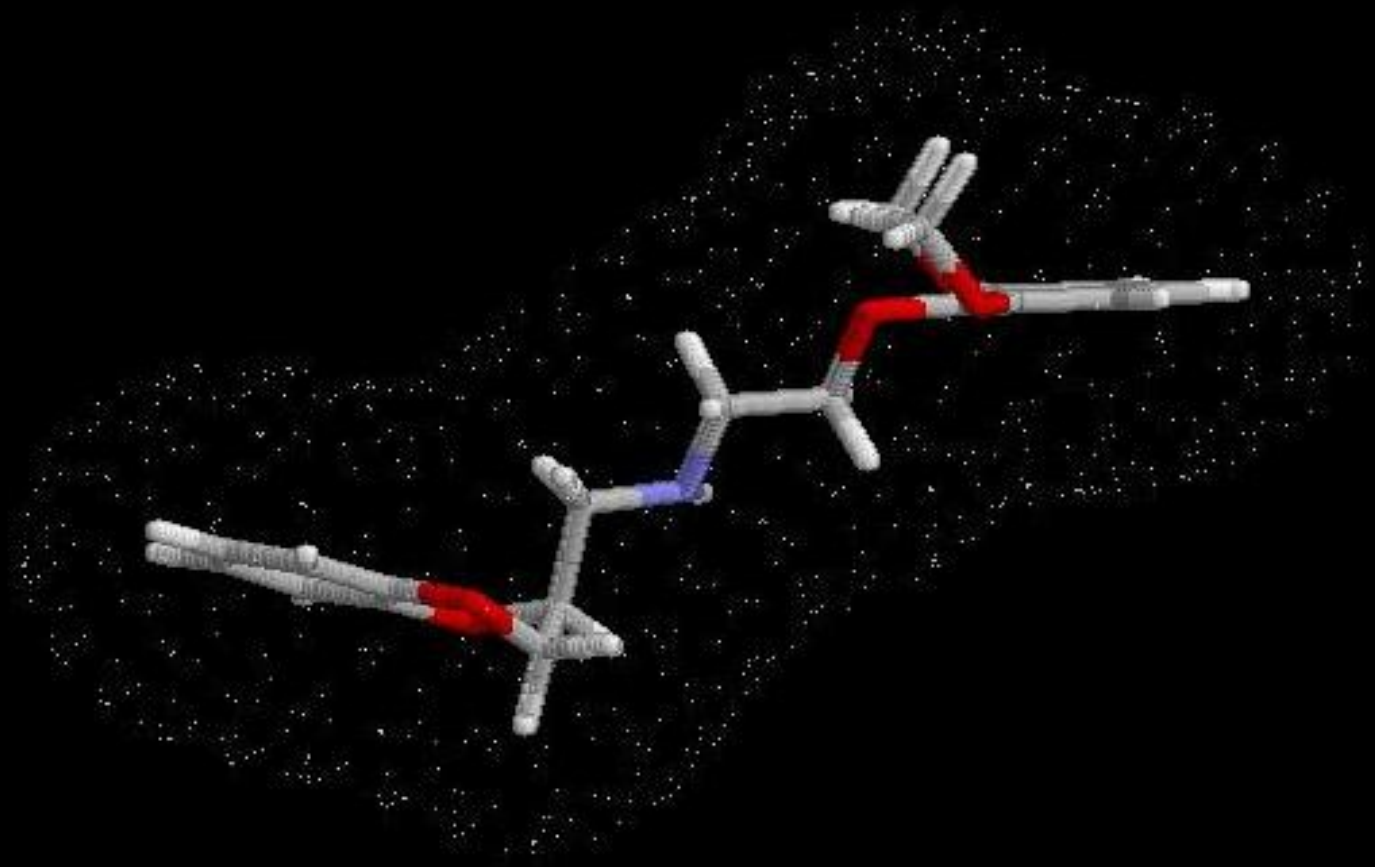
# Our Objective



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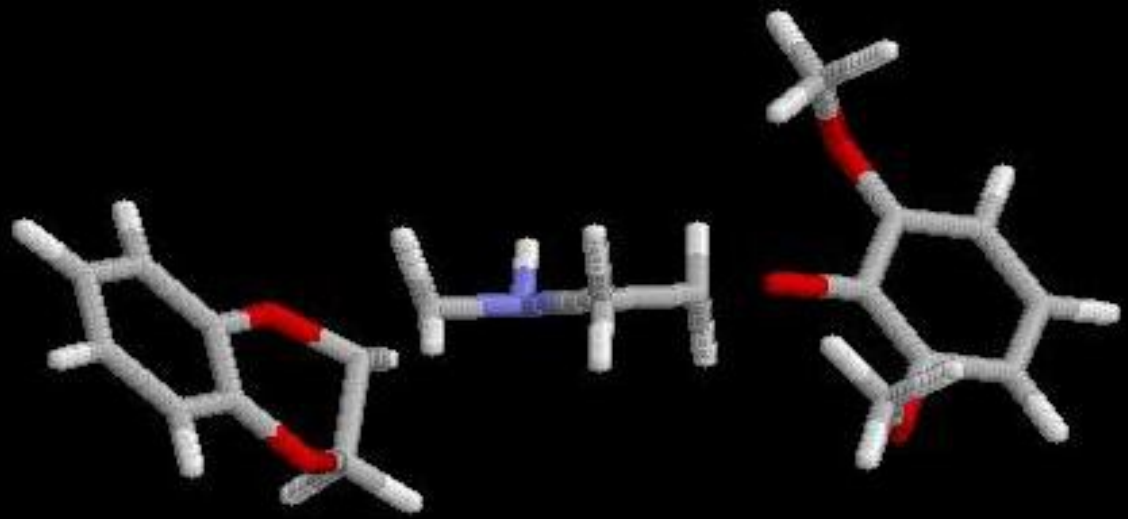
# The Approximation



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# Understanding the System

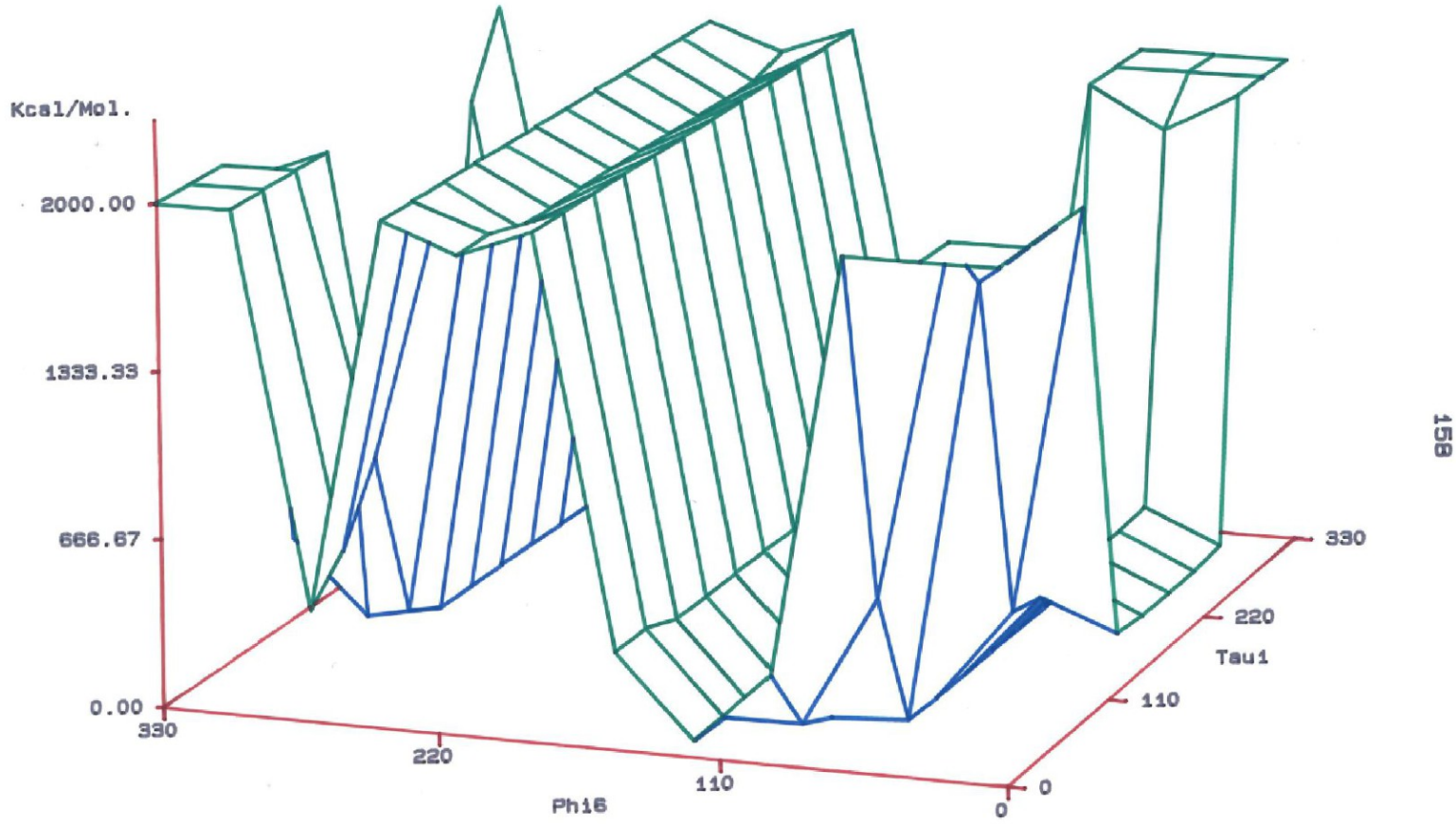


FIGURE 8–6: Conformational energy map of Phi6–Tau1 torsional interaction. Energy relative to local minimum.

# Quantum Mechanical Influences on Modeled Autonomous Systems

- Semi-empirical approximations.
- Degenerate representations of observable states.
- System trajectory paths.

# Modeling Platform Behavior

Life was easy in quantum mechanics:

$$\mathcal{H}\psi = E\psi$$

Dirac-von Neumann mathematical formulation structures the 'observable' states of a system to be the result of a self-adjoint hermitian operator applied to a Hilbert space.

Commonly implemented as a Linear Combination of Atomic Orbitals using various implementations of 1-electron Gaussian functions as the basis set.

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# Definition of an Operating System

## Formal:

The collection of software that directs a computer's operations, controlling and scheduling the execution of other programs, and managing storage, input/output, and communication resources.

## From a security perspective:

A software abstraction layer which is responsible for mediating information exchange events between a context of execution (Actor) and a data source or destination (Subject).

$$B = \mathrm{M}\left(\mathrm{A} \overset{\rightarrow}{\circ} \mathrm{S}\right)$$

# Actor/Subject Identity Composition

Actor and subject identities are functional compressions of entity specific identity characteristics.

**Actor (context of execution – process/thread)**

DAC components: uid, gid, euid, eguid, suid, sguid etc.
Capability masks: effective, permitted, inheritable, ambient

**Subject (inodes)**

Ownership and mode.
Content digest.
Filesystem components:  name, superblock.

**Model parameters can be extracted by tooling from standard software development processes.**

# Actor/Subject Identity Modeling

- **Premise 1**

  The interaction of an actor and subject identity yields an 'eigenvector' in the behavioral field.

- **Premise 2**

  The individual extension sums of the behavioral eigenvectors yield the 'eigenstates' of the platform behavioral field.

- **Premise 3**

  The behavior of a device is the extension sum of the device identity projected behavioral eigenstates.

$$B_{[eigen]} = \sum_{i=0}^{A_n} \sum_{j=0}^{S_{m[a]}} M\left(H_n(A_i) \vec{\|} H_n(S_j)\right)$$

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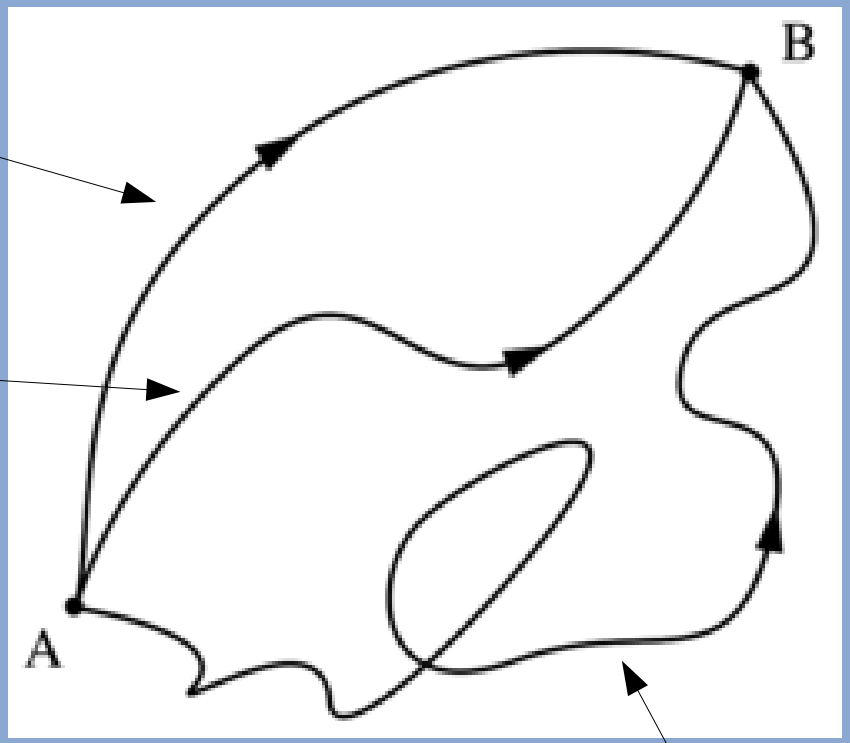
# Behavior Compromise Modeling

- The Hamiltonian path of a single actor identity over its subject field yields an *'iso-identity contour'.*
  - In QM terms the *'Orbit'* of the actor through its field.
- Extra-dimensional compromise.
  - Platform behavior goes 'off-contour'.
  - Detectable by deterministic behavior modeling.
- Intra-dimensional compromise.
  - Platform behavior remains 'on-contour'.
  - Requires detection by stochastic methods.

# Path Integral Formulation

## With apologies to Richard Feynman

**Platform Behavioral Field**




Actor process 1

Actor process 2

System Boot State

Operational Measurement State

Dr. Wettstein's process.

# Linux Implementation – 4.4 LTS

- Originally based on Linux Integrity Measure Architecture (IMA) which treated integrity only as a function of file contents for privileged users.
  - Sailer, Zhang, Jaeger, Doorn; IBM TJ Watson Research
- Extensions and eventual re-write to implement full actor/subject modeling, trajectory modeling and forensics capture.
- Significant focus on addressing engineering issues surrounding deployment tractability.

# Modeling Engine Interface

## /sys/kernel/security/ima/iso-identity

```
-r--r------  1 root root 0 Aug 11 02:31 contours
-r--r------  1 root root 0 Aug 11 02:31 forensics
--w-------  1 root root 0 Aug 11 02:31 identity
--w-------  1 root root 0 Aug 11 02:31 map
-r--r------  1 root root 0 Aug 11 02:31 measurement
--w-------  1 root root 0 Aug 11 02:31 pseudonym
--w-------  1 root root 0 Aug 11 02:31 sealed
-r—r------  1 root root 0 Aug 11 02:31 trajectory
```

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# Semi-Empirical Approximation
## Subject Pseudonyms

- Implemented to counter long standing problem with integrity systems secondary to writable files.
- Configured by security supervisor during system initialization process.
- Synthetic content digest is derived from platform identity.
- Digest is irrevocably lost in case of inode unlink.
- Under active development from a network inode perspective.

# Degeneracy and Iso-Behavioral States

Non-commutative property of extension operator causes inclusion of time to be a symmetry breaking operation.

$$M(A_1 \vec{\circ} S_1) + M(A_2 \vec{\circ} S_1) \neq M(A_2 \vec{\circ} S_1) + M(A_1 \vec{\circ} S_1)$$

Removal of time component in a trajectory path causes the remaining behavioral eigenvectors to collapse into a set of degenerate eigenstates which are considered to be iso-behavioral representations of an observed platform state.

**Model Simplification:**

Load eigenvalues/contours, seal modeling engine and monitor system for extra-dimensional behaviors.

# System Trajectory Paths

- The modeling engine provides a trajectory summary for the observed behavior field of the platform.
- Tooling generates behavioral eigenstates from system trajectory path as a component of the software development development process.
- Device identity projection causes each trajectory path to be unique.

event{swapper/0:/sbin/init} actor{uid=0, euid=0, suid=0, gid=0, egid=0, sgid=0, fsuid=0, fsgid=0, cap=0x3fffffffff} subject{uid=0, gid=0, mode=0100700, name_length=10, name=cadb8688009d5594acdf21564a7ac45aa93d7ef7d87c303615c3f73f0ab34278, s_id=xvda, s_uuid=feadbeaffeadbeaffeadbeaffeadbeaf, digest=400ee3609683bac35d2f9d07f1646e44b10aec1d714ab4669c41623caff80541}

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# Behavioral Canisters

## 'A Container with a Label'

- Similar to containers (OS virtualization) of operating system resources.
  - Filesystem view (mnt), process identifiers, network resources, inter-process communications, host/domainname, user identifiers.
  - Basis for technologies such as Docker, Rkt, LXC.
- Unsharing the behavior namespace creates a new behavioral domain which models the behavior of a process and its descendants.
- Critically important for addressing deployment complexity issues.
- Current implementation uses SGX to accumulate canister specific behavior measurements.

**/sys/fs/iso-identity/update-NNNNNNNN**

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# Current and Future Work

- More expressive policy engine.
- Support for process scheduler intervention.
- Network socket support.
- Migration of the modeling engine to an extra-OS implementation.
  - VCHAN implementations based on Xen and seL4.
- Increasing the accessible TCB for SGX based applications.
  - Gating OCALL's on behavioral state.
  - Intel would have a great opportunity for silicon enhancements in SGXv2.

**There is much work to do before we can announce our total failure to make any progress…..**

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# Thank you to the supporting cast.

- John Grosen
- Rick Engen
- Scott Stofferahn
- Christopher Trom
- Jaci Stofferahn
- Izzy the Golden Retriever

# Thank you for your indulgence.

Questions?

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