Secure Information and Resource Sharing in Cloud Infrastructure as a Service

Cyber Incident Response

Models for Information and Resource Sharing

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UTSA

I·C·S
The Institute for Cyber Security

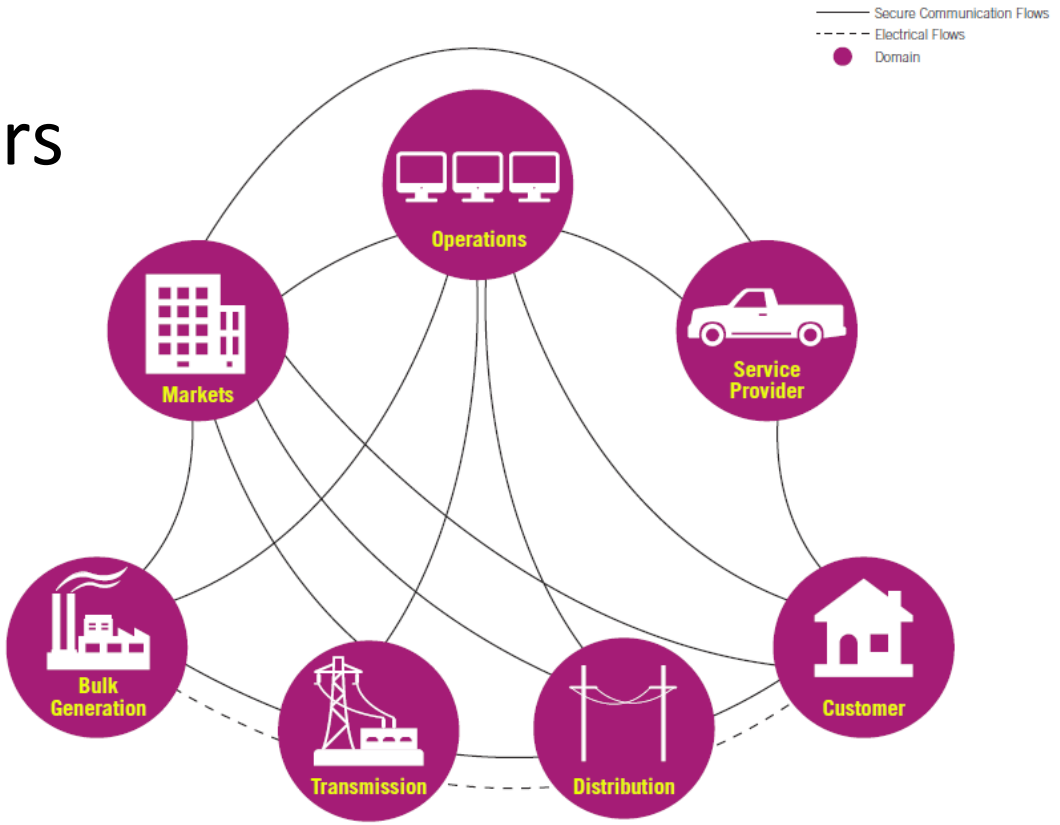
Information Sharing and Coordination Initiatives

- collaboration and coordination to enhance situational awareness
  - Share malicious activities on federal systems
  - Technologies, tools, procedures, analytics

Ref: http://www.whitehouse.gov/issues/foreign-policy/cybersecurity/national-initiative

Electric Grid Scenario

- Cyber incidents in electricity providers
  - Local utilities, regional, state, national operators
- Need a standing platform that facilitates sharing
  - Controlled access



Scope

- Focus on technical challenges
- Sharing amongst a set of organizations
  - Information, infrastructure, tools, analytics, etc.
  - May want to share malicious or infected code/systems (e.g. virus, worms, etc.)
  - Sensitive
  - Often ad hoc
- What are the effective ways to facilitate sharing in such circumstances?
  - Information sharing models
  - Infrastructure, technologies, platforms

Cyber Infrastructure for Sharing

- Traditional platforms
  - Shared storage
    - SharePoint, Dropbox, Google Drive, etc.
  - Shared infrastructure
    - Grid computing
- Modern platform
  - Cloud

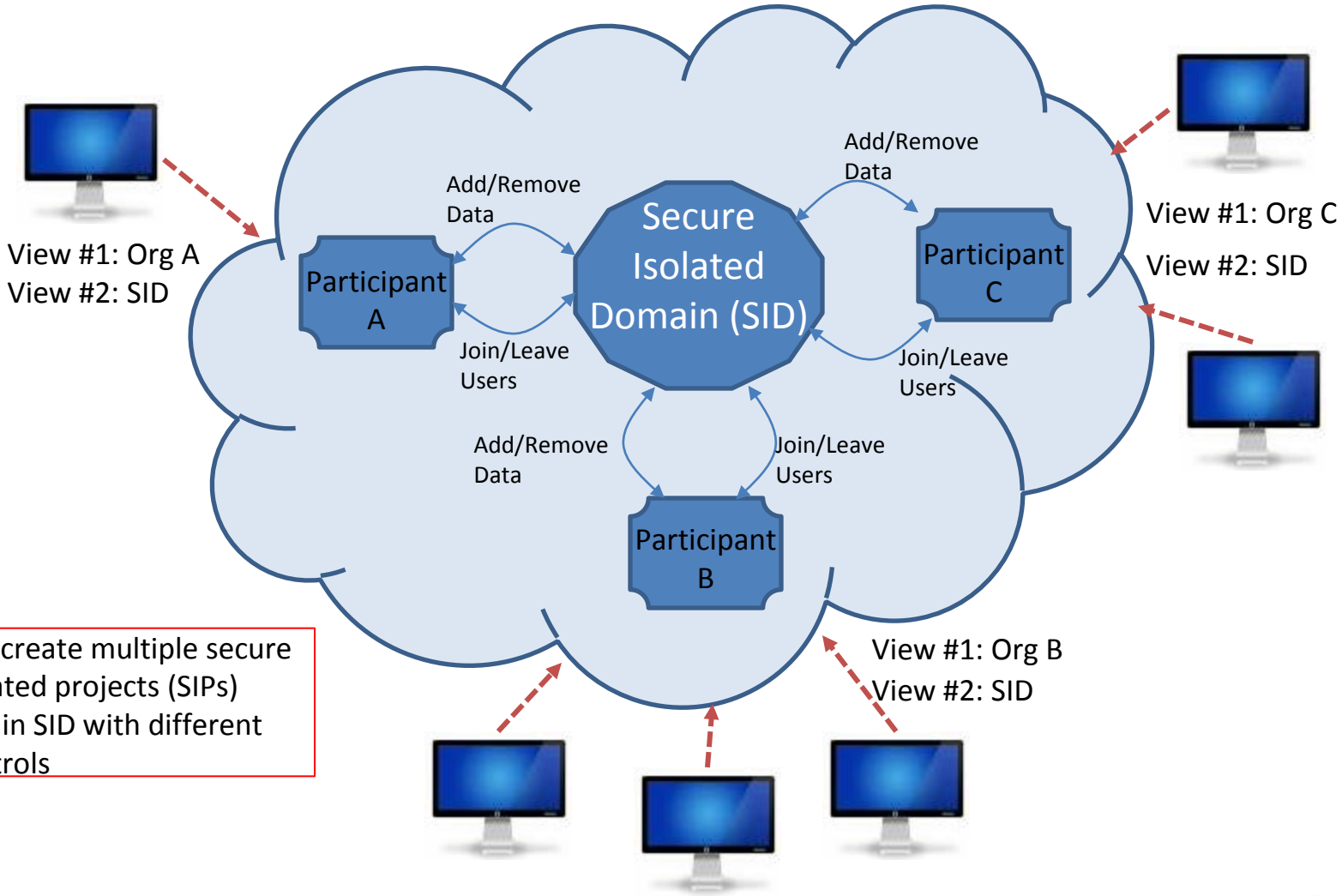
Cloud IaaS Advantages for Cyber Incident Sharing

- Virtualized resources
  - Theoretically, one can take a snapshot and mobilize
- Operational efficiency
  - Light-weight and agile
  - Rapid deployment and configuration
  - Dynamic scaling
  - Self-service

Cloud IaaS Challenges for Cyber Incident Sharing

- IaaS clouds lack secure sharing models
  - Storage
  - Compute
  - Networks
- Need ability to snapshot tenant infrastructure, share, and control who can access
  - Share by copy

Sharing Model in Cloud IaaS

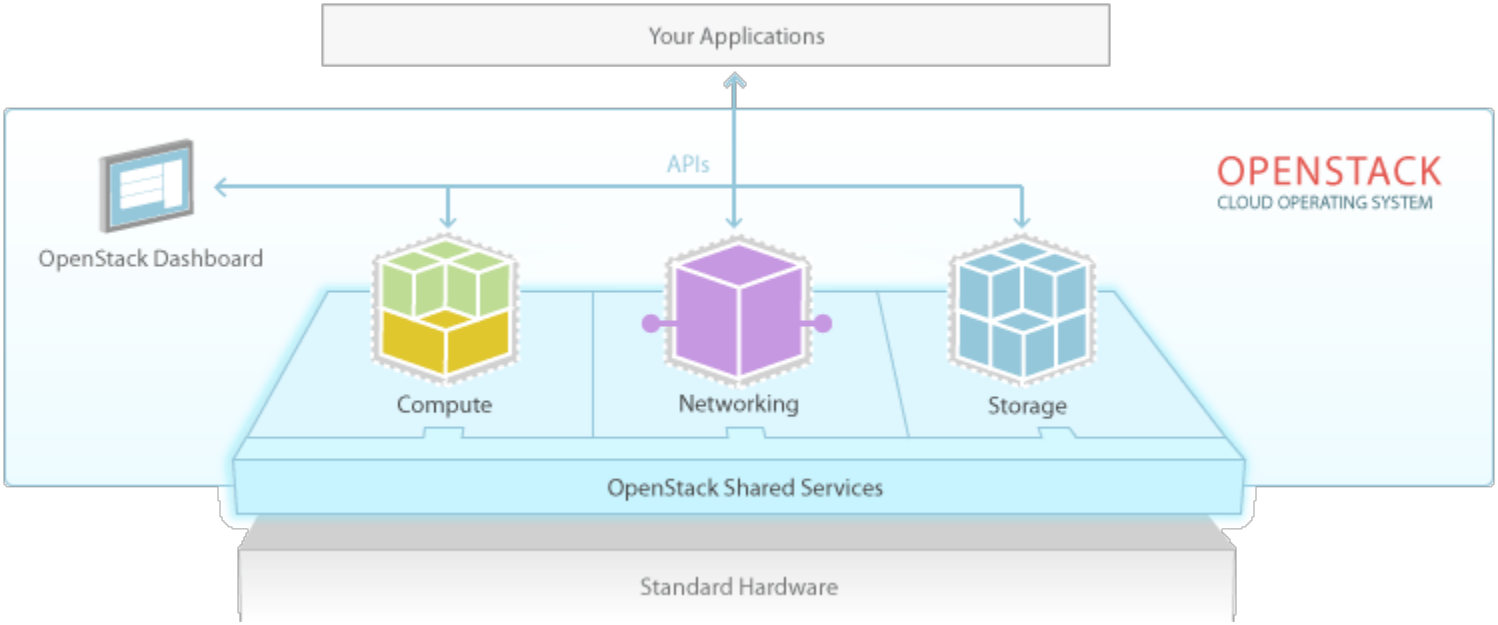


Can create multiple secure isolated projects (SIPs) within SID with different controls

OpenStack

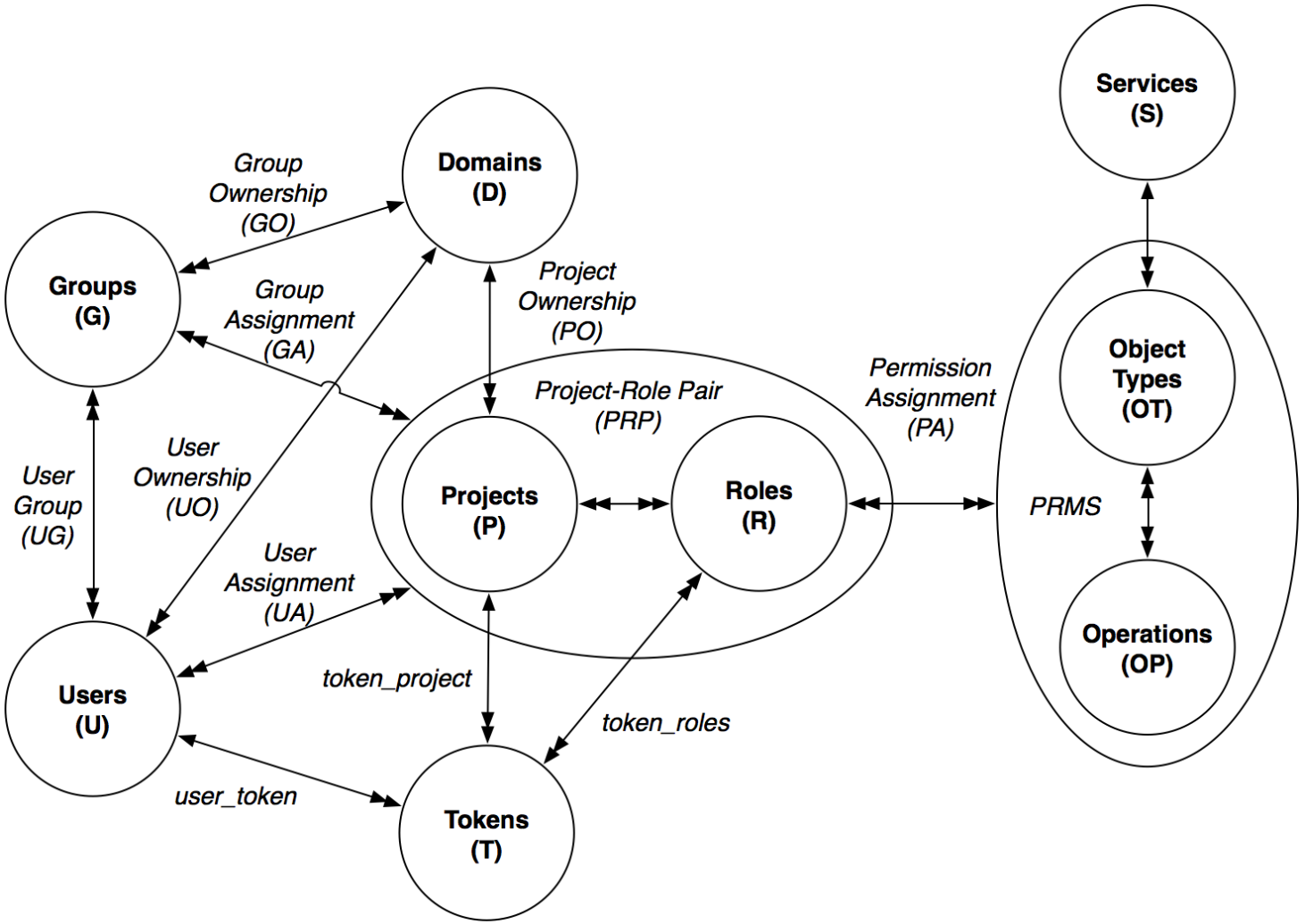
- OpenStack
  - Dominant open-source cloud IaaS software

> 200 companies
~14000 developers
>130 countries

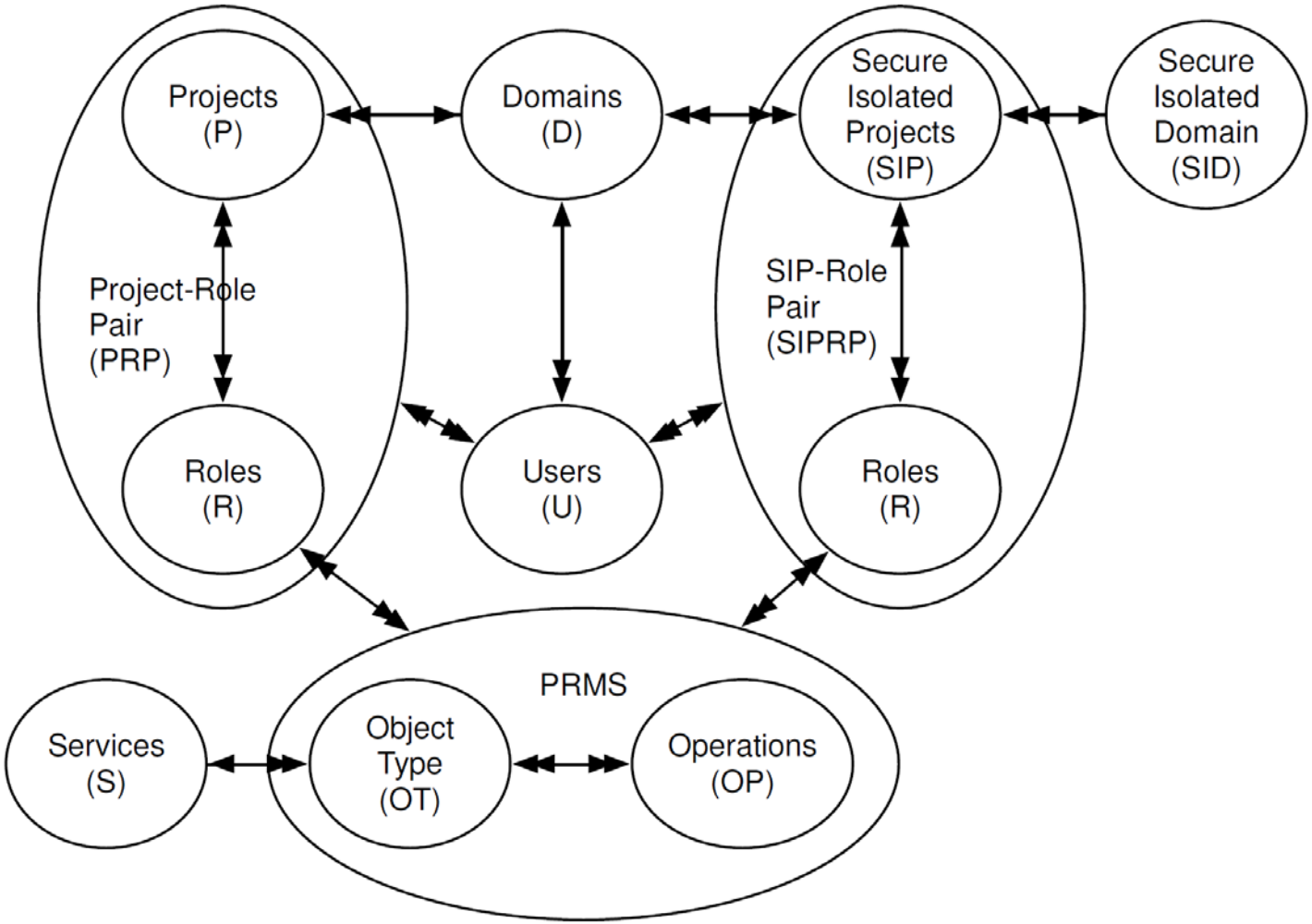


Ref: http://www.openstack.org

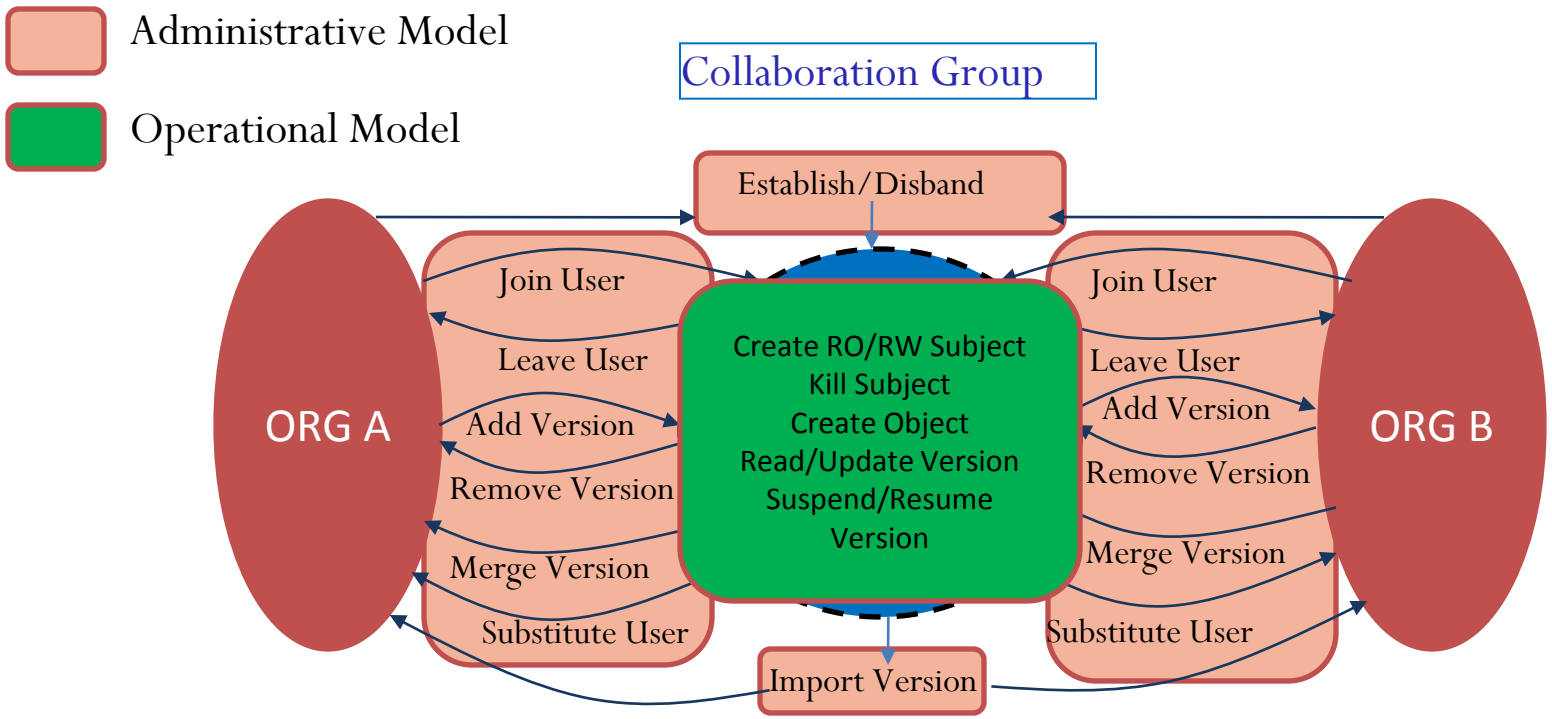
OpenStack Access Control (OSAC)



OSAC-SID


Projects
(P)
Domains
(D)
Secure
Isolated
Projects
(SIP)
Secure
Isolated
Domain
(SID)
Project-Role
Pair
(PRP)
SIP-Role
Pair
(SIPRP)
Roles
(R)
Users
(U)
Roles
(R)
PRMS
Services
(S)
Object
Type
(OT)
Operations
(OP)

Conceptual Model



OSAC-SID Administrative Model

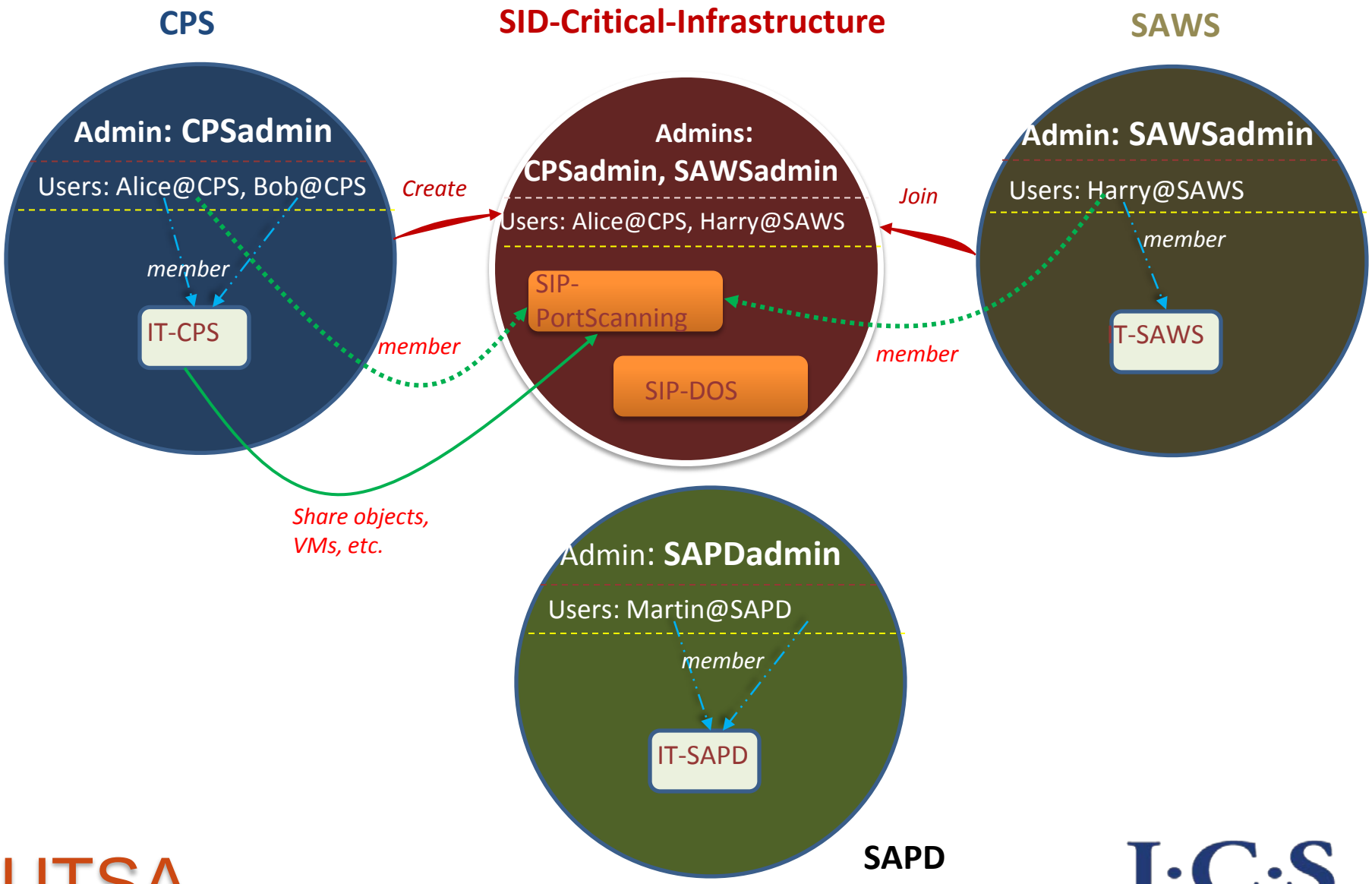
Operation	Authorization Requirement	Update
SipCreate(uSet, sip) */* a set of domain admin users together create a sip */*	$\forall$ u1, u2 $\in$ uSet.((DA(u1)=True $\wedge$ DA(u2)=True $\wedge$ u1 $\neq$ u2 $\wedge$ UO(u1) $\neq$ UO(u2))) sip $\in$ (UNIV_SIP - SIP)	SIPO(sip) = $\bigcup_{\forall u \in uSet}$ UO(u) SIPU(sip) = uSet $\forall$ u $\in$ uSet.SIPA(u) = SIPA(u) $\cup$ {sip} SIP' = SIP $\cup$ {sip}
SipDelete(uSet, sip) */* delete the sip*/*	$\forall$ u $\in$ uSet.((DA(u)=True $\wedge$ sip $\in$ SIPA(u))) $\wedge$ SIPO(sip) = $\bigcup_{\forall u \in uSet}$ UO(u) sip $\in$ SIP	SIPO(sip) = NULL SIPU(sip) = NULL $\forall$ u $\in$ uSet.SIPA(u) = SIPA(u) - {sip} SIP' = SIP - {sip}
SidCreate(uSet, sid) */* a set of domain admin users together create a sid */*	$\forall$ u1, u2 $\in$ uSet.((DA(u1)=True $\wedge$ DA(u2)=True $\wedge$ u1 $\neq$ u2 $\wedge$ UO(u1) $\neq$ UO(u2))) sid $\in$ (UNIV_SID - SID)	SIDO(sid) = $\bigcup_{\forall u \in uSet}$ UO(u) SID' = SID $\cup$ {sid}
SidDelete(uSet, sid) */* delete the sid*/*	$\forall$ u $\in$ uSet.((DA(u)=True $\wedge$ sid $\in$ SIDA(u))) $\wedge$ SIDO(sid) = $\bigcup_{\forall u \in uSet}$ UO(u) sid $\in$ SID	SIDO(sid) = NULL SID' = SID - {sid}
UserAdd(admin, r, u, sip) */* sip admin add a normal user to a sip*/*	sip $\in$ SIPA(admin) $\wedge$ DA(admin)=True $\wedge$ UO(admin) $\in$ SIDO(sid) $\wedge$ sip $\in$ sid $\wedge$ UO(u) = UO(admin) $\wedge$ r $\in$ R $\wedge$ sip $\in$ SIP $\wedge$ u $\in$ U	(u, (sip, r)) $\in$ SIPUA $\wedge$ SIPU'(sip) = SIPU(u) $\cup$ {u}
UserRemove(admin, r, u, sip) */* sip admin remove a normal user from a sip*/*	sip $\in$ SIPA(admin) $\wedge$ DA(admin)=True $\wedge$ UO(admin) $\in$ SIDO(sid) $\wedge$ sip $\in$ sid $\wedge$ UO(u) = UO(admin) $\wedge$ r $\in$ R $\wedge$ sip $\in$ SIP $\wedge$ u $\in$ U $\wedge$ (u, (sip, r)) $\in$ SIPUA	(u, (sip, r)) = NULL $\wedge$ SIPU'(sip) = SIPU(u) - {u}
CopyObject(u, so1, c1, p, d, so2, c2, sip, sid)	so1 $\in$ SO $\wedge$ c1 $\in$ C $\wedge$ p $\in$ P $\cup$ SIP $\wedge$ d $\in$ D $\cup$ SID $\wedge$ so2 $\in$ (UNIV_SO - SO) $\wedge$ c2 $\in$ C $\wedge$ sip $\in$ P $\cup$ SIP $\wedge$ sid $\in$ D $\cup$ SID $\wedge$ (so1, c1) $\in$ SOO $\wedge$ (c1, p) $\in$ CO $\wedge$ (p, d) $\in$ PO $\cup$ SIPO $\wedge$ (c2, sip) $\in$ CO $\wedge$ (sip, sid) $\in$ PO $\cup$ SIPO $\wedge$ u $\in$ U $\wedge$ (u, (p, r)) $\in$ UA $\wedge$ (u, (sip, r)) $\in$ SIPUA)	SO' = SO $\cup$ {so2} SOO' = SOO $\cup$ {(so2, c2)}

† uSet: a set of domain admin users.

OSAC-SID Operational Model

Operation	Authorization Requirement	Update
Nova:		
CreateVM(vm, sip, u)	vm ∈ (UNIV_VM - VM) ∧ sip ∈ SIP ∧ u ∈ U ∧ ∃ (perms, r) ∈ PA.(perms = (vm, create) ∧ (u, (sip, r)) ∈ SIPUA)	VM' = VM ∪ {vm} VMO' = VMO ∪ {(vm, p)}
DeleteVM(vm, sip, u)	vm ∈ VM ∧ sip ∈ SIP ∧ u ∈ U ∧ ∃ (perms, r) ∈ PA.(perms = (vm, delete) ∧ (u, (sip, r)) ∈ SIPUA)	VM' = VM - {vm} VMO' = VMO - {(vm, p)} vm = NULL
Swift:		
CreateContainer(c, sip, u)	c ∈ (UNIV_C - C) ∧ sip ∈ SIP ∧ u ∈ U ∧ (u, (sip, r)) ∈ SIPUA)	C' = C ∪ {c} CO' = CO ∪ {(c, p)}
DeleteContainer(c, sip, u)	c ∈ C ∧ sip ∈ SIP ∧ u ∈ U ∧ (u, (sip, r)) ∈ SIPUA)	C' = C - {c} CO' = CO - {(c, p)} c = NULL
UploadObject(so, c, sip, u)	so ∈ UNIV_SO ∧ c ∈ C ∧ sip ∈ SIP ∧ u ∈ U ∧ (u, (sip, r)) ∈ SIPUA) if ∃ so' ∈ SO. (so = so'), then so' = so	SO' = SO ∪ {so} SOO' = SOO ∪ {(so, c)}
DownloadObject(so, c, u, p)	so ∈ SO ∧ c ∈ C ∧ sip ∈ SIP ∧ u ∈ U ∧ (u, (sip, r)) ∈ SIPUA)	
DeleteObject(so, c, sip, u)	so ∈ SO ∧ c ∈ C ∧ sip ∈ SIP ∧ u ∈ U ∧ (u, (sip, r)) ∈ SIPUA)	SO' = SO - {so} SOO' = SOO - {(so, c)} so = NULL

SID and SIP in OpenStack



Conclusion and future work

- Developed sharing models
  - Formal specification
- Enhanced OpenStack with SID/SIP capabilities
  - Cyber incident response capabilities
    - Self-service
    - SID/SIP specific security
    - Share data, tools, etc. in an isolated environment
    - Ability to execute and analyze malicious code in an isolated environment
  - Practitioners can deploy a “cyber incident response” cloud
  - Potential blueprint for official OpenStack adoption
- Future work
  - more fine grained access control within a SIP
  - harden the implementation to prevent overt information flow

Thanks

- Q&A