Relationships in a “Cloudy” Environment – There is Life Beyond Your Current Cloud

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Outline

• Challenges
• Inter-domain Relationships
• Billing System Use Case
• Conclusions
What do we really want from Cloud Computing?

Another “Distributed RPC/Object” paradigm that provides “binding flexibility” over a static set of services.

- or -

A highly dynamic environment that responds to changes in environment, context, consumer needs and provider capabilities to build adaptive services.
Traditional Inter-Domain Relationships

• Static,
• Specialized code involving “one-of” (usually hand-crafted) sets of interfaces (APIs),
• Require large amounts of resources to develop and test (1 to 2 years not unusual),
• Frequently poorly documented,
• Because of the “one-of” nature, dramatically increase management effort,
• Generally exist until failure (and many times beyond)!
Inter-Domain Relationships in a Dynamic Environment

• Declarative (Goal-based) rather than procedural (Process-based),
• Domains defined by scope-of-authority of Role rather than arbitrary or “ad-hoc” domains,
• Adaptability on both peer-to-peer (horizontal) and vertical (top-down and bottom-up),
• Requires better modeling of environment “between the domains”,
• Requires an ontological understanding of relationships between domains,
• Requires dynamic ability to create/modify/delete relationships between domains.
Domain Relationships Challenges

• Dynamic and adaptable method for construction and maintenance of Inter-Domain Relationship Maps that document Semantics (meaning), Capabilities (form) and Policies (use).
• Method for assuring that External Goals, Policies, Semantics and Capabilities are consistent with Internal Ones,
• Method for assuring that potential or currently Inter-Operating Domains have compatible Semantics, Capabilities and Policies.

**NEED:**

*Inter-Domain Relationships defined using a model-driven approach supporting dynamic re-definitions, re-configuration, transformation to multiple models and facilitating analysis, verification and testing.*
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• Challenges
• **Inter-domain Relationships**
• Billing System Use Case
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Traditional Model of Domain Offering External Interfaces
Traditional Inter-Domain Relationship (API Based)
Domain Characteristics – A New View

• Boundaries dictated by the scope of authority of the role of the Domain; i.e., any policy governing a resource or artifact that is outside the scope of authority of the role of the Domain is external to the Domain (i.e., it’s in another Domain or is governing a relationship between Domains),
• Contains a set of Internal Goals,
• Contains a set of Internal Policies,
• May have sets of External Goals and Policies (which govern relationships with other Domains),
• May expose capabilities (Contracts) and data (via Contracts),
• Exposed capabilities (and data) are governed by External Goals and Policies contained in Inter-Domain Relationship Map(s),
• External Goals and Policies must be consistent with Internal Goals and Policies,
• Processes must be contained within Domain (cannot span two or more scope of authorities).
Model of Domain Supporting Dynamic Relationships

Domain
(Scope of Authority of Role)

Domain Knowledge Base
(Policies, Rules, Vocabulary, Goals, Processes, …)

Inter-Domain Relationship Map(s)
Inter-domain Relationship Map

Domain Knowledge Base

Constrain

Consistent with

Inter-domain Relationship Map

Relationship Vocabulary (Semantics)

Relationship Business Goals

Relationship Governance Rules

Relationship Operations

Goals
Strategy
Vocabulary
Ontology
Rules
Policies
Models
- Resource
- Information
Inter-Domain Relationship Map

- **Specification** (Business Vocabulary and Rules)
- **Data** (from Business Vocabulary)
  - **Ontology** (OWL or RDF)
  - **Policies**
    - Technology Neutral (N3 from Business Rules)
  - **Software Contracts** (Assertions, Invariants, Pre & Post Cond.)
    - Technology Neutral (UML from Business Vocab.)
  - **Technology Specific**
  - **Technology Specific**
General Inter-Domain Relationship Characteristics

• All External Goals of a Domain must be consistent with the Internal Goals of the Domain,
• All External Policies exposed by a Domain must be consistent with the Internal Policies of the Domain,
• A Domain must be wholly contained within one Tier,
• A Domain must be wholly contained within one Enterprise,
• A Domain may contain both Documented and un-Documented Policies,
• Two Domains are related by a Relationship,
• Relationships may be either hierarchical or peer-to-peer,
• Each Relationship must be described by an Ontology,
• For each Relationship of which the Domain is a member, there exists a Domain Relationship Map which describes the Domain’s perspective of the Relationship.
Inter-domain Relationship Map Generation

Domain Knowledge Base
- Local Business Strategy
- Local Business Goals
- Local Business Rules
- Local Resource Models
- Local Policies

Inter-domain Relationship Map
- Outgoing Relationship Knowledge Model (OWL 2.0)
- Incoming Relationship Knowledge Model (OWL 2.0)
- Relationship Specification (Concept Map)
- Semantics of Business Vocab. and Rules
  - SBVR Vocabulary
  - SBVR Rules
- Technology Neutral Contract Representations (UML)
- Technology Neutral Policy Representations (N-tuples)
- Technology Specific Contract Stubs
- Technology Specific Policies

Generate
- Relationship Traceability Maps, Adjacency Matrices and Connectivity Maps
- Adaptive Stimuli Generation
- Pattern Analysis Tools and Analytics
- Stochastic Analysis Tools and Analytics

Constrain
- Consistent
- Transform

Govern
- Relationship Realization
- Manage

Technology Tool Chain
- Transform

NIST Federation Workshop 29 October, 2014
Types of Inter-Domain Relationships

• Two core types of Relationships between Domains:
  – Compositions (Hierarchical relationships within a concern),
  – Federations (Peer-to-peer relationships within a tier).
Inter-Domain Relationship Artifacts - Extended

Domain
(Scope of Authority of Role)

Domain Knowledge Base
(Policies, Rules, Vocabulary, Goals, …)

Composition Export Maps
Composition Import Maps

Federation Export Maps
Federation Import Maps
Peer Inter-Domain Relationships

• Federations:
  – Are 1 Domain (peer) to 1 Domain (peer),
  – Each constituent Domain must be a member of the same Tier,
  – Domain Federations may span Enterprises,
  – Each constituent Domain provides two Relationship Maps that govern a Federation from the perspective of the constituent Domain: an Export Map and an Import Map. Each Map is visible to the Federation,
  – The Semantics of each Domain’s Map must be consistent with the Semantics of the other Domain’s corresponding Map,
  – All other parts of a Domain’s Relationship Map must be compatible with the other member’s Import/Export Map parts,
  – The Federation Export and Import Map Semantics must be consistent with the Internal Semantics of the Domain.
Inter-Domain Peer Relationship (Federation)

Test for Consistency of Ontologies and Compatibility of all other Parts of Map

If Incompatible at any Part of Map or Inconsistent Ontologies exist then Reject Federation Proposal

If Compatible at all Parts And Consistent Ontologies then Create Federation
Hierarchical Inter-Domain Relationships

• Compositions:
  – Are 1 Domain (higher level) to 1 or more Domains (lower level),
  – Domain Compositions may span two Tiers,
  – Domain Compositions may be within a single Tier,
  – Each constituent Domain provides two Relationship Maps that govern a Composition from the perspective of the constituent Domain: an Export Map and an Import Map. Each Map is visible to the Composition,
  – The Relationship Map for each Composition constituent Domain must be consistent with the Map for the other member,
  – The Composition Export and Import Semantics, Usage and Form must be consistent with the Internal Semantics, Form and Usage of the Domain.
Inter-Domain Hierarchical Relationship (Composition)

If Consistent then Create Composition

If Inconsistencies exist then Mediate or Abandon Composition

Test for Consistency of Ontologies and all Parts of Map

Domain A

Domain B

Consistent?

Consistent?

Consistent?

Consistent?
Complex Inter-Domain Relationships

Enterprise 1

Enterprise 2

Domain (Scope of Authority of Role)

Domain Knowledge Base (Policies, Rules, Vocabulary, Goals, …)

Federations

Compositions
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• **Billing System Use Case**
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Use Case: Traditional Single Domain Billing System

Normalization & Mediation
- Raw Records
  - Discount Plans

Rating
- Rating Plans
  - Tariffing
- Discounting

Prepaid Calc.
- Prepaid Balances
  - Presentation
    - Presentation Records
    - Online Push
    - Online Pull
    - Offline

Discount Plans

Use Case: Billing System with External Domains

Communications Service Provider

Normalization & Mediation

Raw Records

Rating Plans

Rating

Discounting

Tariffing

Discount Plans

Third Party Prepaid Support

Prepaid Balances

Prepaid Calc.

Third Party Billing Presentation

Online Push

Online Pull

Offline

Presentation

Presentation Records
Use Case: Billing System with Internal and External Domains
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Conclusions

• New technologies (i.e., the ‘aaS’ Cloud models) require a dynamic means to build and maintain Inter-Domain Relationships,

• “Just-in-time” linking of services/applications requires a high degree of confidence that the desired service/application will be available,

• There is a strong need to manage “the space between” domains/clouds,

• The Model(s) must be adaptive!!

A Model driven approach to managing Inter-Domain Relationships provides a means to achieve all of these.
Dawn on St. Regis Pond, St. Regis Wilderness Canoe Area, Adirondacks, New York
Backup Slides and References
Specification Using Extended Concept Maps
Transform to Common Semantics Form
Transform to Common Semantics Form (2)
Transform to Common Semantics Form (3)
Transform to Common Semantics Rules
Transform to UML and OCL
Contextual Information Generated from Transforms
Selected References


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