User-centered Security Management of API-based Data Integration Workflows

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Overview

- Cloud Integration – Introduction and Approaches
- API-based Integration: Use Case, Protocols, Practice
- Proposed Approach
- Integration in the Workflow
- Discussion
- Summary and Further Work

Cloud Integration – Introduction

- Broad adoption of cloud paradigm ⇒ organizational data assets are increasingly getting transferred to and consumed from the cloud
- Traditionally, integration assumes point-to-point or point-to-multipoint connections originating from organizational premises
- What happens when this process starts from the cloud?

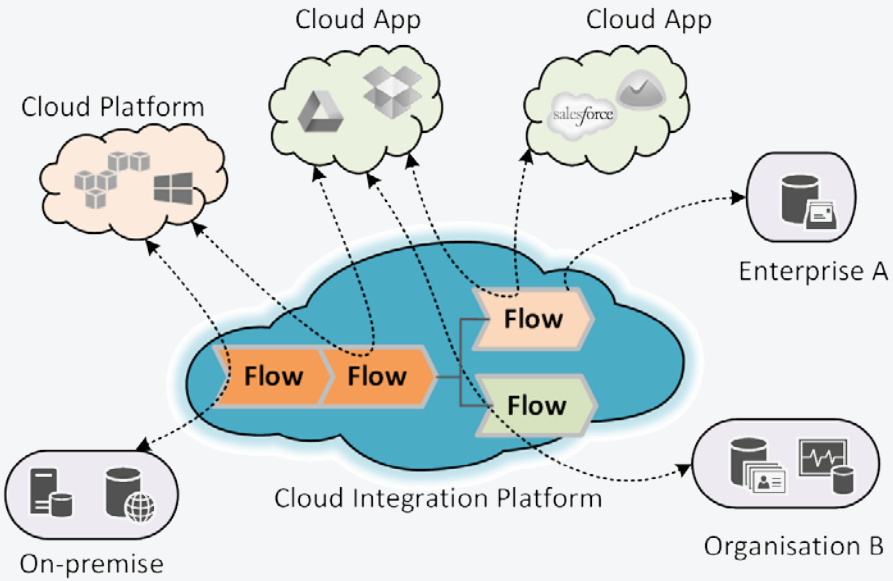
- Integration Platform as a Service *(IPaaS)* - a new approach that transfers the complete business process execution to the cloud
- IPaaS defined by Gartner as:

> *… a suite of cloud services enabling development, execution and governance of integration flows connecting any combination of on-premises and cloud-based processes, services, applications and data within individual, or across multiple organizations* [1)]

[1)] M. Pezzini and B. Lheureux. *Integration platform as a service: moving integration to the cloud*. Gartner, 2011.

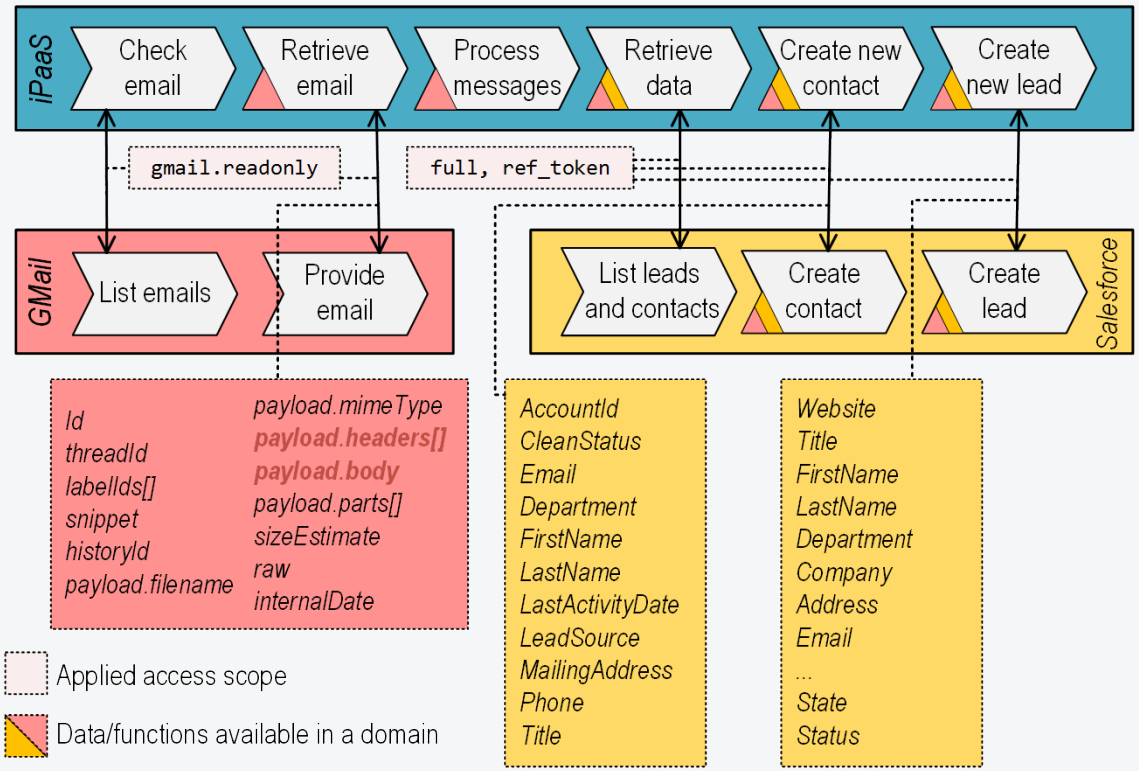
Cloud Integration – Approaches

- Typical integration scenarios:
  - Cloud to on-premises
  - Cloud to cloud
  - On-premises to on-premises
- Resources are stored, transferred and processed entirely in the cloud, which becomes the central point of integration
- Like standard data sharing, but: increased complexity, many actors



API-based Integration – Use Case

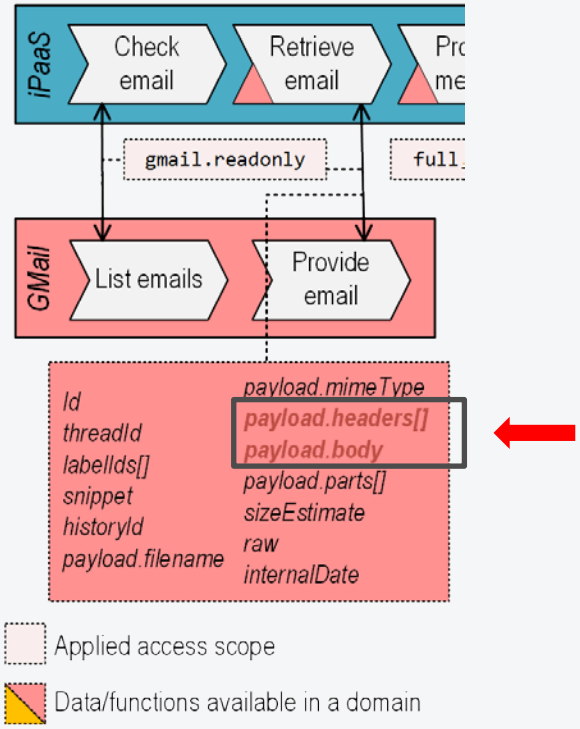
- Organization owns the accounts at three clouds: iPaaS, Gmail, SalesForce
  - iPaaS (platform): periodically checks, retrieves and processes email, creating the leads and contacts at Salesforce
  - Based on REST-API interactions, secured using OAuth 2.0 and *access scopes*



API-based Integration – Use Case

- *Authorization scope* : abstract term, non-structured, out-of-the-band, opaque
- Gmail: supports a limited set of static scopes
- Able to read all emails and metadata in an account
- There is no specialized view, data filtering, limitation on fields…

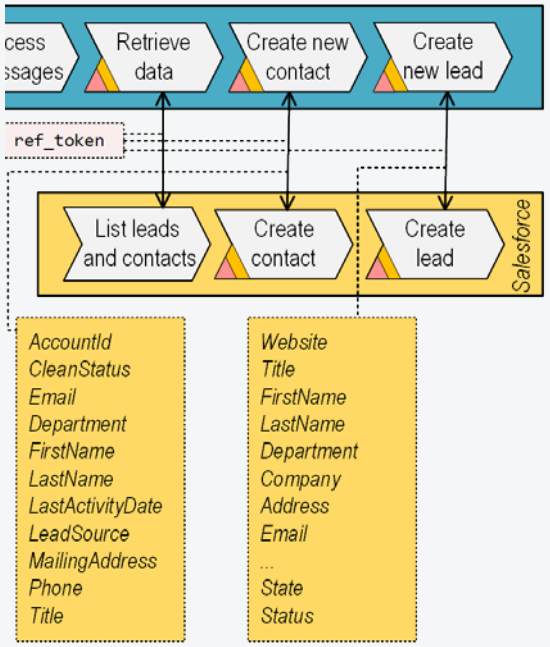
Scope	Meaning
gmail.readonly	*Read all resources and their meta-data*
gmail.compose	*Create, read, update and delete drafts, including sending of messages and drafts*
gmail.send	*Sending of messages, without read or update privileges*
gmail.insert	*Inserting and importing messages*
gmail.labels	*CRUD of labels*
gmail.modify	*All R/W operations except perm. deletion of threads and messages*
https://mail.google.com/	*Full access to the account*



API-based Integration – Use Case

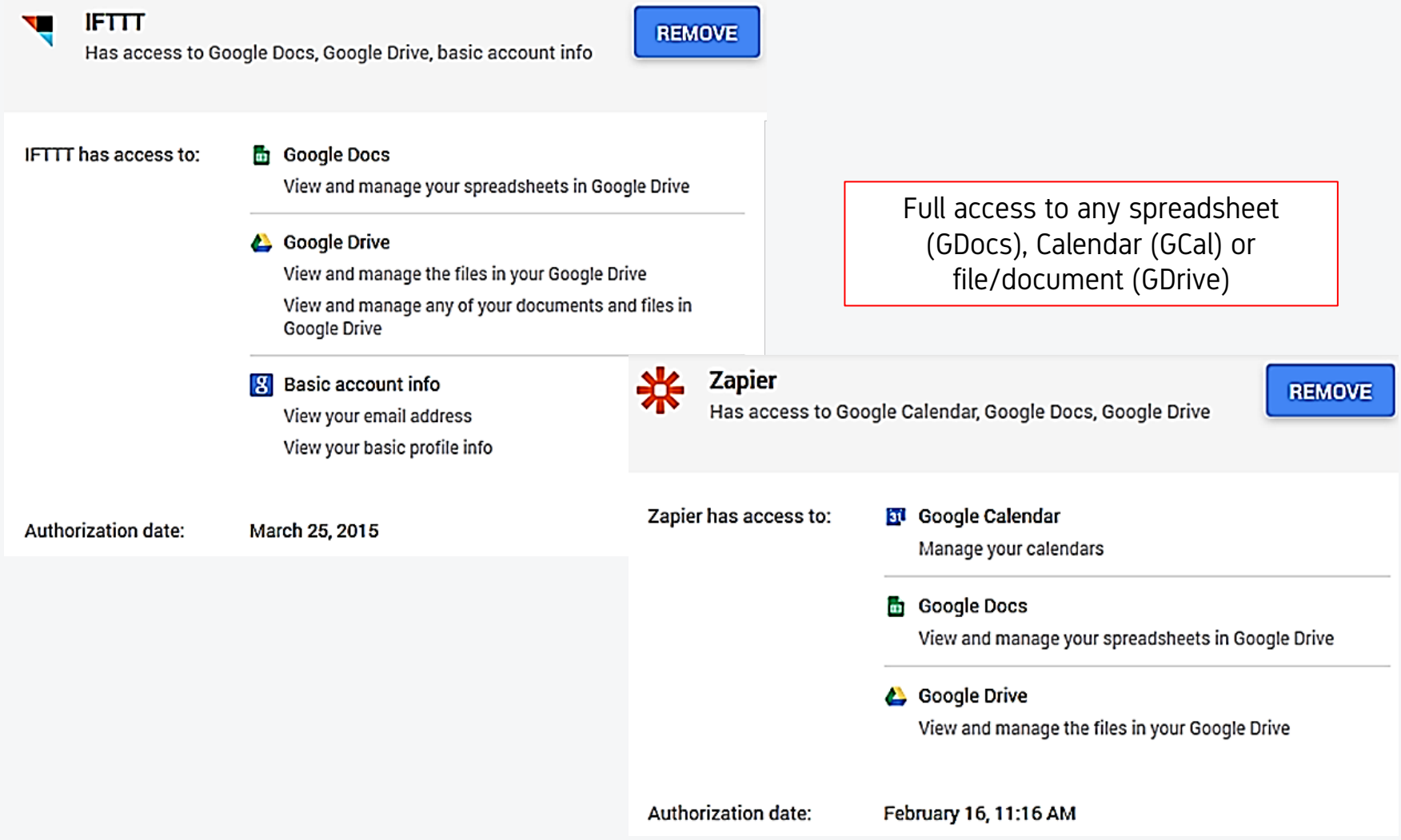
- *Authorization scope* : abstract term, non-structured, out-of-the-band, opaque
- Salesforce: in many cases full scope required
- Able to perform a broad set of operations well beyond the required use case
- Coarse-grained scopes - *Least privilege principle?*

Scope	Meaning
api	*Access to user's account using API. Encompasses chatter_api scope*
chatter_api	*Access to Chatter API resources*
custom_permissions	*Access to the custom permissions in a client-associated organization*
full ⬅	*Full data available to the user. Encompasses all other scopes*
id	*Access to the identity URL service*
openid	*Unique identifier of user in OpenID Connected applications. Can be used to retrieve token conforming to OIDC specifications*
refresh_token	*Allows provision of refresh tokens to eligible users, enabling the client to interact with the resource in offline mode.*
visualforce	*Provides access to Visualforce*
web	*Allows to use the token on the web, incl. access to Visualforce pages*



API-based Integration in Practice

Coarse-grained OAuth 2.0 access scopes in practice (managing authorizations):



Issues and Challenges

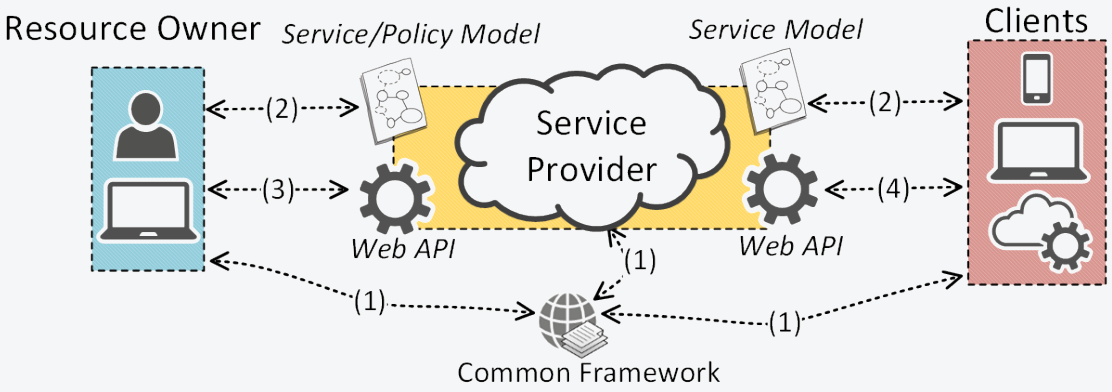
- Issues
  - Unilateral definition of security concepts, APIs, management interfaces
  - Manual and proprietary management of security functions
  - Tools or approaches cannot be reused (many-to-many)

- Management of security requirements from the perspective of resource owner?
  - *Interoperable:* apply the same approach among different providers/platforms
  - *Automated:* support autonomous agents
  - *Dynamic:* allow dynamic definition of owners' policies and clients' requests
  - *Granular constraints:* restrict access to resources or their parts relevant for an activity – principle of least privilege
  - *Contextual views:* enforcement and resource transformations based on a context

- Goals
  - Enabling cooperative, dynamic and granular access management
  - Considering complex API-based interactions in cross-domain environments

Proposed Approach

- Actors:
  - Service provider (SP): exposes the service, such as XaaS
  - Resource owner (RO): consumes services, outsources data and processing
  - Clients (C): consume the resources provided by SP and owned by RO
- Steps:
  - Establish relationship with the common framework {SP, RO, C} [1]
  - Expose and consume model of services – resources and capabilities {SP, RO, C} [2]
  - Expose model of security policies {SP, C} [2]
  - Update and manage security policies {RO, SP} [3]
  - Request resources {C, SP} [4]



Exposing Services and Capabilities

- Characterizing APIs exposed by service provider
  - Web-APIs – there is a broad range of RESTful approaches and models
  - Exposed APIs specific to provider's use-cases, environment, data models, processes, with different maturity levels
  - Development and maintenance overhead: clients need to be developed and maintained separately for each service provider through the whole lifecycle
  - Hard-wiring: out-of-the band contracts, underlying semantic unknown
- Service description
  - Lightweight model based on *semantic interoperability layer*
  - Modeling the resources and operations *from security perspective*
  - Relies on an external or common model to represent the exposed services, resources and operations that can be managed
  - Reusing existing blocks

Exposing Services and Capabilities

- Core and domain-specific vocabularies
  - *Core vocabulary* provides the general concepts
  - Can be reused to expose general concepts
  - *Domain-specific* vocabularies extend the core, optional
  - Refine domain-related concepts
- Categories and application of concepts:
  - Entity classes - represented in object hierarchies
  - Object properties - establishing relations between the entities
- Next: excerpts of classes and properties

Entity Classes (Excerpt)

- Service:
  - The primary point in service provider's offer to clients
  - Class members denote different types of services that correspond to a particular use case
  - Examples: *CloudService, EmailService, StorageService*
- Resource:
  - Class of entities exposed by a service, manageable and consumable
  - Represents entities at different levels of abstractions, allowing specification of the granularity of resource sharing and application of (pre)processing operations.
  - Examples: *Object, Drive, Directory, File, Document, Media, Email, MsgBody, MsgHeader*
- Operation:
  - Operations are actions that can be executed on resources prior to their sharing
  - Effectively provide a resource view adjusted to a particular context
  - Examples: *RemovePII, MaskPII, Encrypt, Mask*

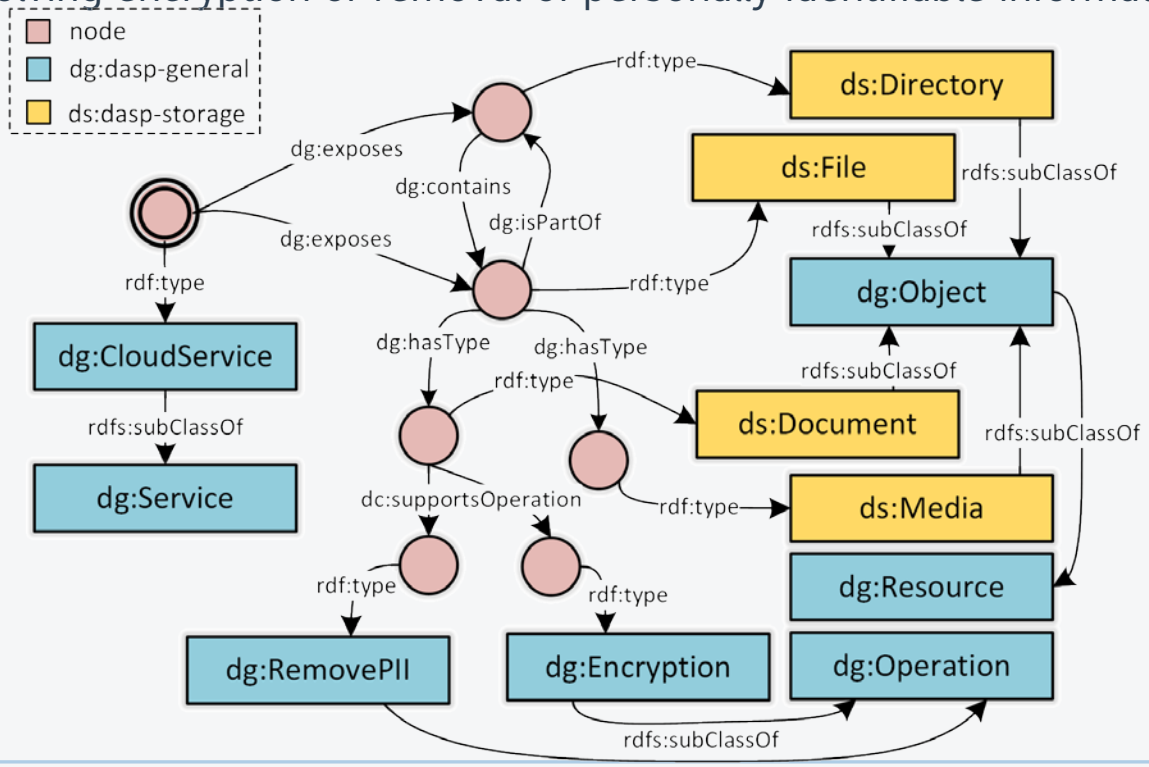
Object Properties (Excerpt)

- Connect entity instances of different concepts, establishing relations
- Behavioral and constitutional
- Examples:

exposes	Entity that service exposes to clients using web API
contains, isPartOf	Relationships between entities stating constitutive (hierarchical) relationship between instances
subClassOf	An abstract description of possible inter-class relations
type	Class type of particular entity instance
hasType	Supported class specialization for exposed resources
requestsAccess	Used to relate an access requests with a service
supportsOperation	Denotes operations that can be executed on entity
acceptsOperation	Denotes operations that are accepted by the client
acceptsSubtype	Subtype of resources satisfying a client request

Exposing Services and Capabilities

- Example model using *core* and *storage* vocabularies
  - *Nodes* are instances of concepts; labeling does not affect the workflow
  - Starts with *CloudService*, which exposes *File* and *Directory*
  - *File* may be further specialized (property) as a *Document* or *Media*
  - Prior to the delivery to the client, a *Document* can be subjected to operations involving encryption or removal of personally identifiable information



Security Policies Classes (Excerpt)

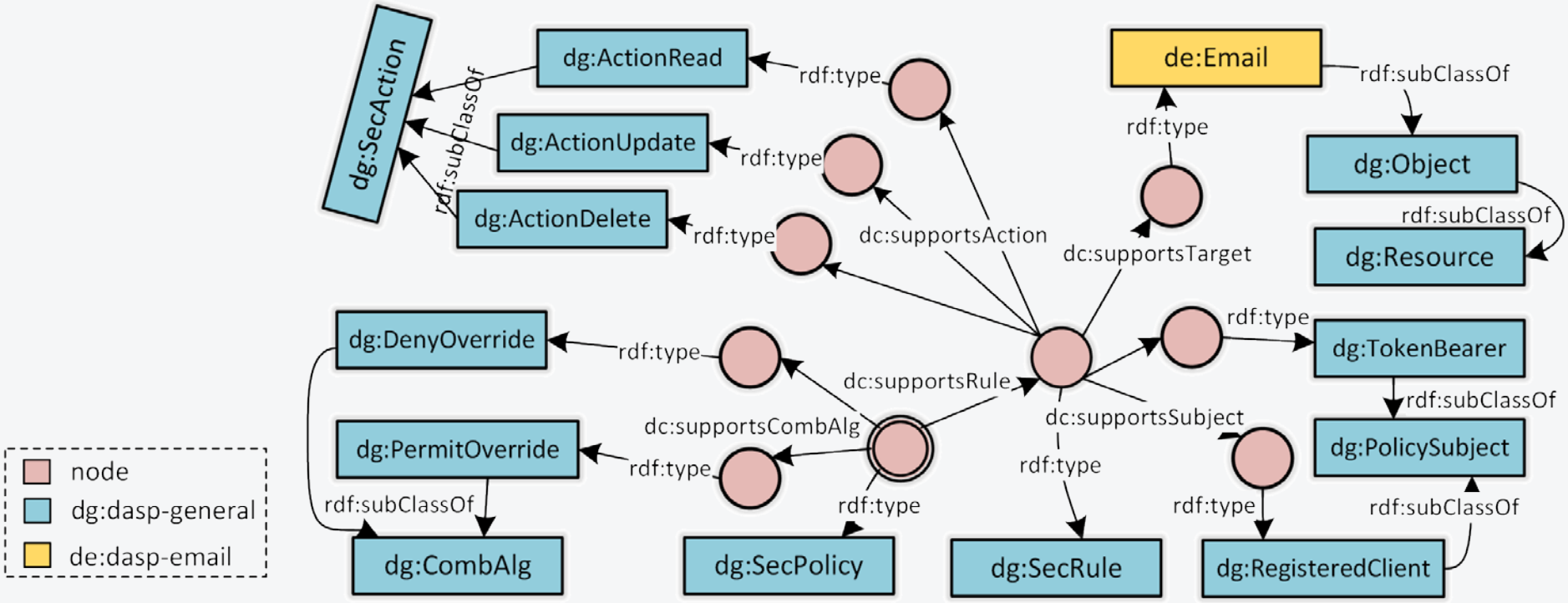
- SecPolicy:
  - The primary point in the definition of security policies.
  - One policy contains one or more rules with associated combination algorithm
  - Similar to the concept of XACML
- SecRule:
  - Defines a node used to connect policy subject, target, action, condition and obligation
- PolicySubject:
  - States a range of subjects or their attributes
  - Integration of different access control models and mechanisms such as OAuth 2.0
  - Examples: *RegisteredClient, TokenBearer*
- SecAction:
  - This class includes different actions that may be defined on a resource
  - Examples: *ActionDelete, ActionRead, ActionUpdate, ActionCreate, ActionPatch*

Security Policies Classes (Excerpt)

- CombAlg:
  - Policy contains one or more rules with associated combination algorithm
  - Defines a range of algorithms applied in the process of making a policy decision
  - Examples: *PermitOverride, DenyOverride*
- Context:
  - Establishes a range of conditions as multi-level classes whose instances may be evaluated in the process of making a policy decision
  - Examples*: TimeContext, SystemContext, RiskContext*
- Obligation:
  - Defines a range of actions that may be applied in the process of policy enforcement, both in pre and post resource delivery stages.
  - May include resource transformation using operations provided in the scope of resource sharing model
  - Examples: *LogPre, LogPost, CustomView, RemovePII*

Exposing Security Capabilities

- Example model using *core* and *email* vocabularies
  - *Nodes* are instances of concepts; labeling does not affect the workflow
  - Starts with *SecPolicy*, which refers to security rules and supported capabilities
  - The model is exposed for each endpoint or resource type separately, describing its specific capabilities

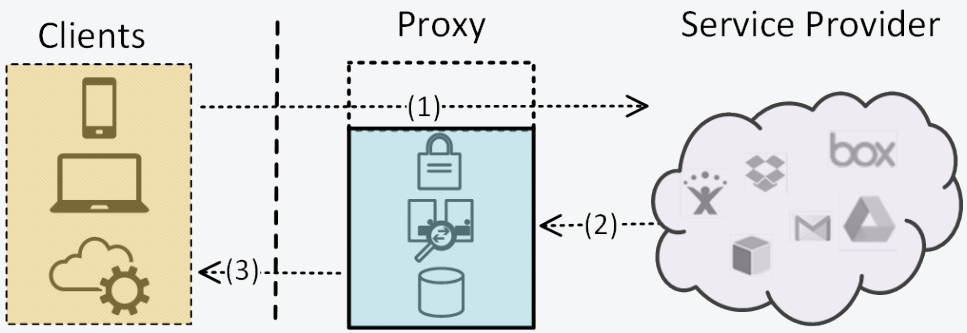


Defining Security Policies

- Discovering policy model
  - Client (resource owner's agent) fetches the model of policies applicable to particular resources or endpoints
  - The model represents a range of supported concepts (actions, subjects …)
  - These concepts may be reused to define security policy
- Delivering the model
  - *Embedding models with resources:* retrieved together with resources by using web API endpoints and providing the models as separate descriptions
  - *Separate policy endpoints:* policy management is done using dedicated API endpoint
- Managing the policy
  - Based on retrieved model, the client instantiates the policy by applying provided concepts and relationships
  - These policies are retrieved or applied separately for each resource or endpoint

Integrating in the Workflow

- Limited proof-of-concept
  - Introduces additional management layer in existing OAuth 2.0 workflows
  - Transparent proxy between the service provider and the client
  - Complements OAuth 2.0 coarse-grained scopes by reducing the provided resource sets and enforcing client-specific resource view (resource transformation)
- Workflow steps
  - Client requests the resource using existing token [1]
  - Main application provides resource by relying on a token scope [2]
  - Based on a registered resource set and annotation returned by service provider, proxy performs second layer of security enforcement and delivers the resource [3]



Discussion

- Cross-entity messaging
  - Management of policies (RO), requesting resources (C), exposing models (SP)
  - Different possibilities: RDF or JSON-LD
  - JSON-LD - lightweight format, readable by humans (illustration at the bottom)
- Integrating in existing environments
  - Using additional HTTP headers for models and descriptions
  - Using HTTP methods (e.g. OPTIONS) to retrieve the models

```
{ "@context": {
  "dasp-email": "http://www.daspsec.org/on/dasp-email#",
  "owl": "http://www.w3.org/2002/07/owl#",
  "rdf": "http://www.w3.org/1999/02/22-rdf-syntax-ns#",
  "xsd": "http://www.w3.org/2001/XMLSchema#",
  "rdfs": "http://www.w3.org/2000/01/rdf-schema#",
  "dasp-general": "http://www.daspsec.org/on/dasp-general#"
}, "@graph": [
  { "@id": "http://www.daspsec.org/on/dasp-general",
    "@type": "owl:Ontology", "owl:imports": [
      { "@id": "http://www.daspsec.org/on/dasp-general" },
      { "@id": "http://www.daspsec.org/on/dasp-email" } ] },
  { "@id": "dasp-general:AccessRequest",
    "@type": [ "dasp-general:Request", "owl:NamedIndividual" ],
    "dasp-general:acceptsOperation": { "@id": "dasp-general:RemovePII" },
    "dasp-general:acceptsSubtype": { "@id": "dasp-email:MsgHeader" },
    "dasp-general:requestsAccess": { "@id": "dasp-email:Email" } } ] }
```

Discussion

- Scalability and overhead
  - Per-resource or endpoint models and policies – scalable management
  - Low overhead for smaller models (transport or policy execution)
  - Separated vocabularies allow supporting different domains iteratively
- Interoperability challenges
  - Not everything can be covered by a model
  - It is hard to provide a model for complex concepts or environments
  - Integrating it in practical scenarios – even harder
  - However: conceptualized as a bottom-up approach
  - Providers may extend existing or define own models
  - Reducing many-to-many to (partial) many-to-one mappings

Summary

Questions and challenges

- Cloud-based integration adds complexity by executing processes and connecting resources hosted at various organizations
- Challenging management of security and privacy
  - Which resources and services are consumed by an organization
  - How to control resources and policies at different, distributed systems?
  - Automated management of security?
- Centralized systems such as iPaaS are gaining significant power:
  - Can access client's resources on many providers using broad access scopes
  - Multi-tenant environment: extrapolating that to all customers using iPaaS's services

Summary and Future Work

Summary

- Our proposal aimed to advance interoperability of security management
- Abstracting and modeling services, resources and policies
- Following lightweight, bottom-up approach
- Initial prototype was applied to extend management of existing OAuth 2 flows

Further work

- Extend vocabularies with additional domains, refine and improve existing
- Investigate integration with other protocols (UMA, XACML)
- Separate approach?
- Mapping of concepts and policies (automated alignment)

Any questions?

Thanks for your attention!