Just in Time Assurance

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Weinberg's Second Law

"If builders built buildings the way programmers wrote programs, then the first woodpecker that came along would destroy civilization."

- Anyone can get a system certified with enough time, money, threats, and waivers
- It takes skill to design a system that is practical and affordable to certify
- It takes a virtuoso to design a system that is practical and affordable to recertify given unpredictable but inevitable obsolescence events
- ***This presentation discusses how practical and affordable recertification can become the norm instead of the rare exception***

What Does Just in Time Mean?

- Manufacturing:
  - Parts arrive only when needed because inventory is waste.
    - Requirement: Quick notice of stock depletion
- Assurance:
  - Only modified components are reevaluated because total system reevaluation is waste.
    - Requirement: **NEAT** system architecture

What is NEATness?

- ***N***on-bypassable:
  - The infrastructure guarantees critical reference monitors in information flow paths can't be circumvented
- ***E***valuatable:
  - Each critical reference monitor is small and simple enough to enable unambiguous specification and rigorous evaluation
- ***A***lways Invoked:
  - Critical reference monitors enforce their ***local*** security policy for every object they manage
- ***T***amper Proof:
  - The infrastructure guarantees subversive agents can't modify any critical reference monitor's security functions or data.

Local Security Policy Enforcement

"**Critical reference monitors enforce their *local* security policy for every object they manage**"

- Why the ***local***?
  - A reference monitor should not know anything about any other part of the system
  - Reference monitor scope is constrained to the objects it manages
- A local reference monitor can be maintained, updated, and replaced with minimal effect on the rest of the system
  - A firewall or controlled interface in an enterprise network should not have knowledge about anything other than the policy it must enforce
  - A reference monitor in a real-time embedded system should not have knowledge about the specific platform on which it has been deployed
- A system can be certified, deployed, updated, recertified, and redeployed with reevaluation required only for the new components
- **RESULT:** the cost spiral caused by obsolescence events can be controlled

NEATness Verification

- Provide assurance that the infrastructure has security properties that protect reference monitors from ***TIME*** events
- ***TIME*****:**
  - ***T***ype safety violation
  - ***I***nfiltration violation
  - ***M***ediation violation
  - ***E***xfiltration violation

TIME: Type Safety Violation

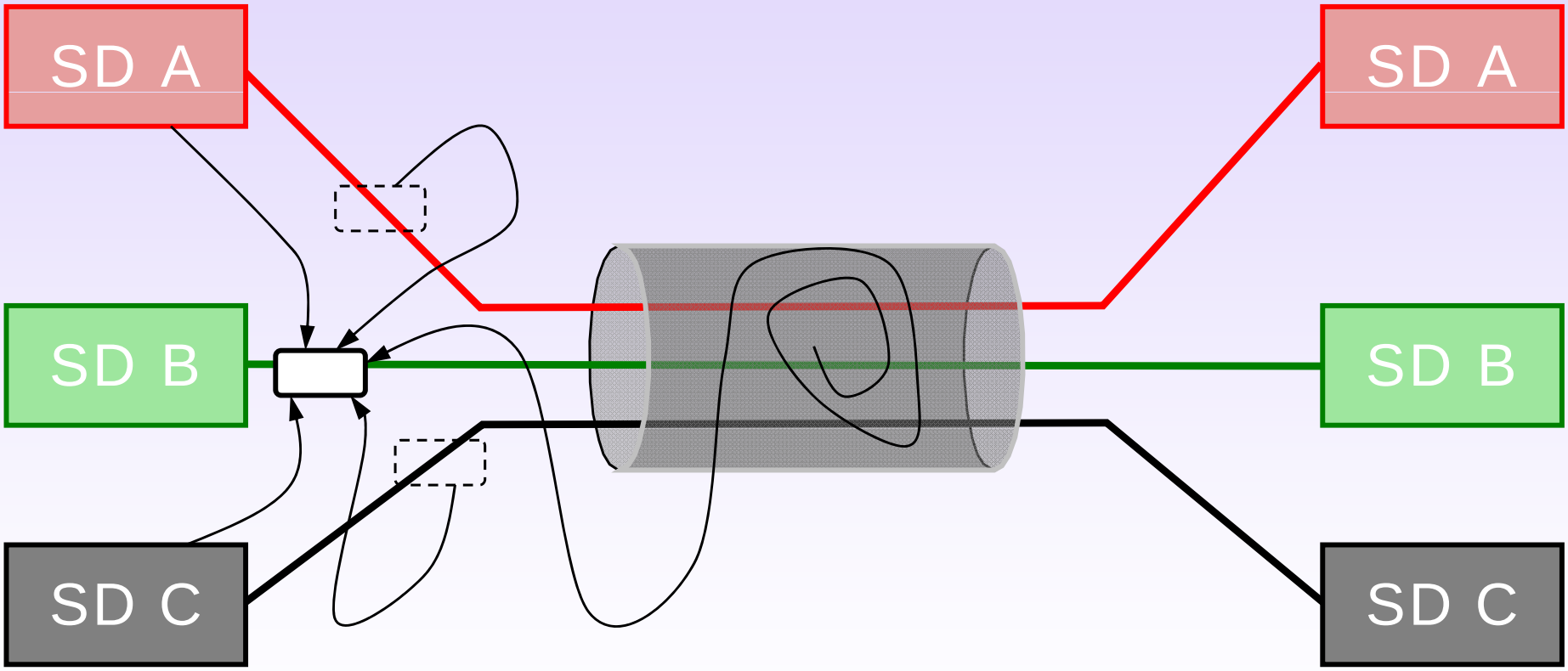
- When an object of one type is expected, a different type is delivered
- Consequences:
  - Buffer overflow
  - Address redirection
  - Unauthorized configuration modification
  - Activation of unintended code
    - Mission software turned into malware
    - Virus contagion
    - Root kit injection
    - Access control bypass

TIME: Infiltration

An unauthorized party may insert data into a channel, compromising integrity

- Party 1: An entity not authorized to send content on certain channels
- Party 2: Software, hardware, or systems that can attempt modification of traffic on certain channels but are not authorized to send content on those channels

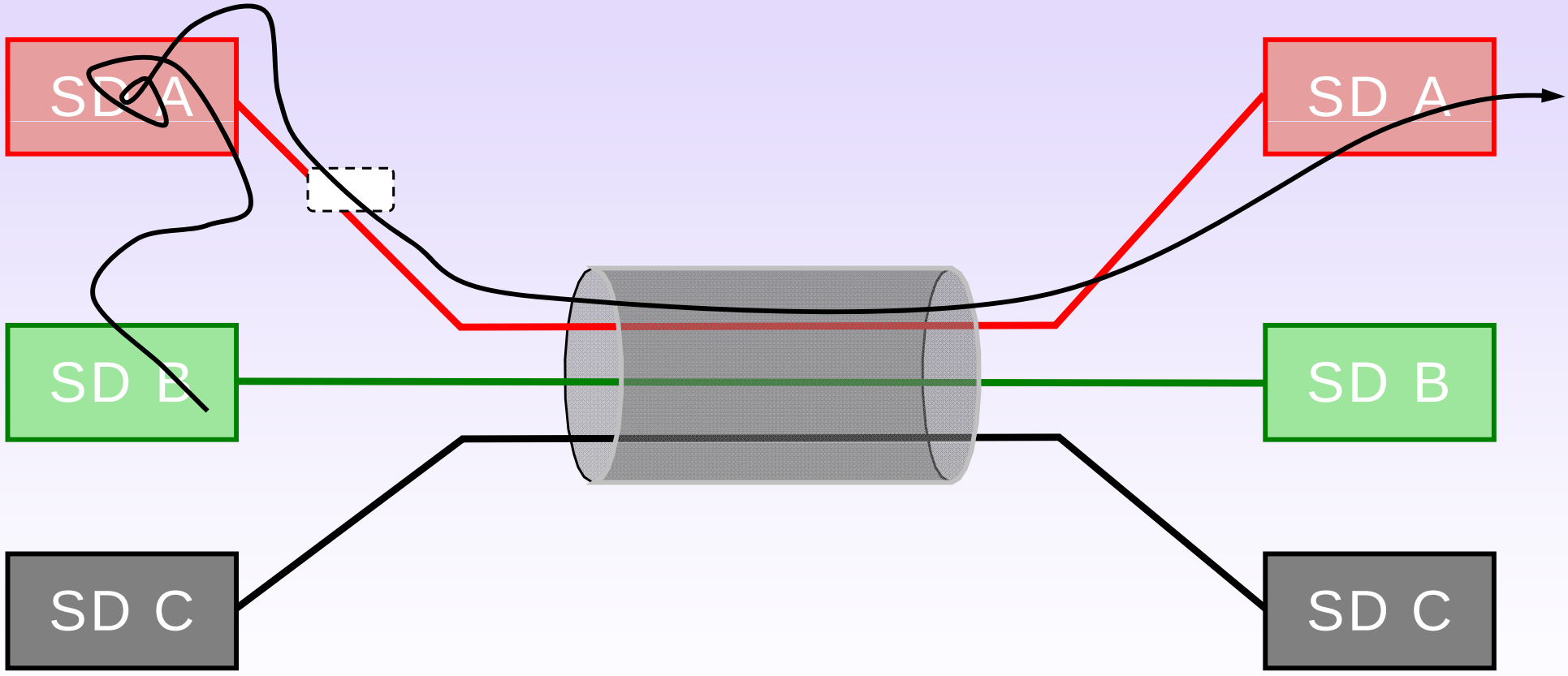
Infiltration



TIME: Mediation

- An unauthorized party may initiate or cause an information flow, compromising control
- Party 3: An entity that is not authorized to send content or cause content to be sent on certain channels

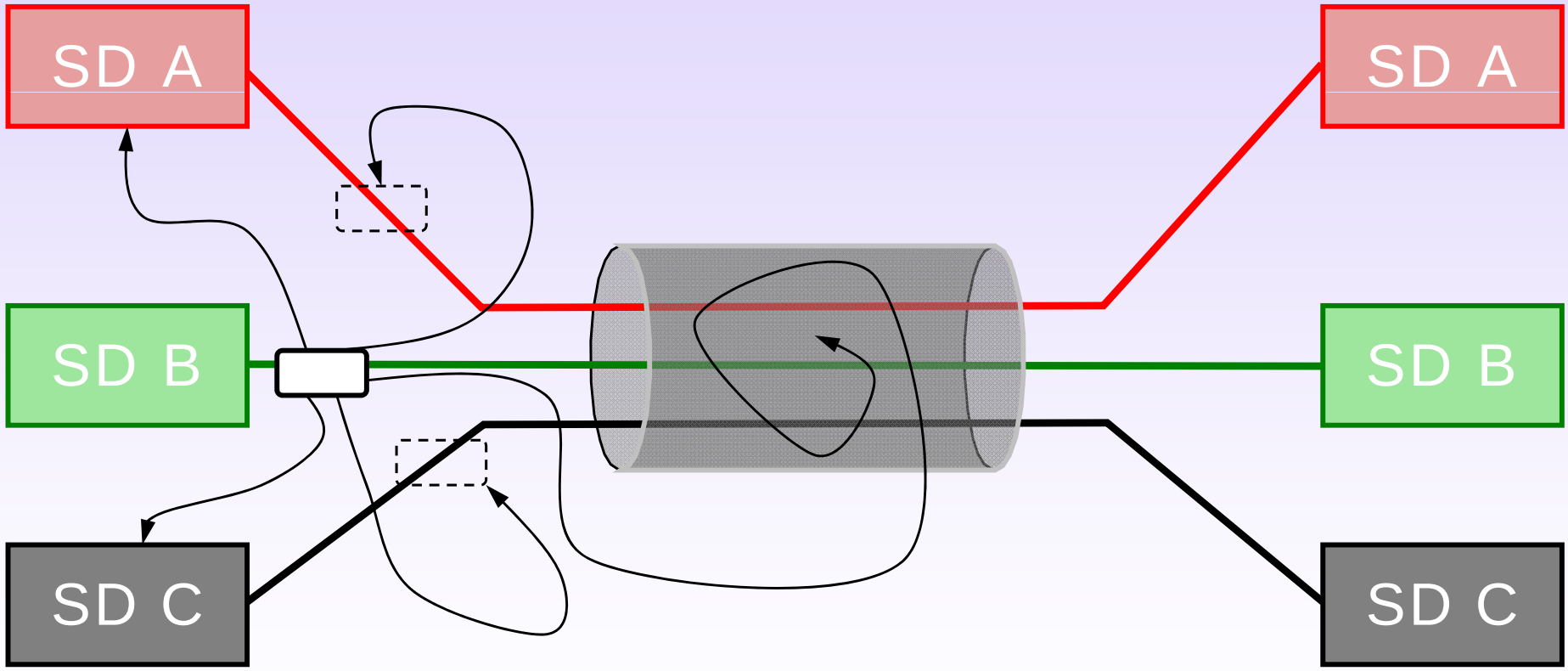
Mediation



TIME: Exfiltration

- An unauthorized party may perceive data in a channel, compromising confidentiality
- Party 4: An entity that is not authorized to receive content on certain channels
- Party 5: Software, hardware, or systems that can “see” all traffic of certain channels but are not authorized to receive the content of those channels

Exfiltration



Mitigating *TIME* Threats to *NEAT*ness

- Trustworthy separation enables security policy enforcement to be decomposed along structural lines
- Separation with respect to:
  - Space: Private data remains private
  - Time: Periods processing
  - Information Flow:
    - Only when initiated by authorized subjects,
    - Only delivered to authorized recipients
    - Sender authenticated to receiver

Benefits of Separation

- Specified interfaces are the only way that information may flow
  - **T**: Inappropriate data types can't be presented to an interface
  - **I:** There can be no infiltration (information pull violation)
  - M: There can be no mediation (control violation)
  - E: There can be no exfiltration (information push violation)
- Security Policy enforcement behaviors can be localized to each component reference monitor.
- Security policy architecture can then be decomposed as boxes and arrows

Boxes and Arrows Decomposition

- Boxes encapsulate objects
  - Access only local data and incoming communications
- Arrows are channels for information flow among boxes
  - Strictly unidirectional
  - Absence of arrows is just as crucial as their presence
- Draw enough boxes so that the ones that must be trustworthy are small and simple
  - Assume, for now, that boxes and arrows are “free”

Least Privilege Boxes

- A module trusted to enforce a system security policy in one layer can be untrusted in a different layer
- When a vulnerability in a reference monitor is found, it can be fixed without having to change anything else.
  - If we don’t change anything else, we don’t have to recertify the “anything else.”
- The architecture has done its job.

Security Policy Decomposition Benefits

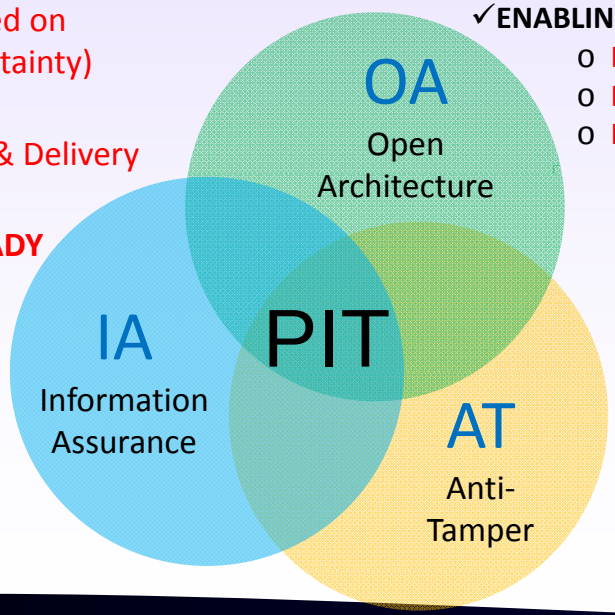
- Each least privilege security policy enforcement box is smaller, simpler, and more readily evaluatable
- Original security policy composition arguments remain unchanged despite obsolescence events
- Systems become more maintainable, adaptable, and extensible
- New threats from smarter and more experienced adversaries can be mitigated without redesigning the entire system

Compositional Assurance

- Compositional assurance is the path towards the goal of JIT Assurance
  - Construct individual assurance case for each trusted component
  - Provide argument that local policies combine to enforce the overall system policy
- ***Composability enables JIT Assurance***
  - A component can be patched, upgraded, refreshed, or replaced without affecting any other “parts”
  - Total system assurance is maintained at reasonable cost despite obsolescence events

Survivability

- ✓**CONFIDENTIALITY**
  - Critical Data **PROTECTED**
- ✓**INTEGRITY**
  - Free of Unauthorized Manipulation
- ✓**AUTHENTICATION**
  - Identity Confirmed
- ✓**AUTHORIZATION**
  - Privilege Confirmed
  - Mutual Suspicion
    (Reduced access based on authentication uncertainty)
- ✓**NON-REPUDIATION**
  - Proof of Data Origin & Delivery
- ✓**AVAILABILITY**
  - Critical functions **READY**



- ✓**DESIGNATE KEY INFORMATION EXCHANGES**
  - Standardize similar areas at Enterprise level across Primes
  - Blue force tracking, strike, mission planning , weather, …
- ✓**MODULARITY & VISIABILITY**
  - Enable affordable, safe and secure Technology Refreshes
  - Enable low cost rapid Technology Insertion
  - Enable recovery and adaptation against Zero-day Defects
- ✓**RE-USEABLE COMPONENTS**
  - Commercial based standards (POSIX, Open GL) - unmodified
  - Published standards (IEEE 1394, 802.11) - unmodified
  - Established proprietary standards (USB, Blue Ray) - unmodified
- ✓**INTEROPERABILITY & SECURITY (CJCSI 6212.01E)**
  - Global Network Information Enterprise Architecture
  - Support for Distributed degree of trust systems
- ✓**ENABLING ENVIRONMENTS**
  - Infrastructure and Enterprise API's Separable
  - Decouple data producers and consumers (cloud computing)
  - Register data grams and data streams within metadata registry

- ✓**DETERRENCE**
  - Undesirable Consequences
  - Strength of Mechanism
- ✓**PREVENTION**
  - Defense in Depth
  - Obfuscation
- ✓**DETECTION**
  - Visual, Alarm, Loss of Function, Attestation
  - Monitoring
- ✓**RESPONSE**
  - Destruction, Disabling, Zeroization
  - Adaption

System Life Total Cost of Ownership

Implementation

Certification / Accreditation

Deployment

Operations, Maintenance, and Administration

Technology Refresh

Growing Attack Surface over time

Obsolescence Events

Summary

- Separation enables JIT Assurance
- Networks of separated modules with proscribed frameworks to integrate them
- Trust of separation infrastructure to be verified.
  - Software implemented separation
    - Deployment of virtualization implementing isolation and redundancy
    - Requires validation of underlying hardware separation mechanisms (i.e., MMU, TPM, VT-d, etc.)
- Verification can be reused during all remaining steps in the system life cycle