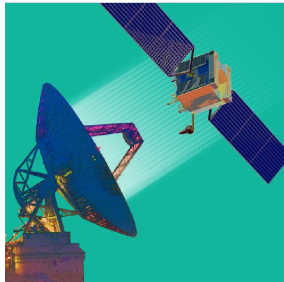




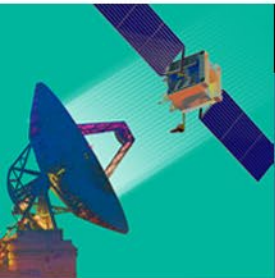
Ground System Architectures Workshop



Session 11C

The Trajectory of the GSAW Cloud Computing Working Group: 10 Years and Counting

Ramesh Rangachar and Craig Lee
The Aerospace Corporation



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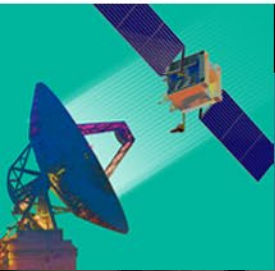
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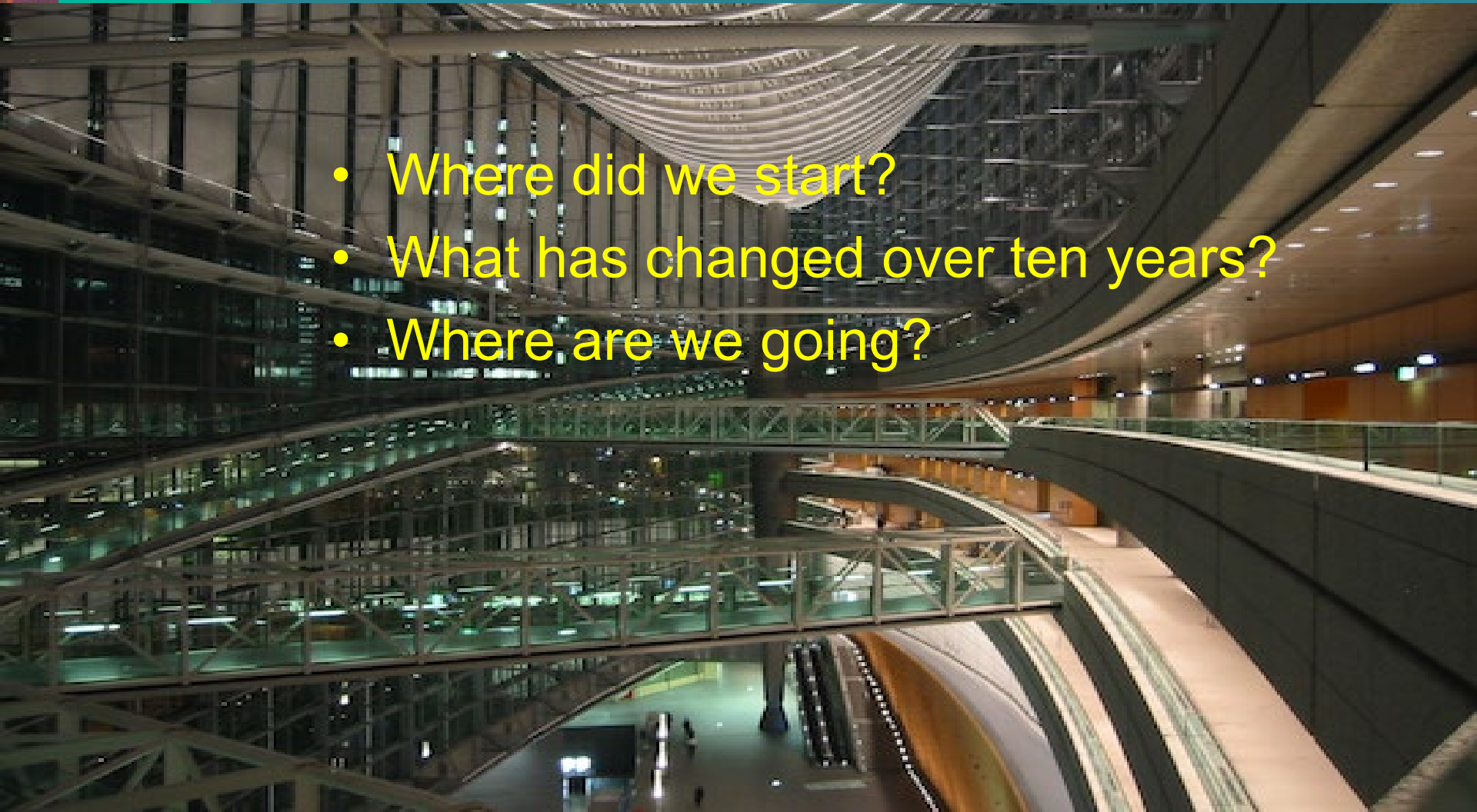
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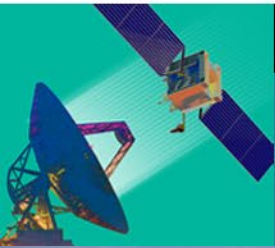


Session 11C

We've Been at It for Ten Years!

- Where did we start?
- What has changed over ten years?
- Where are we going?





A Very Short History

2011 (I)

- Business Case and strategy needs to be refined
- Cloud standards are needed

2012 (II)

- Private Clouds
- Distributed Clouds
- Crossing Trust Boundaries -- Inter-Clouds

2013 (III)

- Security and Trust
- Technology is not the only problem

2014 (IV)

- SLAs for cloud
- Distinction between Public and Private cloud

2015 (V)

- Use cloud where it make sense: cost, reliability, performance
- Issues: data security, governance, org. barriers

2016 (VI)

- Containers and Microservices
- Config. Management: Chef, Puppet, Ansible
- Service Migration: re-host, re-factor, re-build

2017 (VII)

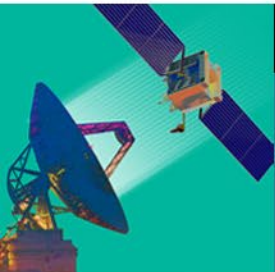
- Big Data, Containers, Microservice Architectures
- Cloud Adoption/Migration

2018 (VIII)

- Ground systems will no longer be monolithic
- They will be conglomerates of open source tools, containers, micro-services, etc.
- Mission and organizational boundaries will software-defined

2019 (IX)

- First time "Big Data" officially in the title
- Expands workshop scope to data-centricity
- Established processes and policies can be impediments



So Where Are We Going?

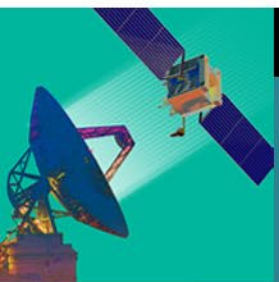


Can We Identify Some Destinations?



Trends

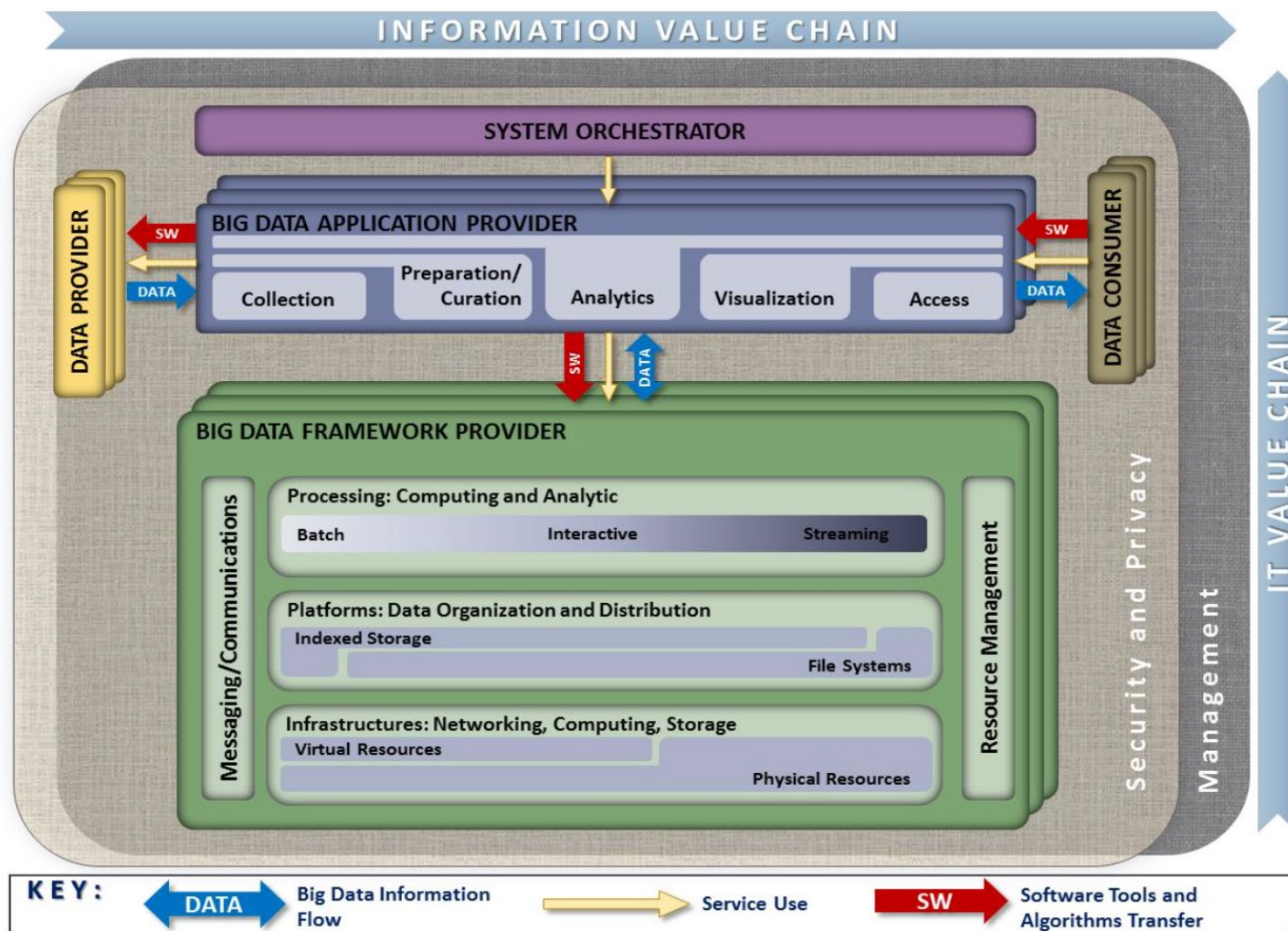
- Diversification up the stack
 - Everything is on-demand -- even *Ground System-as-a-Service*
 - CSPs provide back-haul!
 - CSPs are already operating global Content Distribution Networks (CDNs) with huge back-bone networks connecting their data centers
- Cloud Migration should involve a refactoring of the system arch
 - Migration Approaches: Lift-n-Shift, Green Field, Re-factoring
 - Service Identification
 - Enable more of a uService approach
- System design is much more than just the plumbing
 - *Security Architecture* must be a first-class citizen in the design process
- Cloud Design Patterns
 - Many are *data-access-oriented*
 - Many depend on some type of *API Gateway* or *Policy Enforcement Point*



Data-Centric Architectures: The NIST Big Data Reference Architecture

- Data does not “live in” any one application
- Data is available to all applications

Figure 2 from *NIST Big Data Interoperability Framework*, NIST SP 1500, Version 2, Volume 6r1 (of nine volumes).
<http://bigdataaws.nist.gov>



A satellite in orbit with solar panels extended, communicating with a large ground station dish antenna on the Earth's surface.

-
- The diagram illustrates the architecture of a Policy Enforcement Point (PEP) within a larger system. It is divided into two main sections: the Control Plane and the Data Plane, separated by a dashed horizontal line.
- Control Plane:**
- On the left, three external inputs are shown: "CDM System", "Industry Compliance", and "Threat Intelligence". Each has a large arrow pointing into the Control Plane.
 - In the center, there is a stack of components: "Policy Engine" at the top, followed by "Policy Administrator".
 - Below the Policy Administrator is the "Policy Enforcement Point" (PEP), which is a large rounded rectangle.
 - On the right, four external outputs are shown: "Data Access Policy", "PKI", "ID Mangement", and "SIEM System". Each has a large arrow pointing away from the Control Plane.
- Data Plane:**
- The "Policy Enforcement Point" (PEP) is also located in the Data Plane, positioned at the intersection of the dashed line.
 - To the left of the PEP is a computer icon representing a client or user.
 - To the right of the PEP is a cylinder icon representing an "Enterprise Resource".
 - An arrow labeled "Untrusted" points from the computer icon to the PEP.
 - An arrow labeled "Trusted" points from the PEP to the Enterprise Resource.

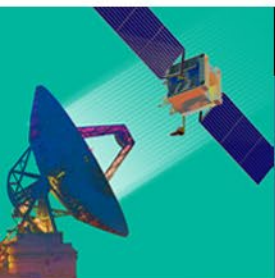
The diagram illustrates the Service Mesh Architecture, divided into two main planes:

- Service Mesh Control Plane (Top):**
 - Admin:** Represented by a blue oval, connected to the Ingress/Egress component.
 - Svc Owner:** Represented by a blue oval, connected to the Ingress/Egress component.
 - User:** Represented by a blue oval, connected to the Ingress/Egress component via a dashed line.
 - Ingress/Egress:** A central component that manages traffic flow.
 - Auditing:** A component for logging and monitoring.
 - Accounting:** A component for resource usage tracking.
 - PAP (Policy Admission and Registration):** A component that interacts with the PDP and Policies.
 - PDP (Policy Decision Point):** A component that interacts with the PAP and Policies.
 - Policies:** A central component that stores and manages policies.
 - Monitoring:** A component for observing system performance.
- Service Mesh Data Plane (Bottom):**
 - μSvc1 (Microservice 1):** A green box containing a **PEP (Policy Enforcement Point) Sidecar**.
 - μSvc2 (Microservice 2):** A green box containing a **PEP (Policy Enforcement Point) Sidecar**.

Interactions:

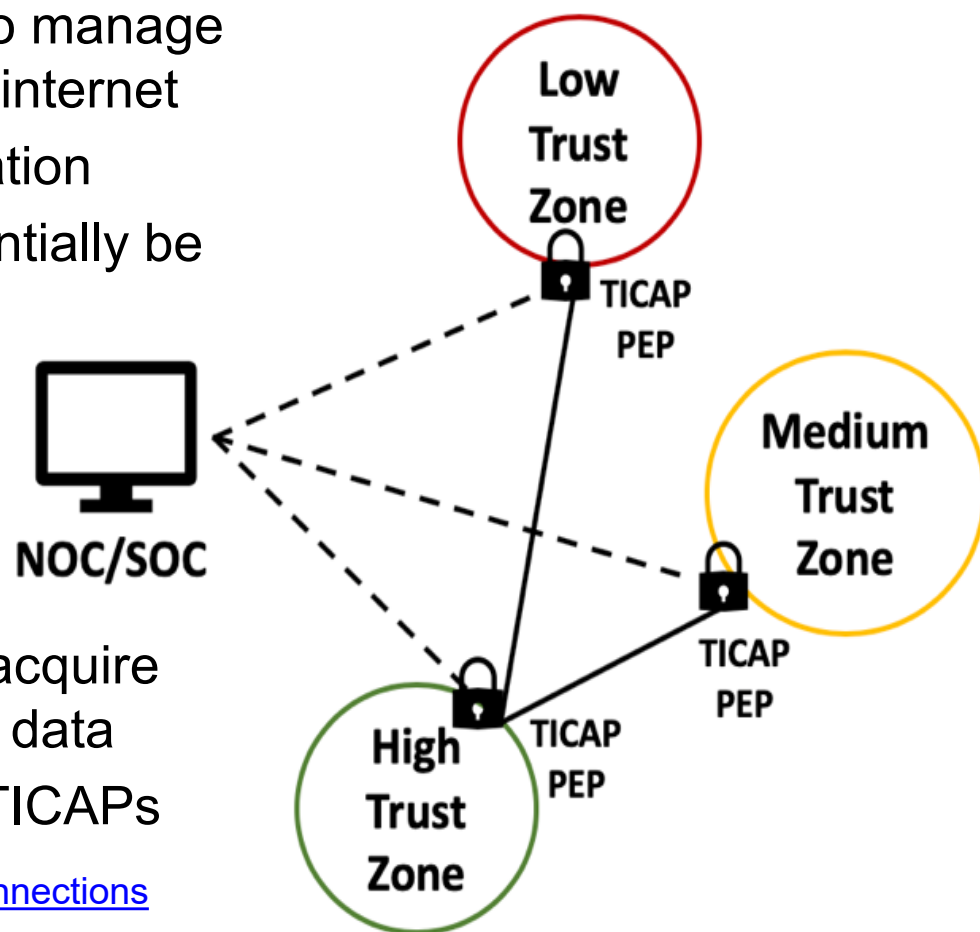
- The **PDP** in the Control Plane sends policy decisions (indicated by a red arrow) to the **PEP Sidecar** in **μSvc1**.
- The **PEP Sidecar** in **μSvc1** sends traffic (indicated by a dashed line) to the **PEP Sidecar** in **μSvc2**.
- The **PEP Sidecar** in **μSvc2** sends traffic (indicated by a red arrow) to the **PEP Sidecar** in **μSvc1**.

Chandramouli and Butcher, *Building Secure Microservice-Based Applications Using Service-Mesh Architecture*, Draft NIST SP 800-204A, January 2020.

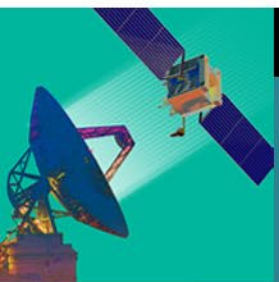


Trusted Internet Connections (TIC) TIC Access Points (TICAPs)

- TIC developed in pre-cloud era to manage how USG system connect to the internet
 - Based on hardware configuration
- TIC 3.0 being developed to essentially be *cloud-native*
 - TICAP *Policy Enforcement Points (PEPs)* will manage distributed *trust zones*
- Example: NOAA N-Wave
 - Global backbone network to acquire massive weather and climate data
 - Enters through five CONUS TICAPs

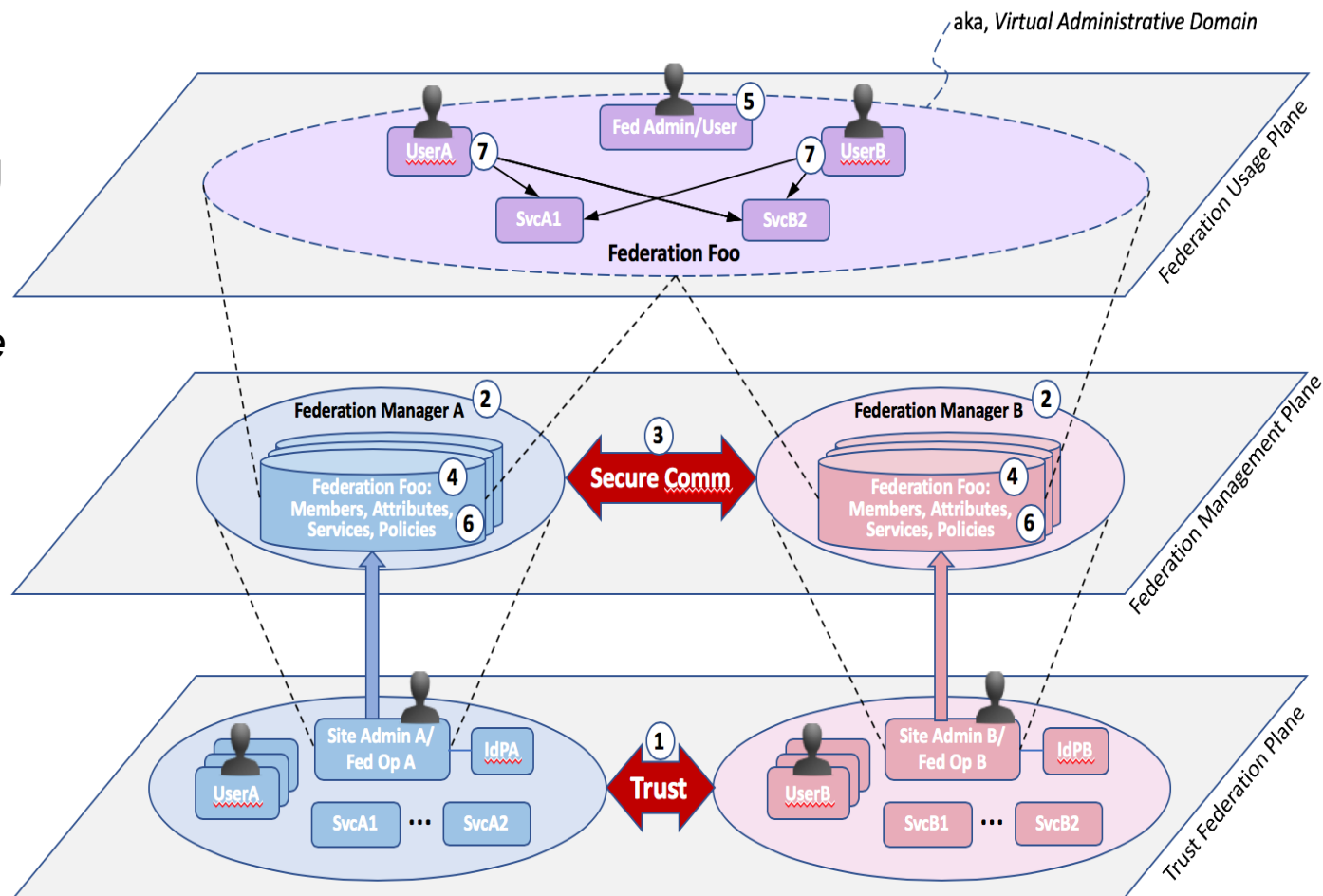


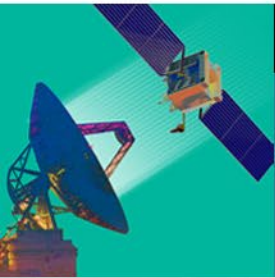
<https://www.cisa.gov/trusted-internet-connections>



The NIST Cloud Federation Reference Architecture

- CFRA explicitly addresses managing *system boundaries*
- Central Concept: *Virtual Administrative Domains*
- Implementations can use *API Gateways*
- CFRA organizes the entire federation design space
- Identifies range of deployment and governance models





Final Observations

As systems move to the cloud, all management and security boundaries will have to be software-defined

These boundaries will all be defined by how identity, credentials, roles, attributes, resource discovery and access policies are managed

These requirements are shared by many system design approaches

The organizational and economic issues will be more difficult than the technical issues

It's not a question of if -- but when and how