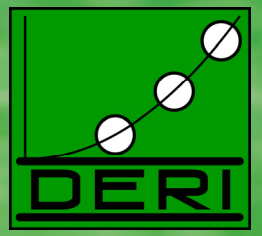


Semantic Business Process Integration

Armin Haller, Eyal Oren
Digital Enterprise Research Institute
National University of Ireland, Galway

Semantic Technology Conference 2007, San Jose, CA

Me

- 4th-year PhD student at DERI
- Research interests
  - Semantic data management
  - Semantic application development
  - Workflow management
  - Service-oriented architecture

http://armin-haller.com

http://eyaloren.org

- Achievements
  - Co-authored WSMO & WSMX standards
  - Developed ActiveRDF, BrowseRDF, SuggestRDF
  - Coined Semantic SOA (Haller et al. 2005)

What are we doing today?

- Workflows widely deployed for office automation
- Business process management promises to allow inter-enterprise automation
- But heterogeneity problems remain
  - Data exchange standards have weak expressivity
  - Data semantics and constraints implicit
  - Process model standards do not cover full process lifecycle
  - No relation between internal/external workflow
- **Semantics** (data and process) help identify and address heterogeneity problems

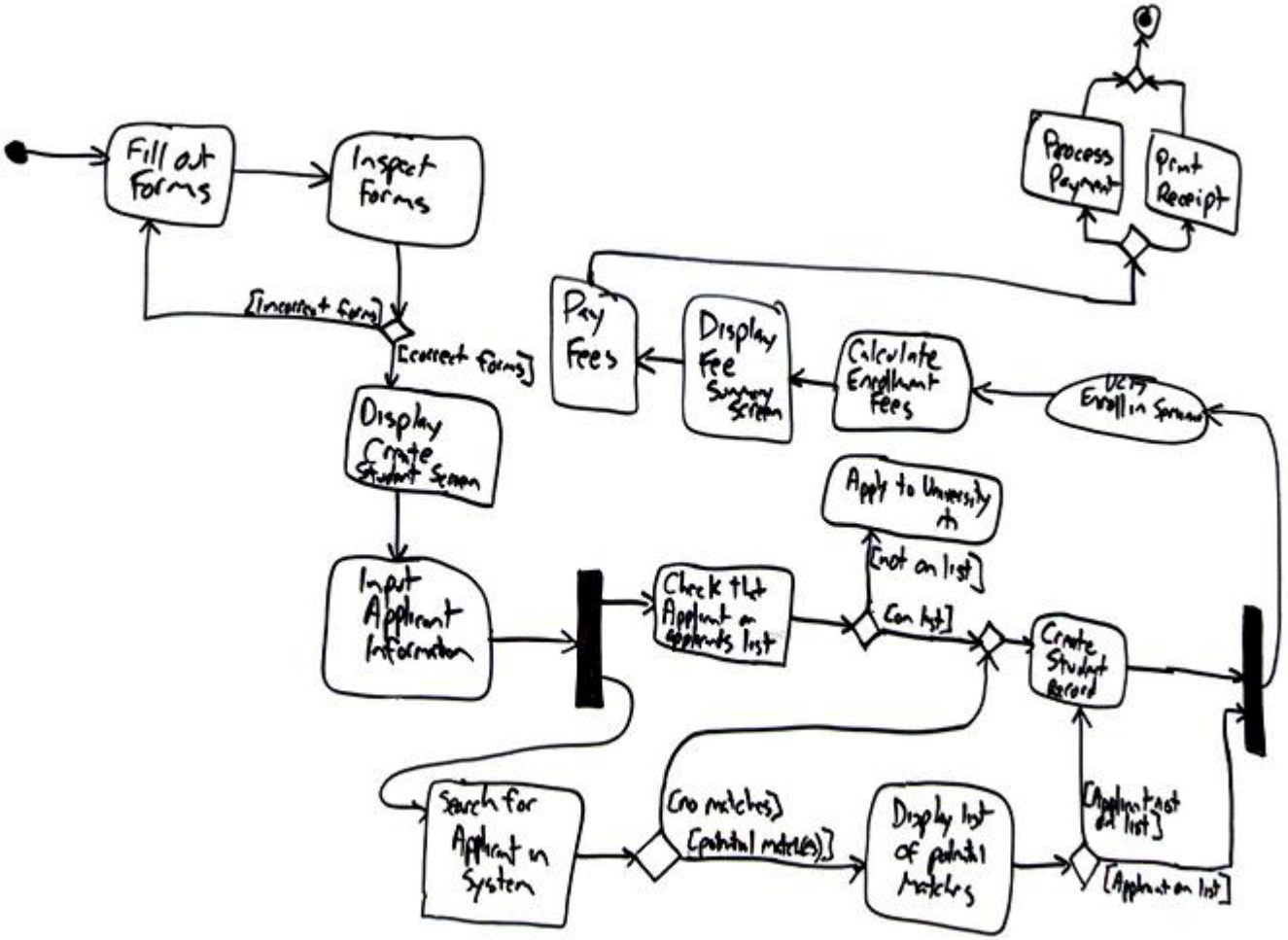
Outline of the Talk

- Background
  - Workflow Management
  - Business Process Management (BPM)
- BPM for B2B Integration
  - Enterprise View vs. Collaborative View
  - Promises
  - Open Issues
- Towards a Unifying Service Model
  - Semantic Data Representation
  - Semantic Process Representation
- Conclusion

Definition

- **Workflow Management**
  - Automation of activities in the **scope of a single control**
  - **People-to-people**
  - **People-to-systems**
  - **Client-Server Model**
- **Business Process Management (BPM)**
  - Composition of service functionality in the **scope of a collaboration**
  - Distinguishes **private** and **public** processes
  - **Systems-to-systems**
  - **Enterprise-to-enterprise**
  - Service-Oriented Architecture
- **Bottom Line: both approaches operate on a Process Model**

Example



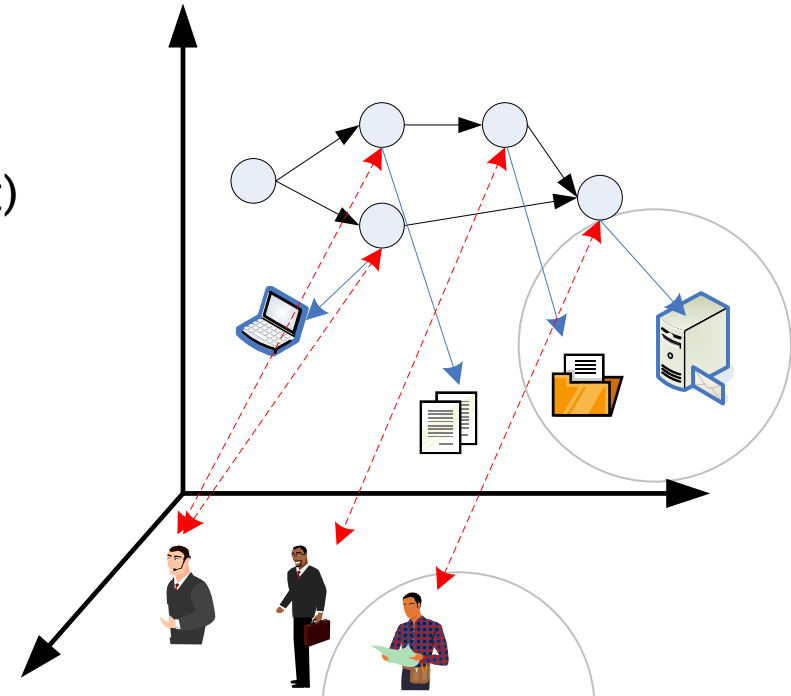
[Amber, S.: http://www.agilemodeling.com/artifacts/activityDiagram.htm]

History

- Information systems with hard-coded workflows
  - early office automation systems
- Generic workflow systems
  - Generic, but proprietary meta and data model
- Generic "standardised" workflow systems
  - Explicit process models
  - Interface architecture to control applications
- Business Process Management systems
  - SOA architecture paradigm
  - Orchestration and Choreography control
- Process Aware Systems
  - Workflow functionality on top of existing systems (ERP, SCM, CRM, CMS)

Dimensions in Workflow

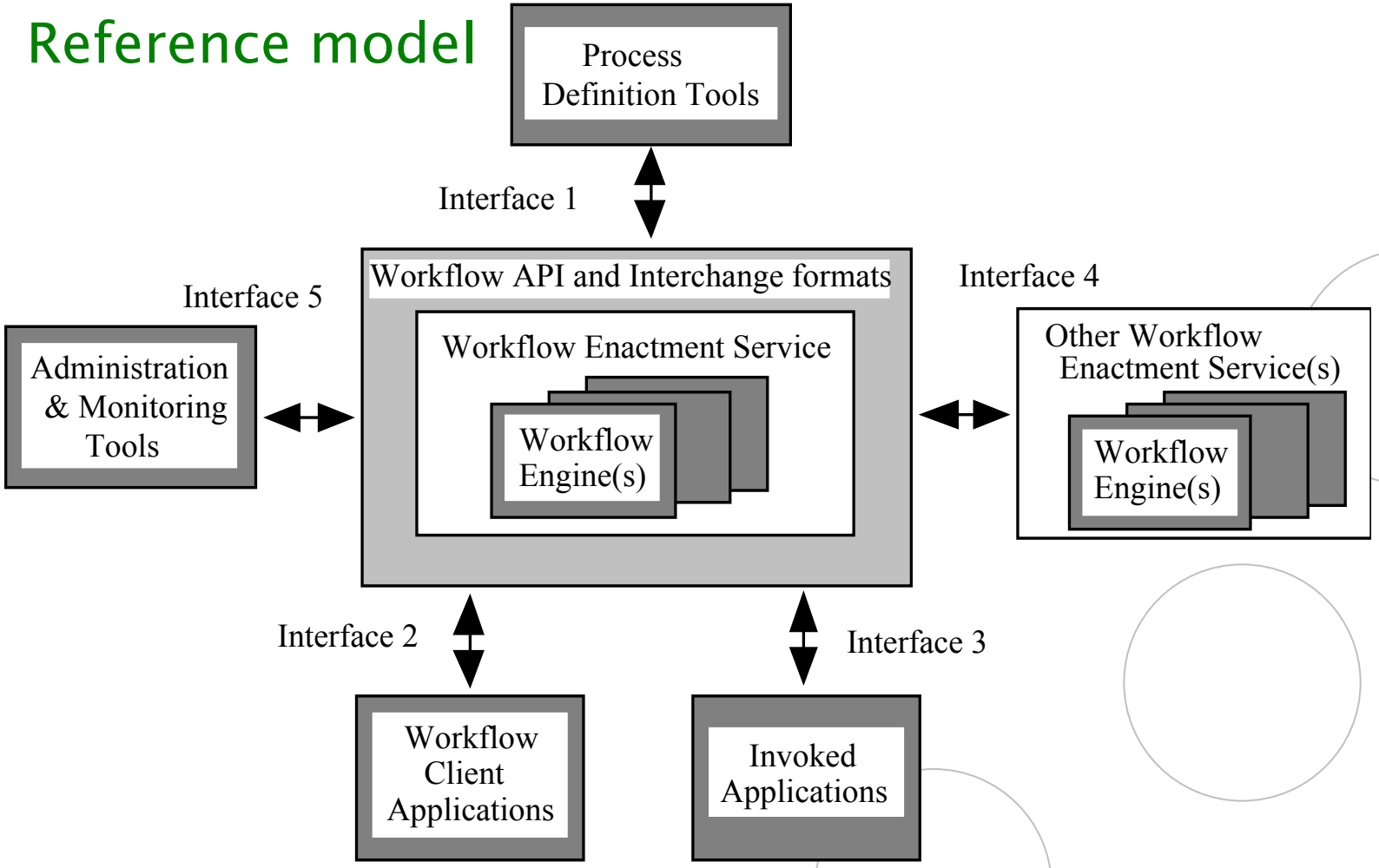
- Workflows perspectives
  - Workflow: what should be done…
  - Control Flow perspective (when)
  - Informational perspective (with what)
  - Organisation perspective (who)
  - Operational perspective (how)
- Other dimensions exist
  - No agreement on standard model
  - Multiple notations and languages for workflows



c.f. [Karastoyanova, D.: SUPER Tutorial Slides. 2007.]

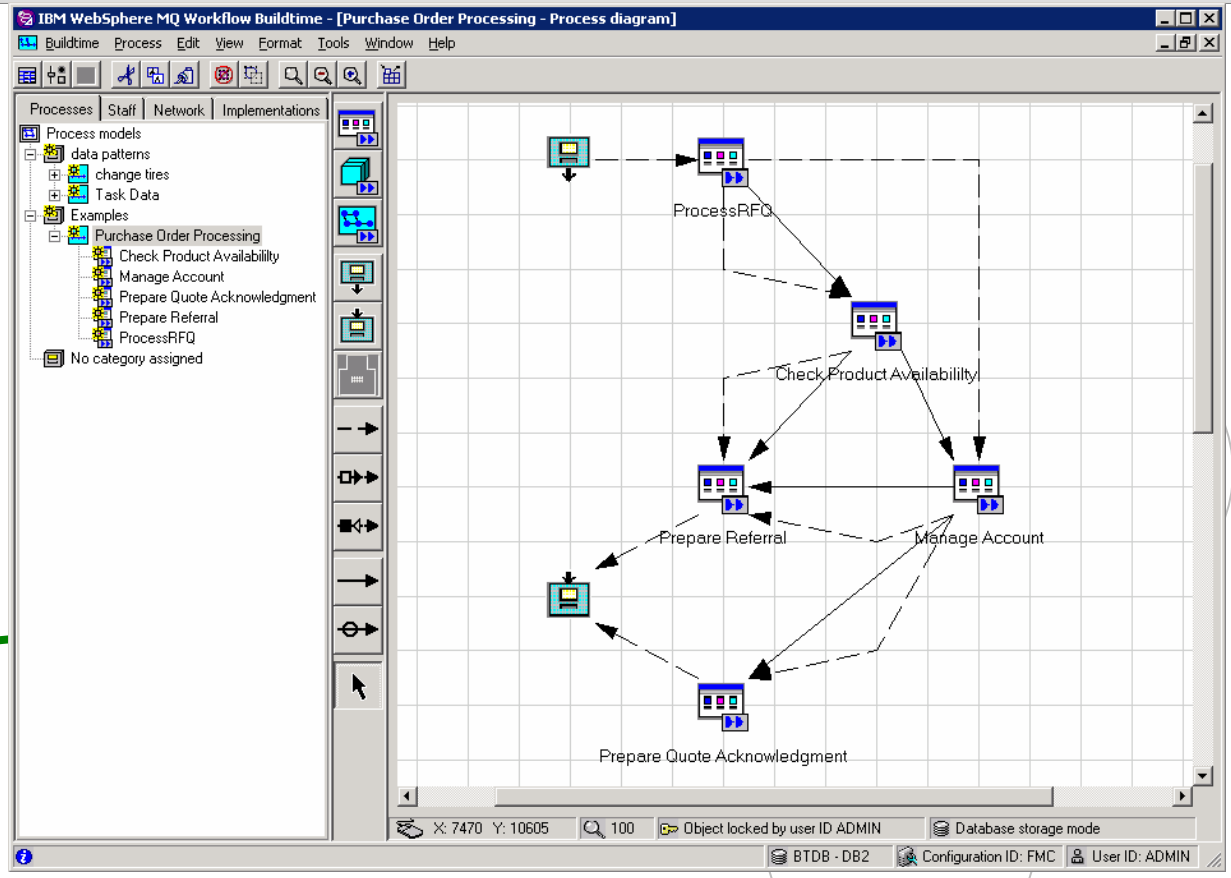
Workflow Management Coalition

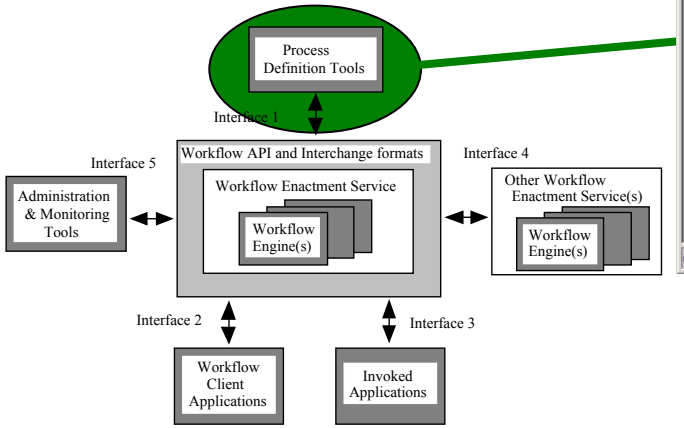
- Reference model



WfMC Reference Model

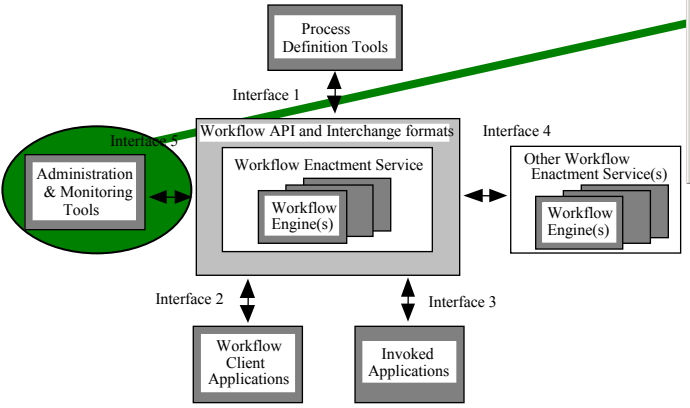
- **Build-time**
  - **Defining**
  - **Modelling**

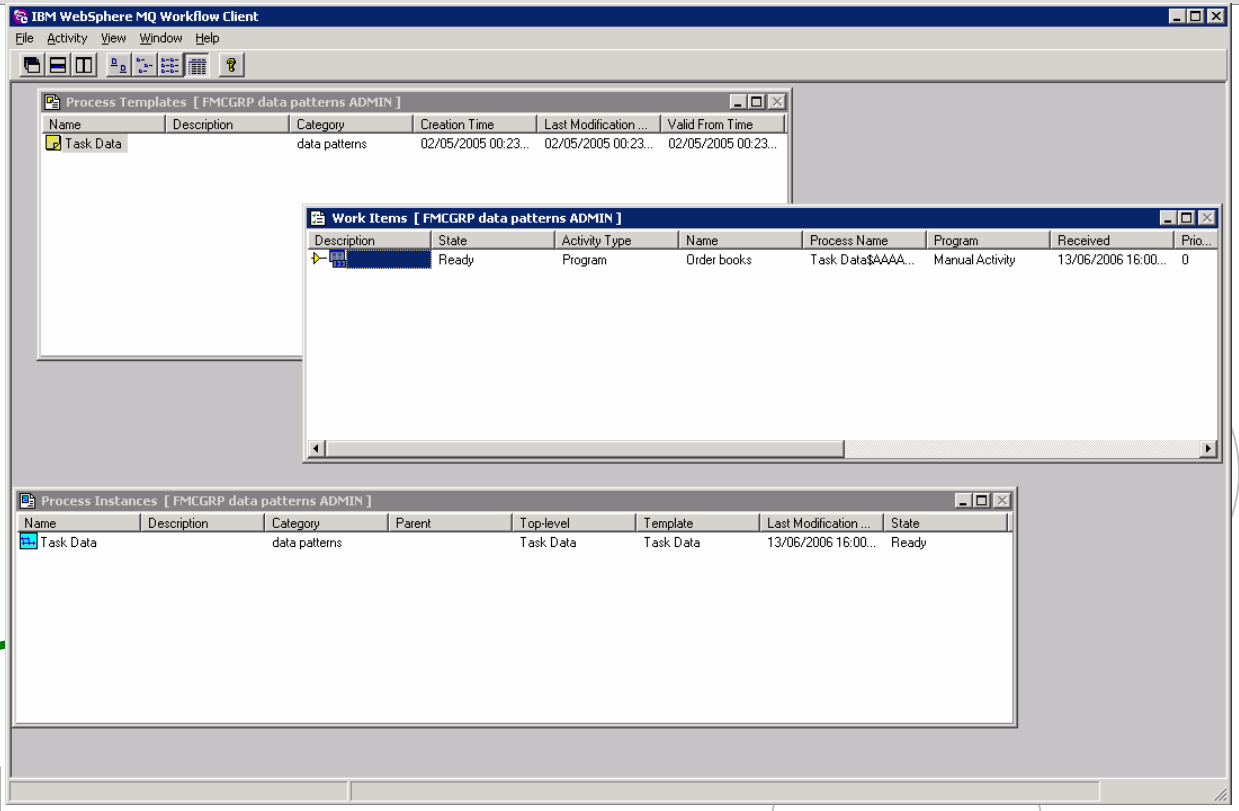




WfMC Reference Model

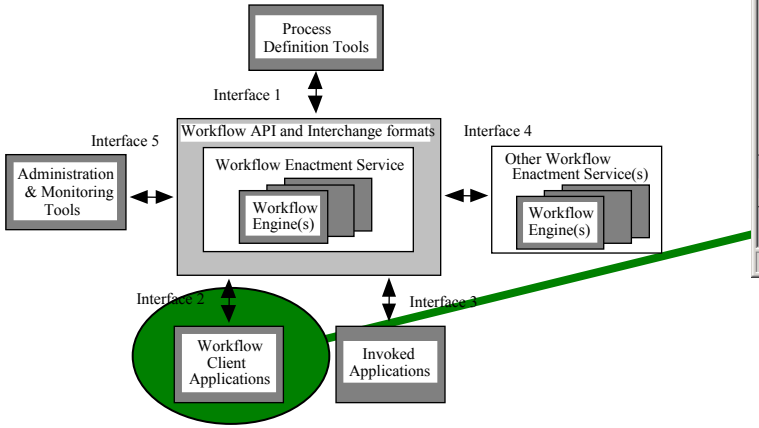
- **Run-time control**
  - Manage instances
  - Sequence activities
- **Run-time interactions**
  - With humans
  - With applications

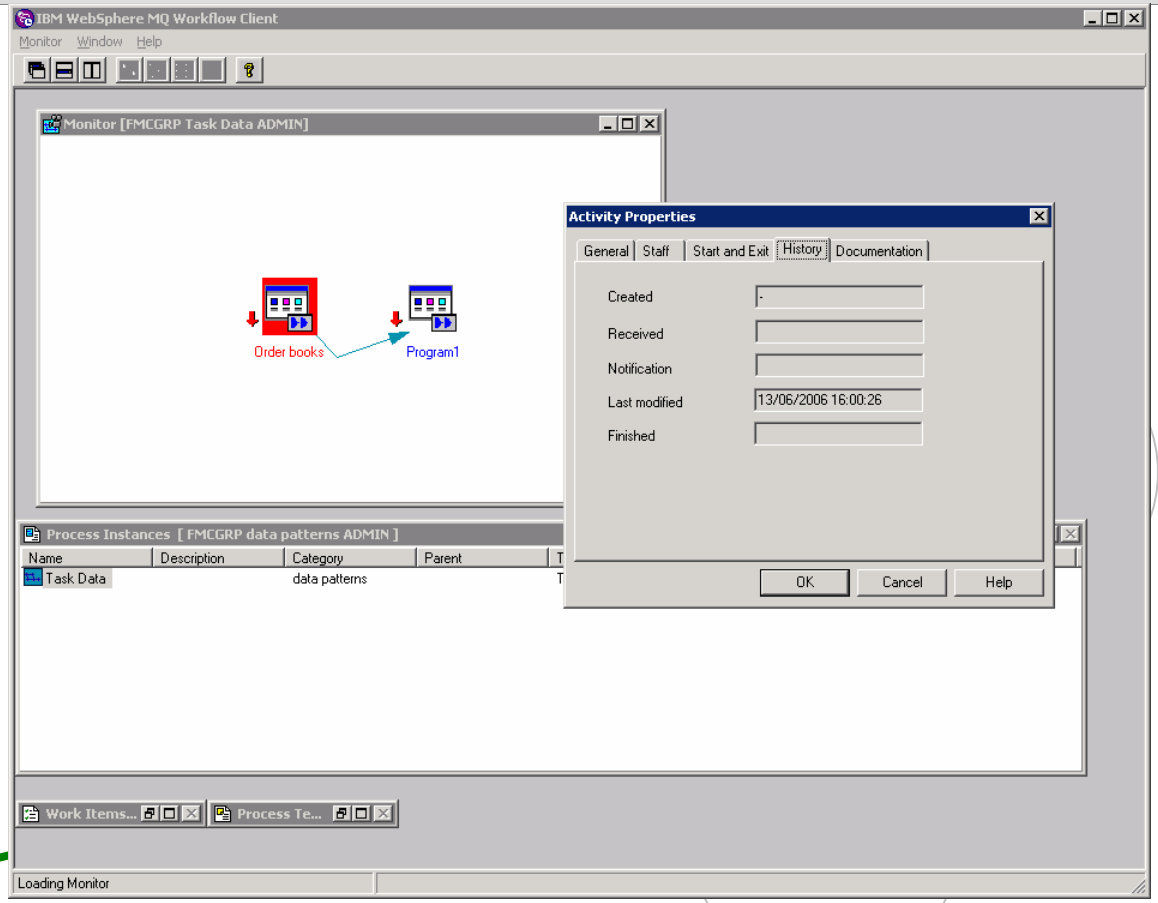




WfMC Reference Model

- **Run-time monitoring**
  - Display status of running or completed workflow instances
  - View task lists for users or roles
  - Display system workload





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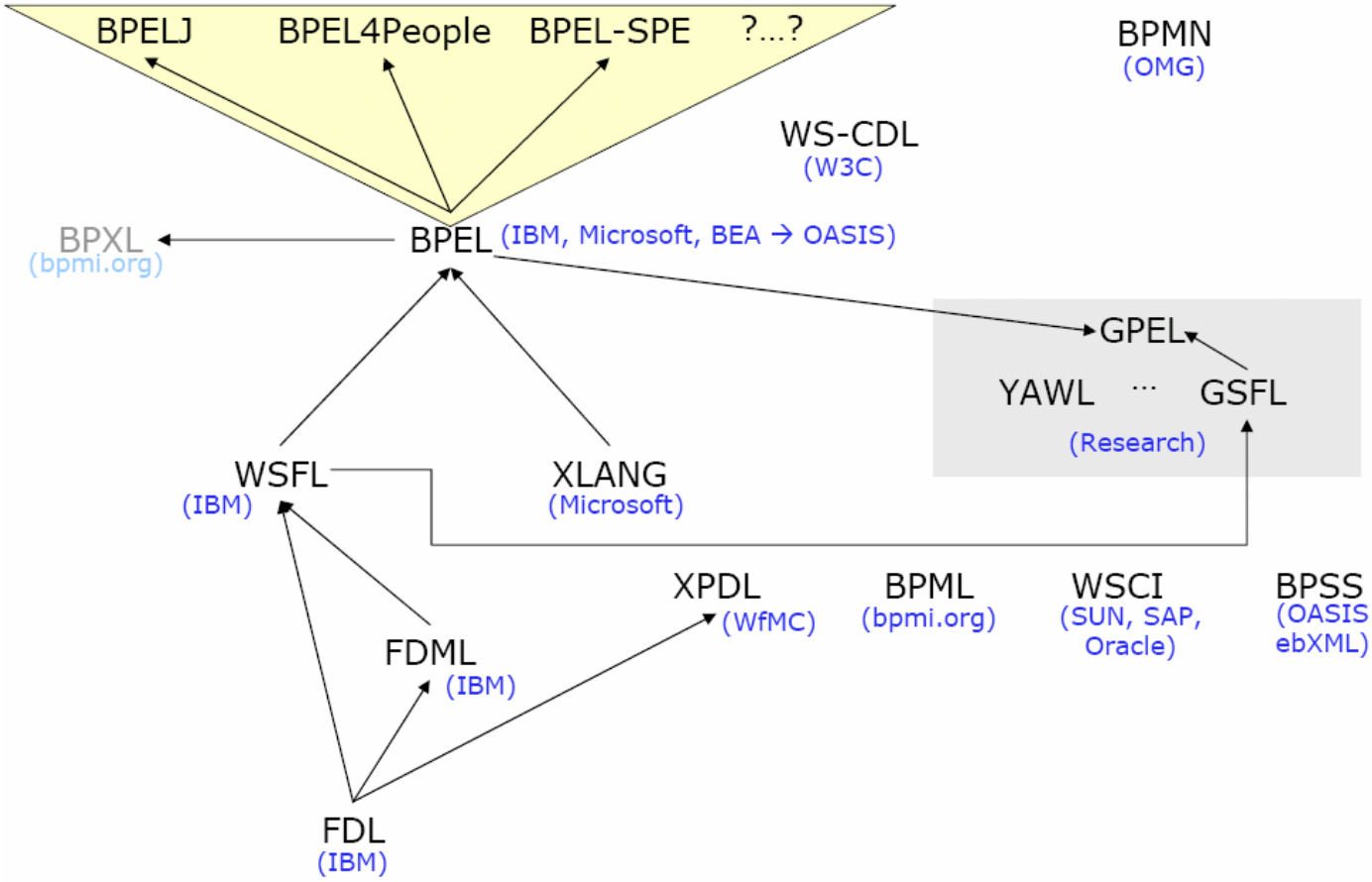
BPM Languages



[Leymann, F., Nitzsche, J.: SUPER Tutorial Slides. 2007.]

BPM Market Space

[Hill, J. B., Sinur, J.: Magic Quadrant for Business Process Management Suites. 2006]

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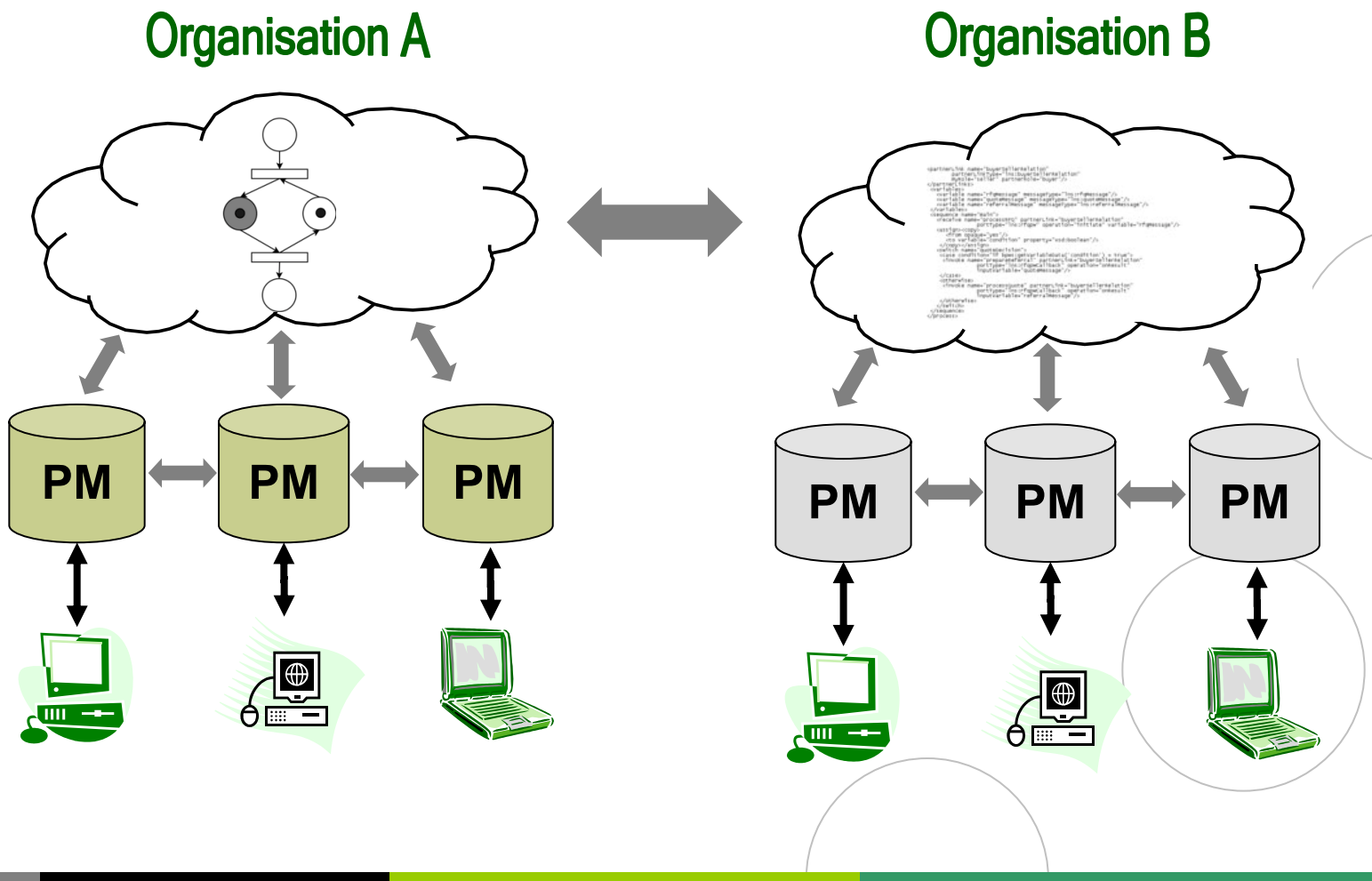
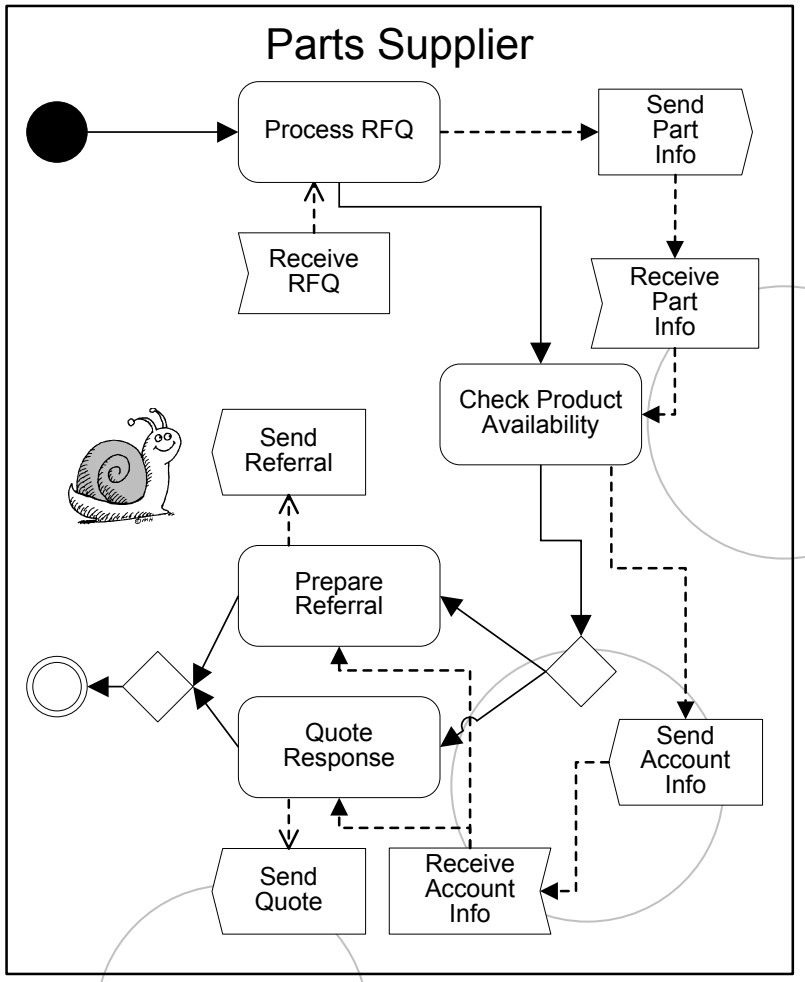
Enterprise and Collaborative Views



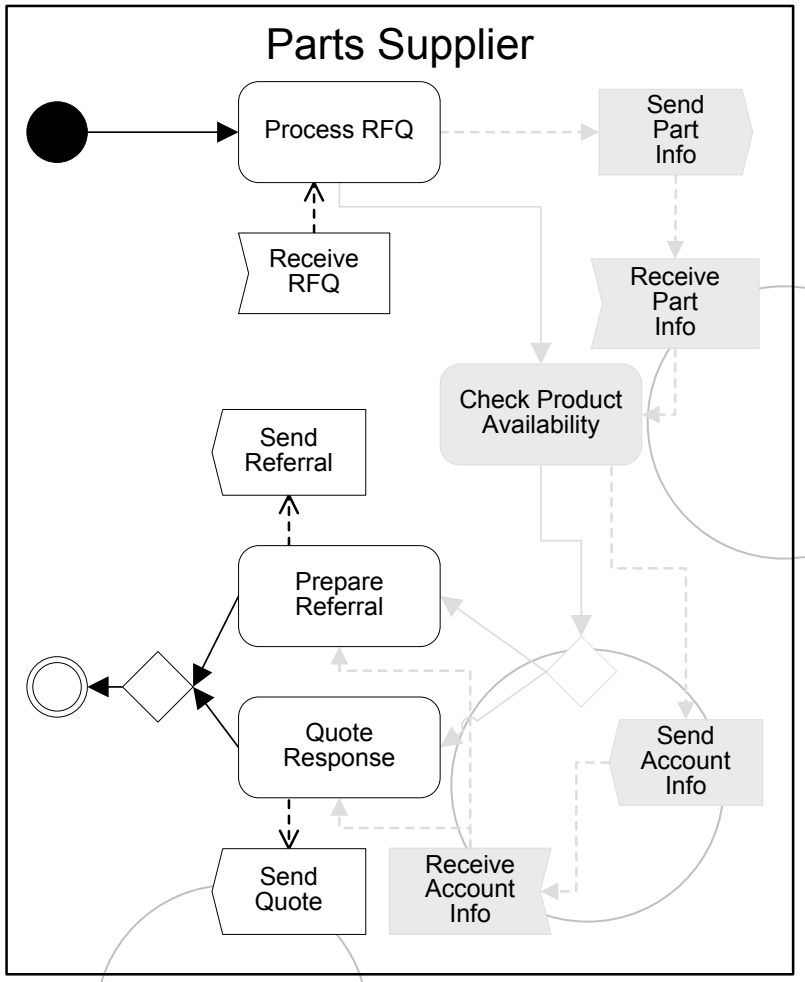
Enterprise View

- Workflow Model
  - Manage internal processes (manufacturing, SCM, HR)
  - (Usually) executable
  - Languages: FDL, UML, Petri Nets, EPC, BPMN, BPEL
  - Communication over EDI, VAN, VPN, snail-mail, …
- Interface Behaviour



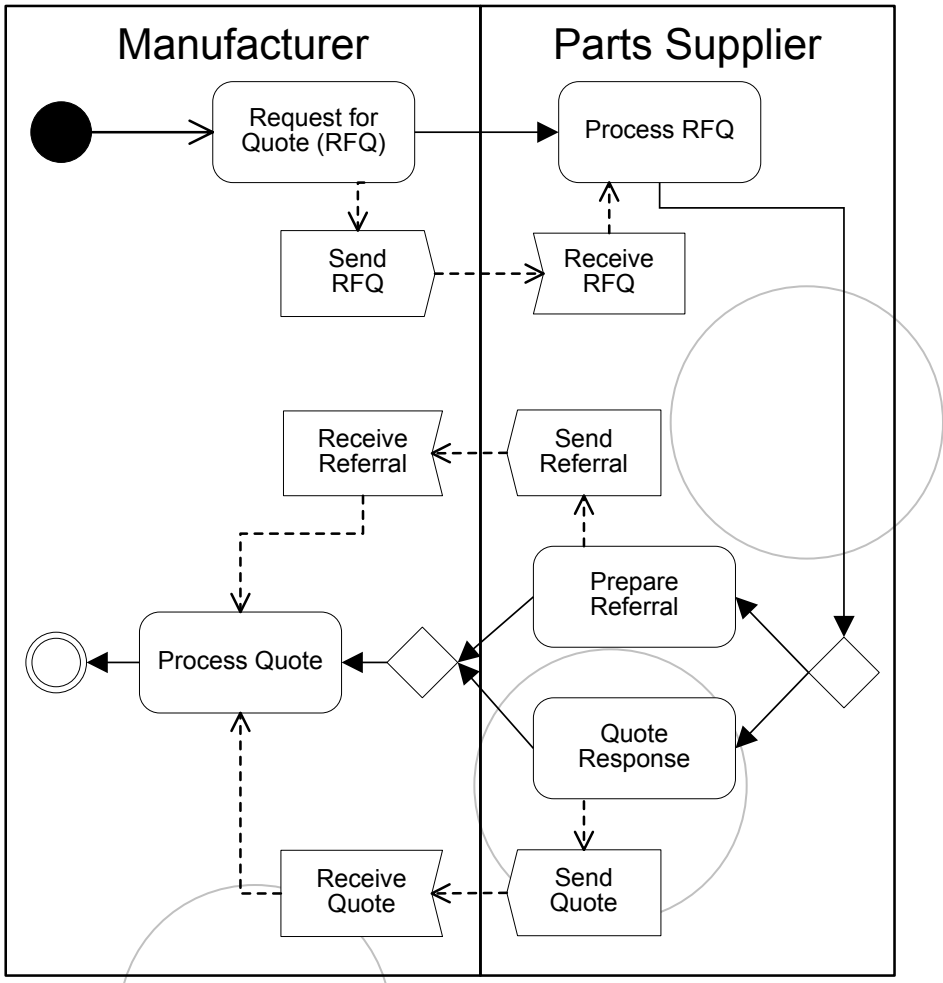
Enterprise View

- Workflow Behaviour
- Interface Behaviour
  - Published workflow abstraction
  - Describes inter-enterprise activities
  - Behaviour of a particular service provider in its communication with a single other entity
  - Languages: WSCI, A-BPEL, WSMO



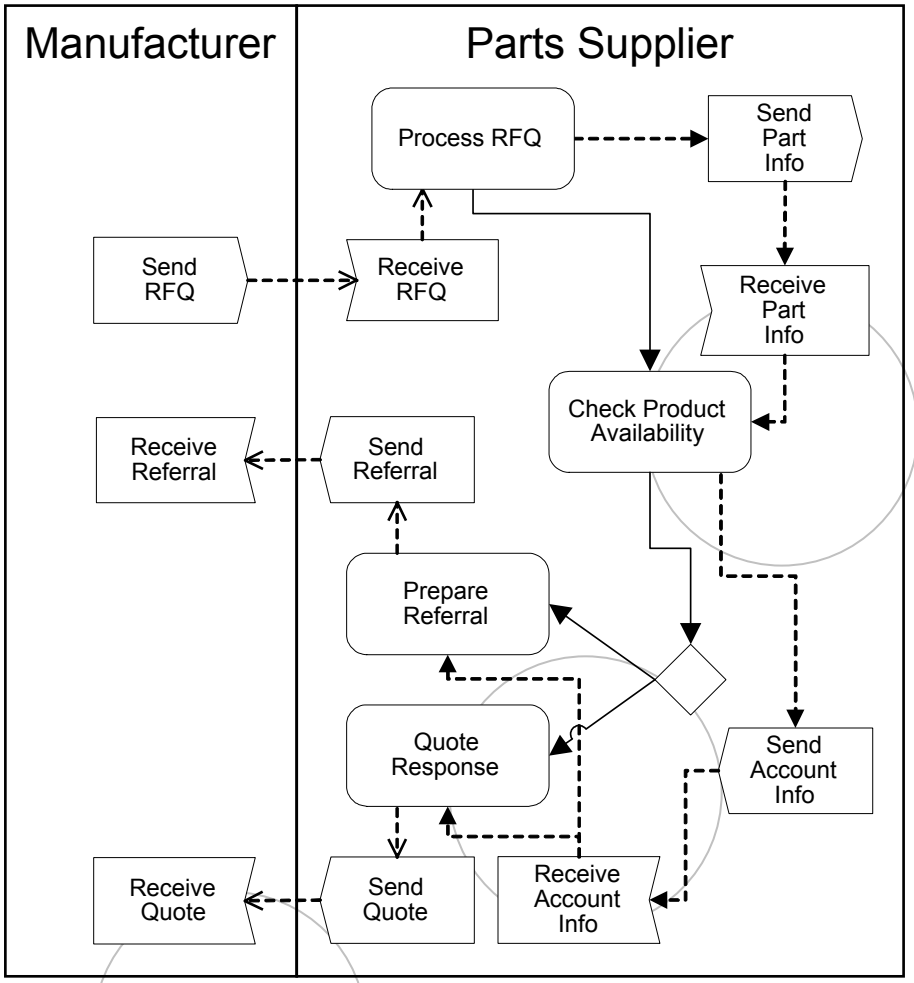
Collaborative View

- Choreography
  - Collaboration between (multiple) service providers and service consumers
  - Abstraction (not executable)
  - Global view
  - Languages: UML, WS-CDL, BPMN
- Orchestration



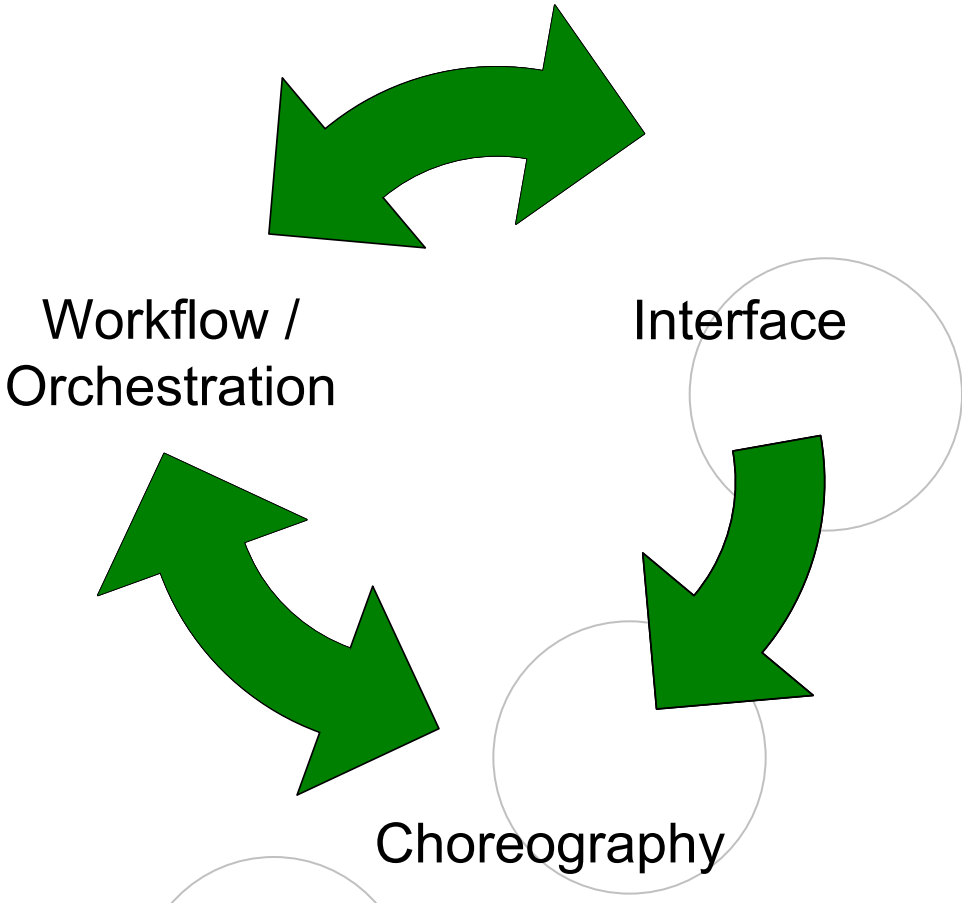
Collaborative View

- Choreography
- Orchestration
  - Internal behaviour of service provider to realise a provided service
  - Executable
  - Uses partners' interface behaviours
  - Conceptually: service-oriented workflow, same languages



Collaboration Lifecycle

- Top-Down
  1. Choreography modelled
  2. Interfaces agreed upon
  3. Workflows / Orchestration implemented
- Bottom-Up
  1. Existing Workflow analysed
  2. Interfaces designed
  3. Choreograpy designed (push by one partner)
  4. Workflows / Orchestrations are realigned



Promises of BPM: Standardisation

- Transportation Layer: SOAP/HTTP ✓
- Data layer: XML/DTD/XSD ⇨ RosettaNet, ebXML ✗
  - Data semantics ambiguous
  - Data constraints implicit
  - Data mapping case-by-case
- Application Layer: WSDL ✓✗
  - Functionality descriptions ambiguous
  - Semantic Web Services: WSMO, OWL-S, WSDL-S
- Process Layer: BPEL ✗
  - No relation between internal/external representation
  - Majority of internal workflows not BPEL-based

Data Layer Issues (e.g. RosettaNet)

- Business definition:

  At least one business identifier must be provided: business name, Global Business Identifier or at least one entry in Partner Business Identification.

- XML DTD

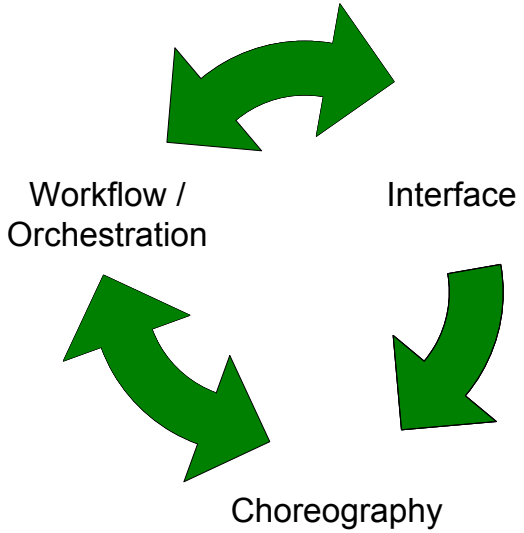
```
<!ELEMENT BusinessDescription
(GlobalBusinessIdentifier?,
 GlobalSupplyChainCode?,
 businessName?,
 PartnerBusinessIdentification*
)>
```

- Measurement units

  1000-pack
  100-Pack
  10-pack
  20-Pack
  25 Kilogram Bulk Bag
  300 Kilogram Bulk Bag
  40 Foot Container
  50 Pound Bag
  500 Kilogram Bulk Bag
  Dozen
  ...
  Piece
  ...

Process Layer Issues

- Horizontal Integration
  [within the lifecycle]
  - Different languages (syntax + semantics)
  - Limited exchange of process models
  - No interoperability support



- Vertical Integration
  [along the lifecycle]
  - No interface view on workflow models
    - No automatic abstraction from internal workflow
    - Indicating private/public process elements not possible
  - Workflows lack support for choreography modelling
    - Notion of messages as aggregation of data missing
    - Public/private role model missing
    - Visibility of activities/data missing

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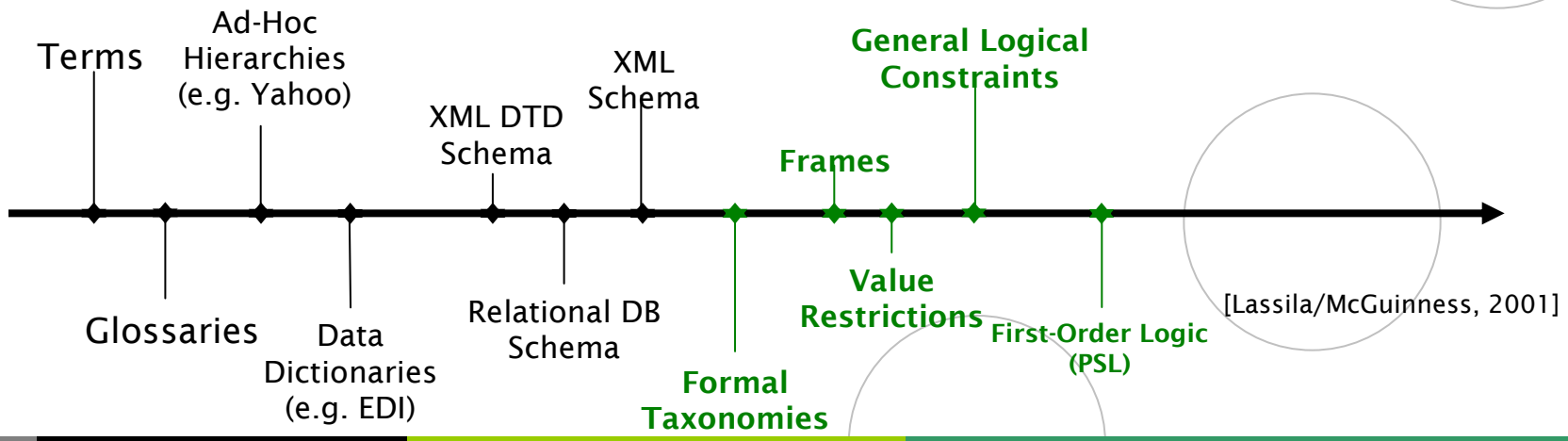
Semantic Business Processes

- Data layer
  - Ontologise message vocabularies
  - Make data semantics and constraints explicit
  - “Semantic RosettaNet”
- Process Layer
  - Ontologise process models
  - Unifying process ontology (and relate to choreography)
  - “Semantic Workflows”

- Benefits of ontology languages:
  - Ontology languages more expressive than DTD/XSD
    - Express constraints in schema (cardinality/uniqueness)
    - Express relation between elements (e.g. measurement units)
  - Ontology can include axioms (rules)
    - Capture business rules or data relations
    - Allow implicit information to be derived at run-time



Semantic RosettaNet

- RosettaNet in WSML ontology language
- Includes constraints which are not expressible in XML Schema
  - Includes facts of implicit knowledge in RosettaNet
  - Makes relations between values explicit
- Built once by knowledge engineers (us, not you)

```
1   axiom resolveMeasurementUnitType
2     definedBy
3       forall ?x(?x[globalProductUnitOfMeasurementCode hasValue "
              dozen"] memberOf quoteLineItem implies ?x[
              globalProductUnitOfMeasurementCode hasValue "12"]).
4       forall ?y(?y[globalProductUnitOfMeasurementCode hasValue "10-
              pack"] memberOf quoteLineItem implies ?y[
              globalProductUnitOfMeasurementCode hasValue "10"]).

295   relation unitPrice (ofType financialAmount, ofType productQuantity,
          ofType decimal)
296     nfp
297       dc#relation hasValue unitPriceDependency
298     endnfp
299
300   axiom unitPriceDependency
301     definedBy
302       forall ?x,?y,?z (unitPrice(?x,?y,?z) equivalent
303           ?x memberOf financialAmount and
304           ?y memberOf productQuantity and
305           ?z = wsml#numericDivide(?z,?x,?y)).
```

Extract of m3po-data ontology (RosettaNet PIP3A4)

Semantic RosettaNet

- Run-time messages
- Created from business systems
  - Added to ontology as instance data
  - Implicit information automatically derived

```
1  instance QuoteLineItem1 memberOf rfq#quoteLineItem
2    rfq#globalProductUnitOfMeasurementCode hasValue "dozen"
3  instance quantitySchedule1 memberOf
4       core#quantitySchedule
5    core#productQuantity hasValue "204"
6  instance substituteProductReference1 memberOf
7       core#substituteProductReference
8    core#GlobalProductSubstitutionReasonCode
9       hasValue "Better product"
10 instance totalPrice1 memberOf core#totalPrice
11   core#financialAmount hasValue FinancialAmountTot
12 instance FinancialAmountTot memberOf
13      core#FinancialAmount
14   core#globalCurrencyCode hasValue USD
15   core#monetaryAmount hasValue "198"
```

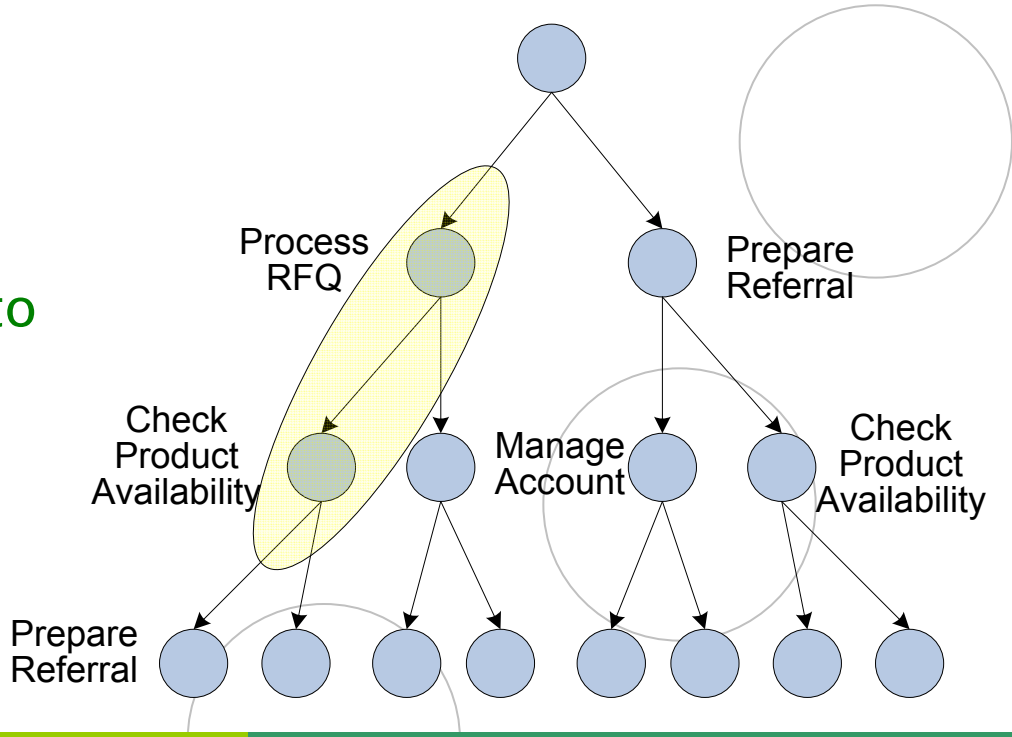
Snippet of m3po-data instance (RosettaNet PIP3A4 message)

m3po – multi meta model process ontology

- Formal ontology
  - Covers all workflow aspects (data, control, operational, …)
- Behavioural semantics based on PSL
- Expressed in WSML
  - A web ontology language
  - URIs to refer to ontological definitions (data alignment)
  - Connects with Semantic RosettaNet ontology
- Supports
  - Different meta models (**horizontal integration**)
  - Complete model including all workflow aspects
  - Native support for choreography elements (**vertical integration**)

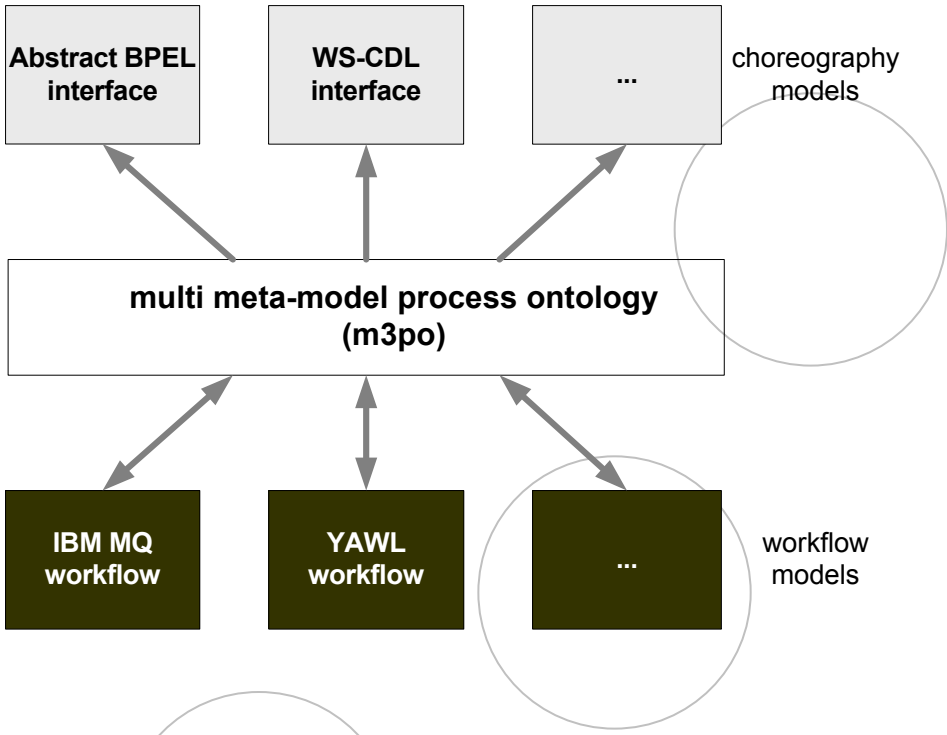
m3po behavioural semantics

- Main modelling concept is `activityType`
- `occurrences` are a runtime execution of `activityTypes`
- All possible `occurrences` form a rooted, directed, acyclic graph
- Control flow structures restrict `occurrence` graph to form a legal activity graph (execution behaviour)



m3po usage principle

1. Automatic model lifting
   - Transformation rules lift underlying model to m3po
2. Annotate model
   - Choreography information
3. Extract choreography model
   - Generate choreography model for a specific role (partner)
4. Choreography description
   - Target choreography description language (WS-CDL, BPEL, …)

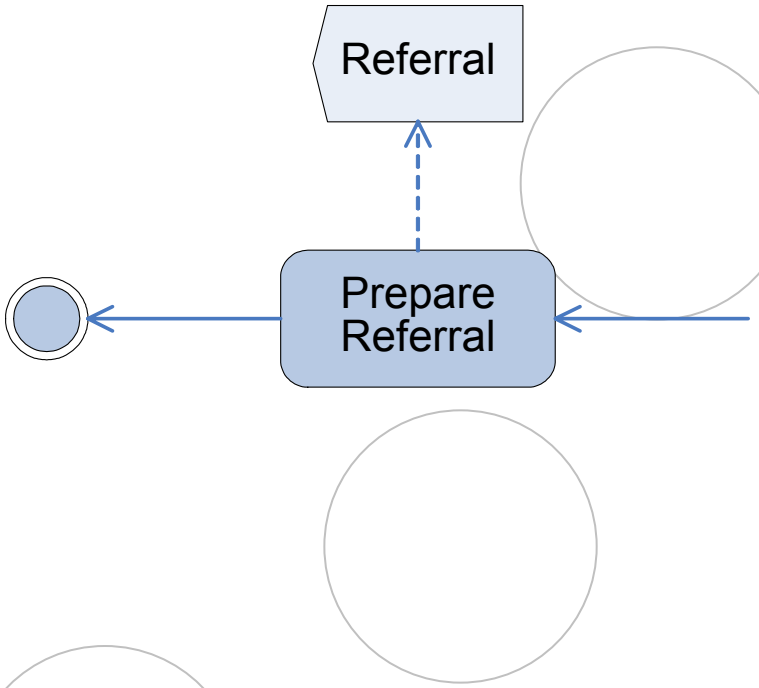


m3po – Example instance


```
instance prepareRef memberOf messageEvent
   hasName hasValue "Prepare Referral"
   hasJoinRestriction hasValue bothReceived
   hasMessage hasValue rn#referral
   isVisibleFor hasValue rn#buyer

instance sinkNode memberOf endEvent
   hasName hasValue "Sink Node"
   isVisibleFor hasValue rn#seller

instance prToEnd memberOf dataConnector
   hasStartActivity hasValue prepareRef
   hasEndActivity hasValue sinkNode
   hasParameter hasValue prInOutEnd
```



m3po – Features

- **Advantages**
  - Natively supports **horizontal** and **vertical integration**
  - True extensibility, one defines not only syntax of extension, but semantics
  - Reuse data ontologies for rich concept definitions
  - Meant as rich interchange format, not for direct modelling
  - Tool support for annotations (wsmt.sourceforge.net)

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Summary

- Semantic Data Representation
  - Captures data semantics explicitly
  - Captures data constraints explicitly
  - Allows semi-automated mediation
  - Allows mapping rule reuse
- Semantic Process Representation
  - Captures process semantics explicitly
  - Captures all workflow aspects (data, control, organisation, operation)
  - Model-driven business integration
  - Semi-automatic workflow stub generation
  - Semi-automatic conformance checking
  - Semi-automatic generation of interface description
- Take Home Message: explicit semantics enables **identification** of **data** and **process heterogeneities**

Conclusion

- "Semantics" help to tackle heterogeneities in BPM
- Our Approach
  - Based on existing standards/representations
  - Not yet another model, but …
  - Unifying ontology
- How does it help YOU!
  - Theoretical Foundation is laid and …
  - Model Transformation Tool is under development, watch out!
- More Information
  - m3pe project: http://m3pe.org/
  - m3po-data: [Haller et al. SAC2007]
  - m3po-process: [Haller et al. SCC2006]

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Ireland
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Questions?