Policy Overlay Networks

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Outline

Introduction

Distributed enterprise computing systems are facing a troubling future. They are:

- *Expensive* — They do not use current commercial resources and use costly partitioning schemes
- *Unreliable* — Too reliant on outmoded security approaches
- *Slow* — Sensitive information is manually reviewed too often leading to the right people being unable to get the right information in time

They need to be re-imagined to take advantage of radical shifts in computational provisioning.

Federal computer systems are a prime example of these kind of problematic distributed systems, and demonstrate the difficulty in implementing new technical solutions.

The Problems — Customer Perspectives

Current policy-centric systems are being forced to move to cloud environments and build much more open systems. Usage management is a key problem in this domain — information needs to be delivered to those who need it as soon as possible:

"...It is imperative to effectively exchange information among components, Federal agencies, coalition partners, foreign governments and international organizations as a critical element of our efforts to defend the nation and execute national strategy..." [1]

— *DoD Information Sharing Strategy*

"...The CIO of the National Security Agency is focusing on IT architecture and a cloud-centric approach to sharing information..." [3]

— *Informationweek*

The Problem — Characteristics

Cloud systems may save money, provide more flexibility, but they also [8]:

- *Are Not Private* — User data control in SaaS is lacking, causing policy concerns for agencies; Data owners have no technical control over secondary use; providers may use offshore development; data can be routed across sensitive countries or secondarily stored on CDNs; data privacy on bankruptcy is ill-defined
- *Are Less Secure* — Controlling data access, data may not be wiped in all XaaS scenarios, availability/backup leads to possible data proliferation, lack of standardization in intercloud communication and data transfer, multi-tenancy and side-channel attacks, difficult logging/auditing
- *Cannot Be Trusted* — Trust relationships, consumer trust

Current Solutions

How are these problems being addressed by impacted organizations?

They're just starting to be actively addressed and are an open research question [2].

Cross-domain architectures are currently the standard for monitoring and information dissemination in an effort lead by the *Unified Cross Domain Management Office*, associated with the Department of Defense (DoD) and the National Security Agency (NSA).

Current Solutions — NSA

Legacy cross-domain notional architecture [6]

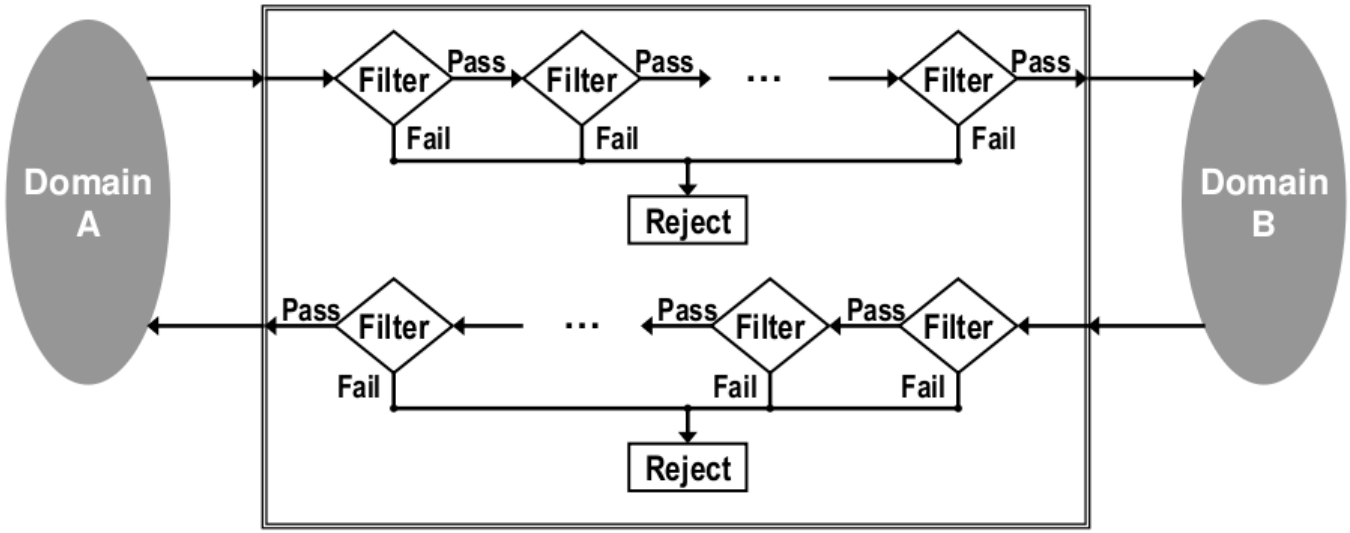


Figure: NSA Legacy Model

Domain A — Private cloud managed by the Air Force
Domain B — A public operational network

Current Solutions — NSA (SoA)

Future cross-domain notional architecture [6]

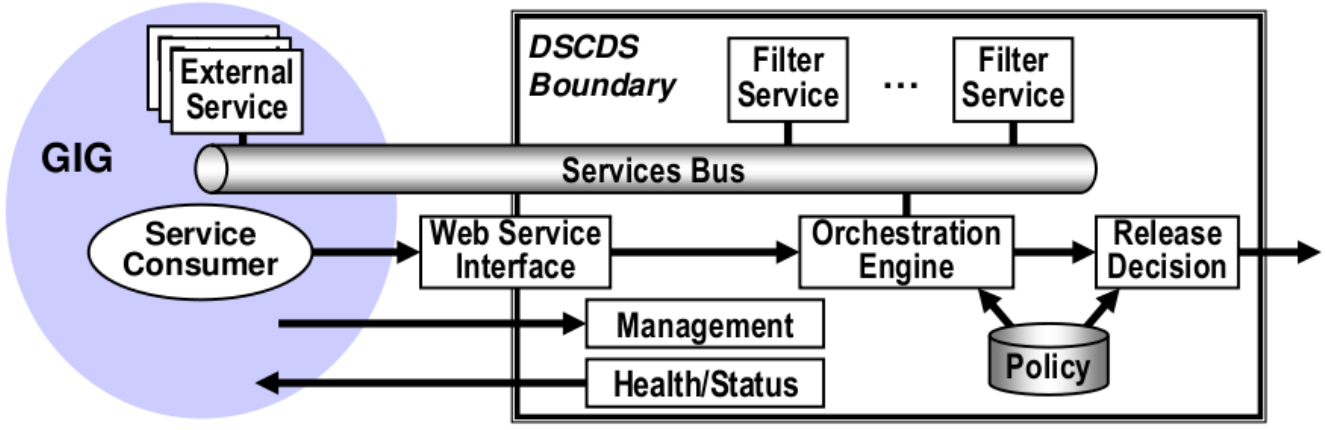


Figure: NSA Service-Oriented Model

GiG — Global Information Grid; a large public cloud operated by the DoD
DSCDS — Distributed Service-oriented Cross Domain Solution

Current Solutions — Raytheon

Raytheon's notional architecture supporting cross-domain information flow [7]:

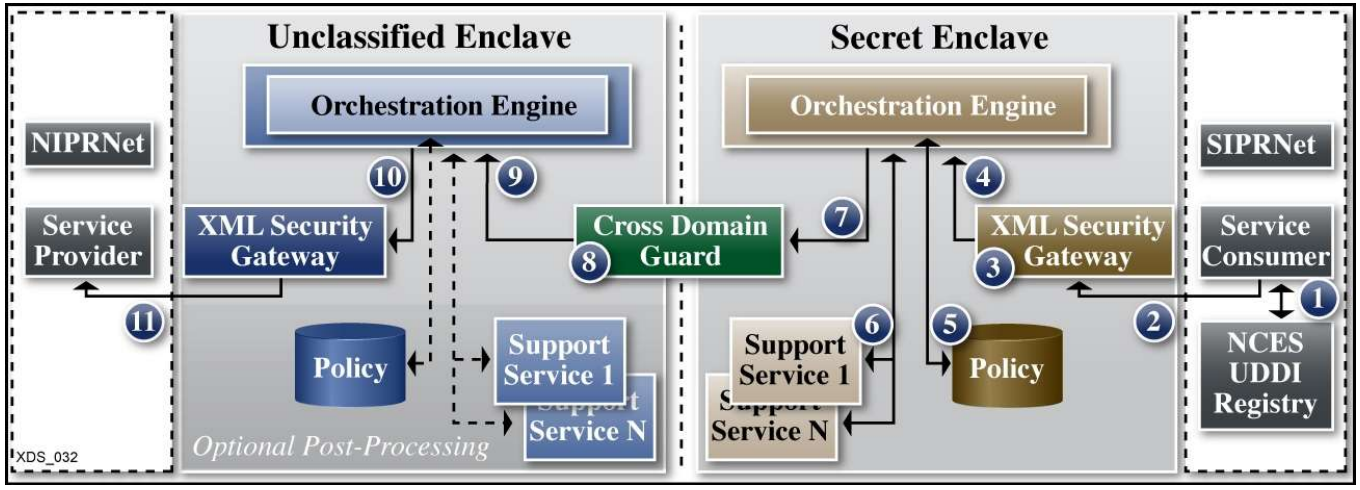


Figure: Raytheon Model

...still uses a single perimeter guard...

Current Solutions — BAH

Booz—Allen—Hamilton presented a service-centric cross domain solution in 2009 [5]:

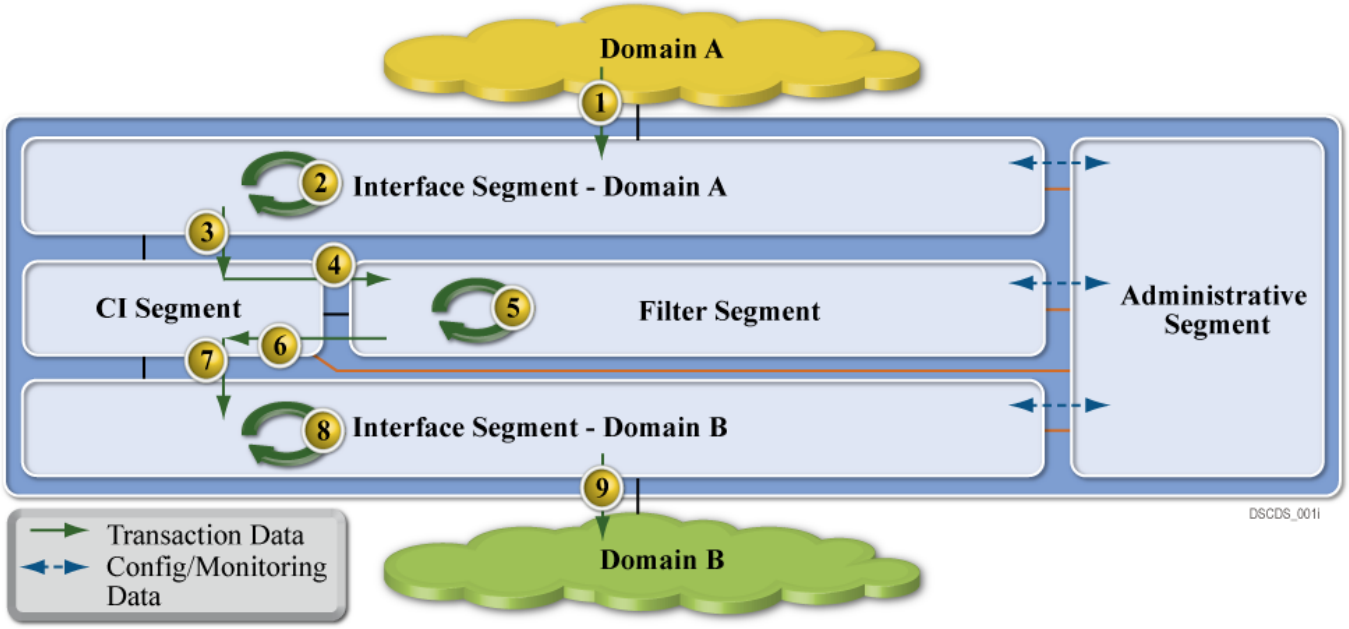


Figure: Booz—Allen—Hamilton Model

...still uses a single perimeter guard (called a filter segment)...

Future Solution

Organizations are falling back on what they know in the scope of new problems.

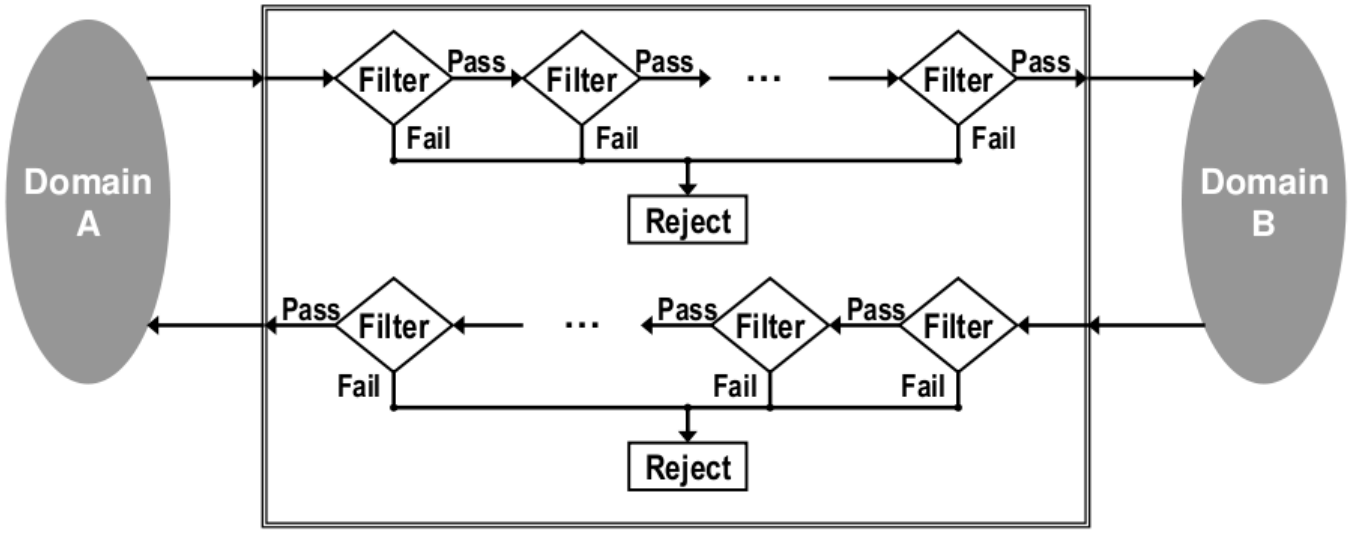


Figure: NSA Legacy Model

Even though we know they don't work [10].

Characteristics of Current Solutions

- *Centralized Policy* — They use centralized policy injection into communication flow. Note that in each sample model, policy is *only* evaluated at guard points.
- *Physical to Compartment Mapping* — In each of these cases, users are only allowed to exchange one type of information per domain. The physical domain systems are locked (by operational policy) to a single classification level limit. Users cannot, for example, have *Top Secret* material on a network accredited for *Secret* material.
- *Perimeter Protection* — The use of a single policy enforcement point at domain interconnects supplies a crunchy exterior to the creamy interior data filling.

What's Wrong with Current Solutions?

- *Centralized Policy* — A centralized policy enforcement system simplifies infrastructural attacks. Adversaries know exactly where to focus efforts to compromise policy enforcement, lowering overall system trustworthiness and reliability.
- *Physical to Compartment Mapping* — The traditional model for multi-level security, enforced in this scheme, is that the network is classified at the level of the most sensitive data that transits it. Ergo, those that have clearances at a level to view sensitive data are unable to view that data generally without extensive swivel-chair integration.
- *Perimeter Protection* — Perimeter protection is a necessary but not sufficient security approach. By itself, it doesn't work [10].

Characteristics of Future Solutions

- *Decentralized Policy* — Policy management is decentralized and integrated within the fabric of the system. The system is both more secure and resilient as a result, better able to control information and operate under stressful conditions.
- *Infrastructure Reuse* — Multi-tenancy can lower costs and increase reliability and is furthermore a common attribute of cloud systems. An appropriately secured system facilitates integration of computing resources into multi-tenant environments.

Characteristics of Future Solutions

- *Cloud Integration* — The ability to handle multi-tenant environments and to reliably secure both data at rest and data in motion leads to computational environments deployable in cloud systems.
- *Security in Depth* — Systems must operate under *all* conditions, including when they are under attack or compromise [10]. Ergo, they must provide protection to sensitive data in depth.

Related Work

Protecting domains...

Domains exist below a specific overlay, and trusted secure paths between domains corresponding to a single overlay network are negotiated *a priori* and then used by the overlay [9]

May be useful in this work, but the authors are a bit obtuse on the application of their ideas

Using specific policies in a policy layer to protect the underlying network strata from abuse by overlays [4]

Doesn't really address content-centric policies

...not content.

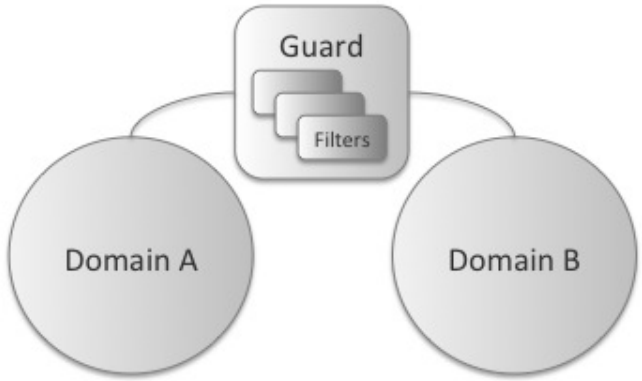
System Architecture

What would this kind of overlay system look like?

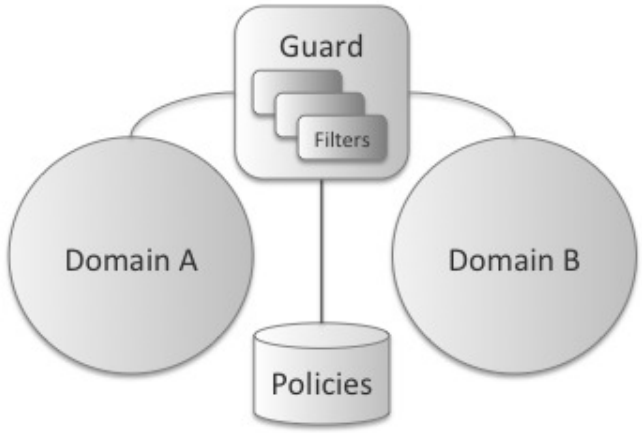
- *Meta-Model*
- *Non-Hierarchical Overlays*
- *Hierarchical Overlays*
- *Ontologies and Taxonomies*

...and what would the migration path to these systems look like?

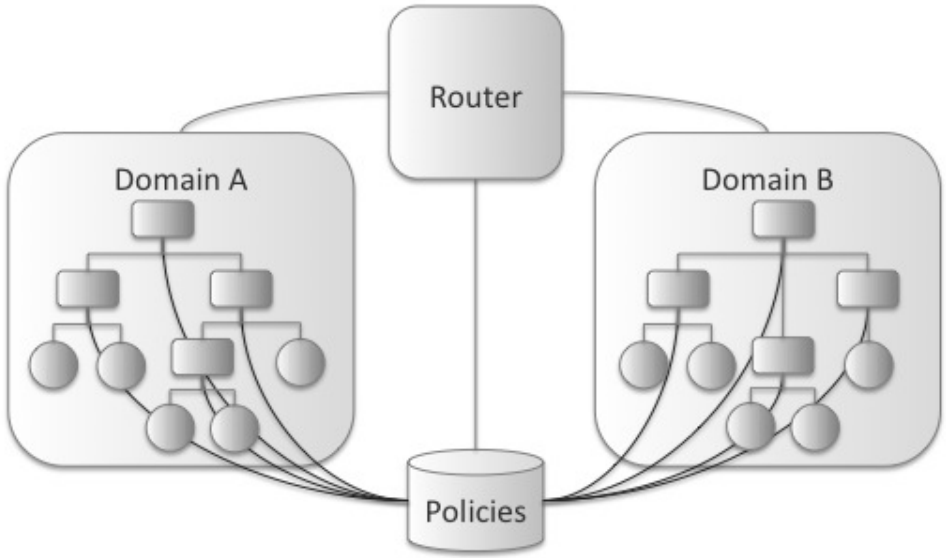
System Architecture - Level ϕ



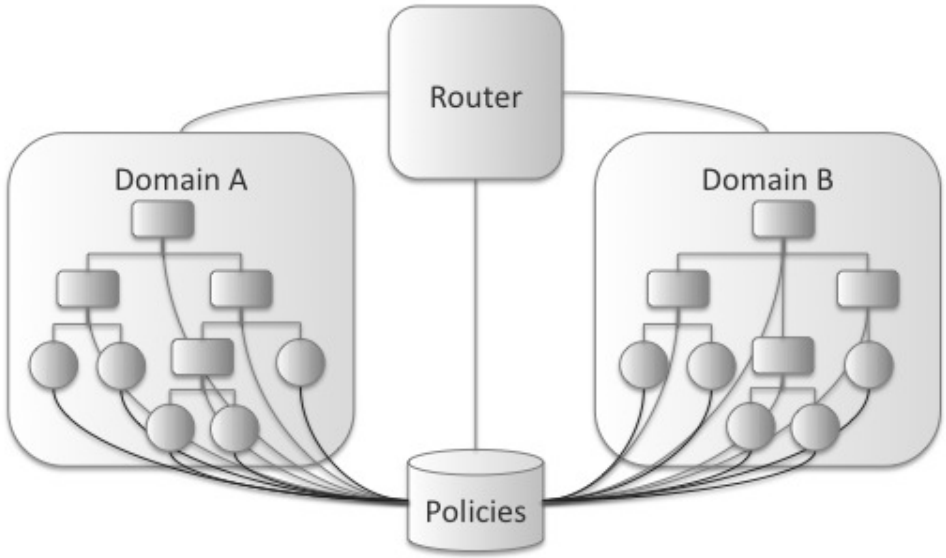
System Architecture - Level α



System Architecture - Level β



System Architecture - Level γ



System Architecture - Level δ

Level 3 system

Fully Integrated Policy Aware Decentralized System

Conclusions

Contribution of Work

The unique contribution of this work is a quantitative analysis of policy-centric overlay network options, associated taxonomies of use, and prototypical technology proofs-of-concept.

- *Overlay Options* — This includes various types of overlay networks and associated strengths and weaknesses addressing centralized and decentralized models
- *Taxonomies of Use* — Depending on the specific usage management requirements and context, different overlays have different applicability; this work will provide guidance on suitability
- *Prototypical Technologies* — Examples and proofs-of-concept will be required to appropriately analyze various architectural alternatives

Questions?

[1] DoD Information Sharing Strategy. http://cio-nii.defense.gov/docs/InfoSharingStrategy.pdf, May 2007.

[2] Assured Information Sharing in Clouds. http://www.zyn.com/sbir/sbres/sttr/dod/af/af11-bt30.htm, August 2011.

[3] NSA Pursues Intelligence-Sharing Architecture. http://www.informationweek.com/news/government/cloud-saas/229401646, April 2011.

[4] I. Al-Oqily and A. Karmouch. Policy-based context-aware overlay networks. In *Global Information Infrastructure Symposium, 2007. GIIS 2007. First International*, pages 85 –92, july 2007.

[5] Booz, Allen, and Hamilton. Distributed service oriented architecture (soa) compatible cross domain service (dscds). Presented at the Unified Cross Domain Management Office Conference, 2009.

[6] NSA. Distributed service oriented architecture (soa)-