Semantic Interoperability for an Autonomic Knowledge Delivery Network

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4th Oct 2005

Contextual Knowledge for Autonomic Agents

- Autonomic communications involves migration of decision making towards network nodes
- Autonomic Agents need context information from
  - Network neighbours
  - Across end-to-end links
  - Across value chains
  - Nodes serving same customer
  - Nodes in the same market
  - Stigmergic nodes

Problem Statement

- Heterogeneity is a barrier to deploying innovative autonomic agent communities across networks
  - Must build on available sources of context
    - e.g. existing SNMP agents
  - Must introduce and exploit new sources of context
    - Typically other agents types e.g. aggregating agents
- Aim: An Open Global Service for exchanging context between autonomic agents

Loose Coupling between Agents Types

- State coupling
  - Publish-Subscribe messaging
- Address/Message Type coupling
  - Content Based Networking
    - Address message by filtering on attributes
- Semantic coupling of attributes?
  - Needed to scale interoperability and to spur innovation
  - Semantic Interoperability using knowledge-based techniques for explicit message meta-data

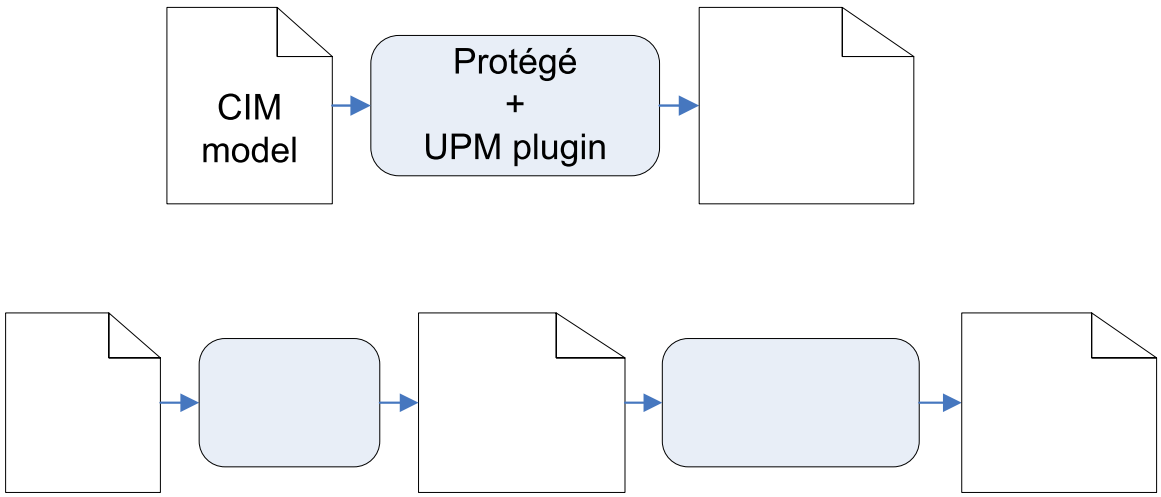
Open Semantics

- General purpose standards exist for exchanging explicit semantics
- W3C's Semantic Web standards
  - Ontology language for sharing semantics as classes, properties and instances (OWL)
  - Description logic and rules for automated reasoning
  - Can leverage existing ontologies, knowledge capture tools, reasoners, planners, repositories etc

Network Operation Semantics

- Good News: Conventional management agents offer a rich source of semantics, i.e. Management Information Bases
- Semantic interoperability complicated by different standard meta-schemas:
  - Structure of Management Information (SMI) for SNMP
  - Managed Object Format (MOF) from the Distributed Management Task Force
  - GDMO for OSI management
- First need to normalise meta-schema using OWL
  - Building on work by de Vergara and Villagra at UPM

Normalising to OWL



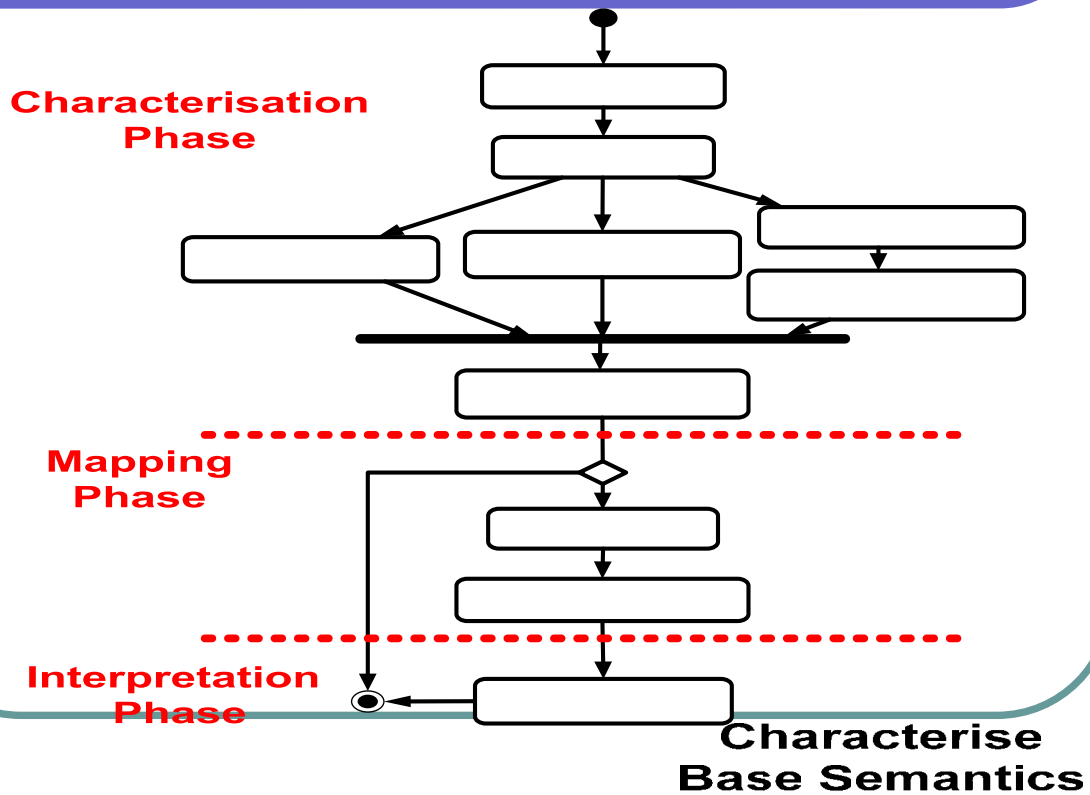
Example Semantic Mapping

- CIM (object-oriented)
  - A `PhysicalElement` realizes 1 or more `LogicalDevices`
  - Each logical device's current status is described by one of a set of 5 enumerated status types
    - `CIM_LogicalDevice->StatusInfo`
- SNMP (table-based information)
  - Each managed resource is made from a set of devices (`hrDevice`).
  - The status of each device within a resource is described by an integer status variable with 5 possible values
    - `hrDevice.hrDeviceTable.hrDeviceEntry.hrDeviceStatus`
- Mapping is usually much more difficult

Semantic Interoperability

- Dynamic semantic interop between two arbitrary ontologies not currently feasible
- Mapping as an industrial process
  - Mappings sought as needed
  - **Not** building canonical management ontologies
  - Third parties identify and publish mappings
  - Plug-in matchers, e.g. lexical using WordNet, domain specific
- Need productivity support for human mappers
  - Use lexical matching and structural analysis to predict cost-benefit of mapping effort

Semantic Mapping Process



Management Specific Matching

- General lexical matching performed poorly for CIM-SMI mapping
- Structural matching restricted by flat nature of SMI-OWL
- Developed domain matcher for mapping DMTF MOF models to IETF SMI models
  - Uses CIM qualifier – `MappingString`
  - Provides hints from CIM authors on mapping to other models
- Otherwise rely on human domain knowledge
  - Identify key mapping anchors between two management ontologies
- Generate XSL Transform bridges at run-time
  - May be context aware

Mappings and Context of Values

- Simple mappings of the same or similar type
  - Require translation of values in a context free manner
    - e.g. CIM int 1 → SNMP int 1
- Simple mappings for different types
  - Still require mapping in a context free manner
    - e.g. int → string, octets → array etc.
    - e.g. SNMP DateTime 1992-5-26,13:30:15.5,-4:0 → CIM DateTime 19920526133015.500000-004
- Composite mappings for different types
  - Translation may require context, or a number of queries or values
    - e.g. CIM_Printer.PrinterStatus → HOST-RESOURCES-MIB::hrDeviceStatus + HOST-RESOURCES-MIB::hrPrinterStatus

Current Status

- Initial implementation trial
  - Uses the Elvin CBN
  - Producer convert SNMP traps to Elvin events using Q3ADE management mediation platform
  - CIM to SMI mapping on consumer subscriptions
- Domain-aware mappers are required
  - Lexical patterns, value-encoded semantics, using documented hints
  - May get easier as context from intelligent agents grows?
- Can combine with agent API masking remote subscriptions and local MIB queries

Future Work

- Location of Mapping Execution
  - Depends on relative distribution of consumers wanting transformed and untransformed versions
  - A producer, consumer or in CBN
- Distribution of Mappings
  - Local, context-aware mapping
  - Distribute via overlay CBN?
- Mapping and subscription languages
  - *Expressiveness*
  - *Ability to specify hints and other intentional metadata*
  - *Ability to capture / specify / exploit map-time context*
  - Composite events and Temporal relationships