

# “Business Artifacts”: Providing a new foundation for the Management of Business Operations and Processes (and Workflow)

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Drawing on discussions and collaborations with  
IBM Research (Watson, Haifa, Zurich, India) and  
UC Santa Barbara, UC San Diego, U Rome La Sapienza,  
U Bozen/Bolzano, and others

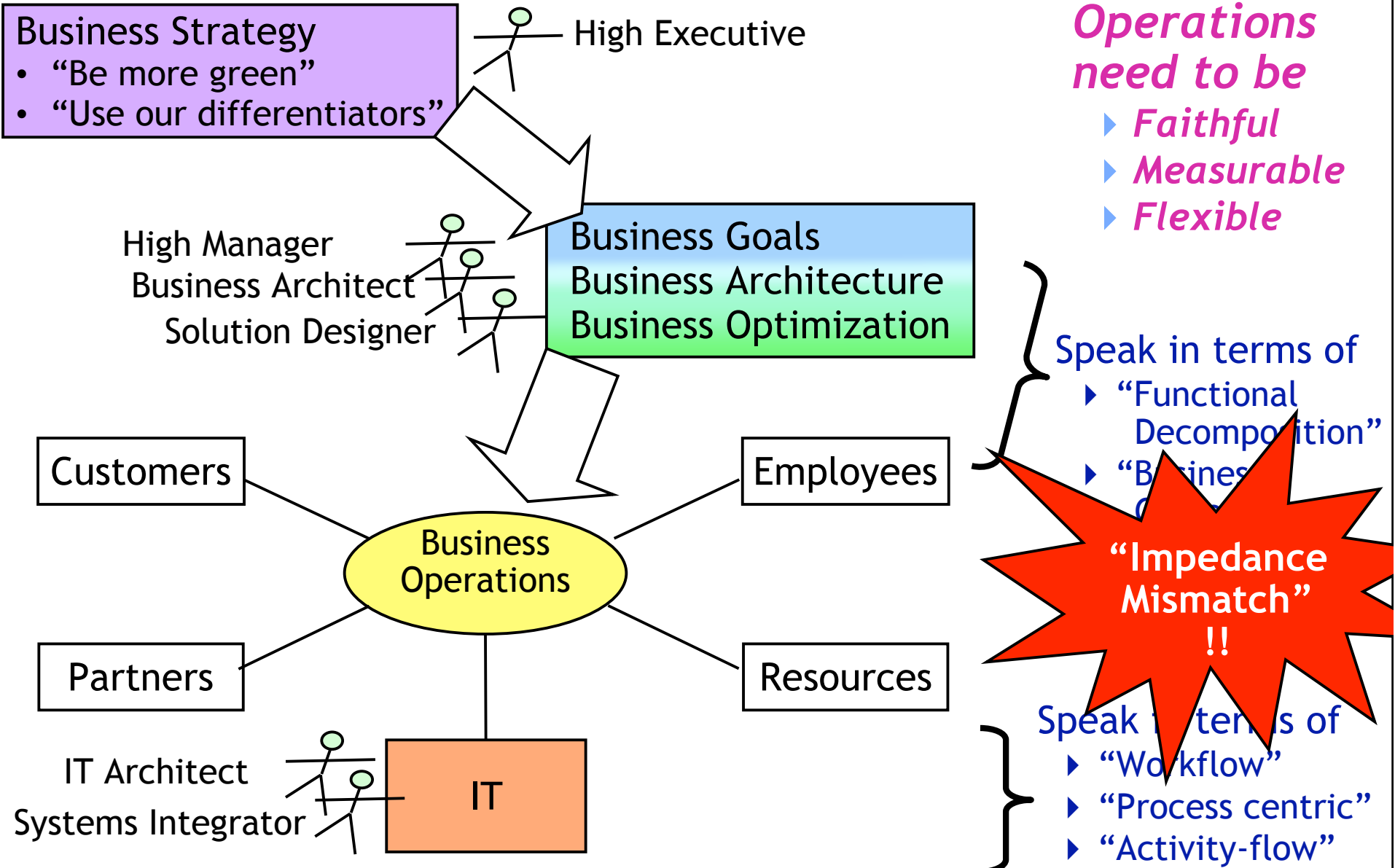


March 17, 2009

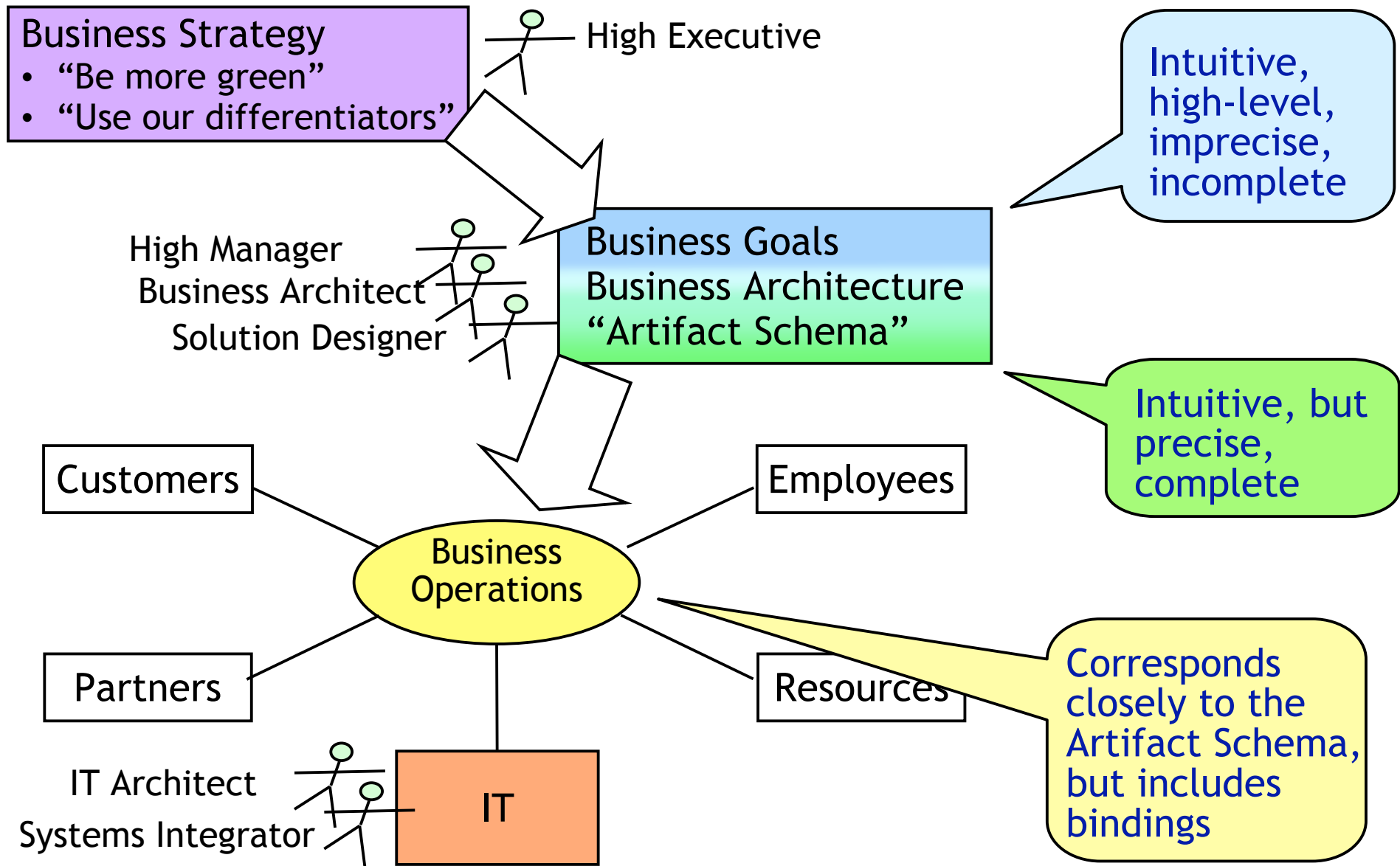
Note: This deck uses animation

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# A Key Challenge in Business Process Management



# Artifact-centric: Overcoming the Impedance Mismatch



# A representative approach at Biz Manager level:

**A *Business Component Map* is a tabular view of the business components in the scope of interest.**

“Business Component”:  
part of enterprise  
that has potential  
to operate  
independently

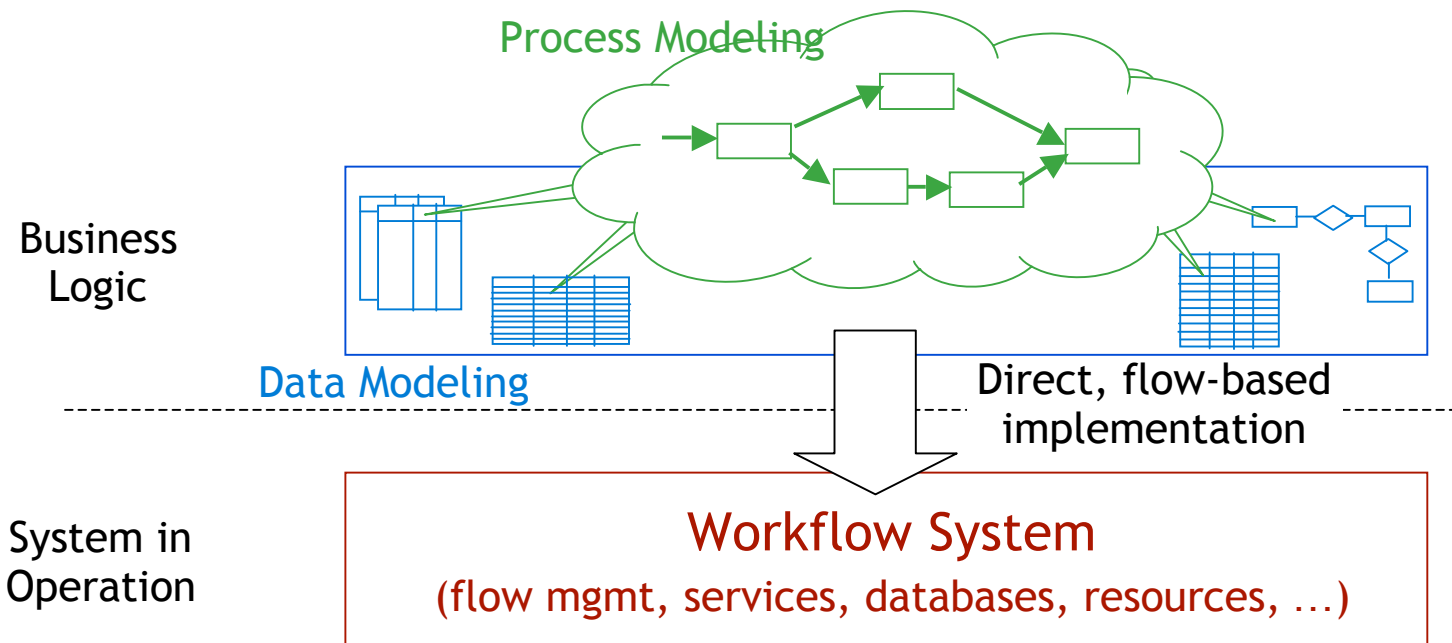
“Business Competencies”: large biz area with characteristic skills and capabilities

“Accountability Level”:  
scope and intent of  
activity and  
decision-making

	Business Administration	New Business Development	Relationship Management	Servicing & Sales	Product Fulfillment	Financial Control and Accounting
directing	Business Planning	Sector Planning	Account Planning	Sales Planning	Fulfillment Planning	Portfolio Planning
controlling	Business Unit Tracking	Sector Management	Relationship Management	Sales Management	Fulfillment Planning	Compliance
	Staff Appraisals	Product Management	Credit Assessment			Reconciliation
executing	Staff Administration	Product Directory	Credit Administration	Sales	Product Fulfillment	Customer Accounts
	Production Administration	Marketing Campaigns		Customer Dialogue	Document Management	General Ledger
				Contact Routing		

# Common approach at IT Level:

An **Activity Flow** is a (typically) graph-based specification of how activities/processes are to be sequenced



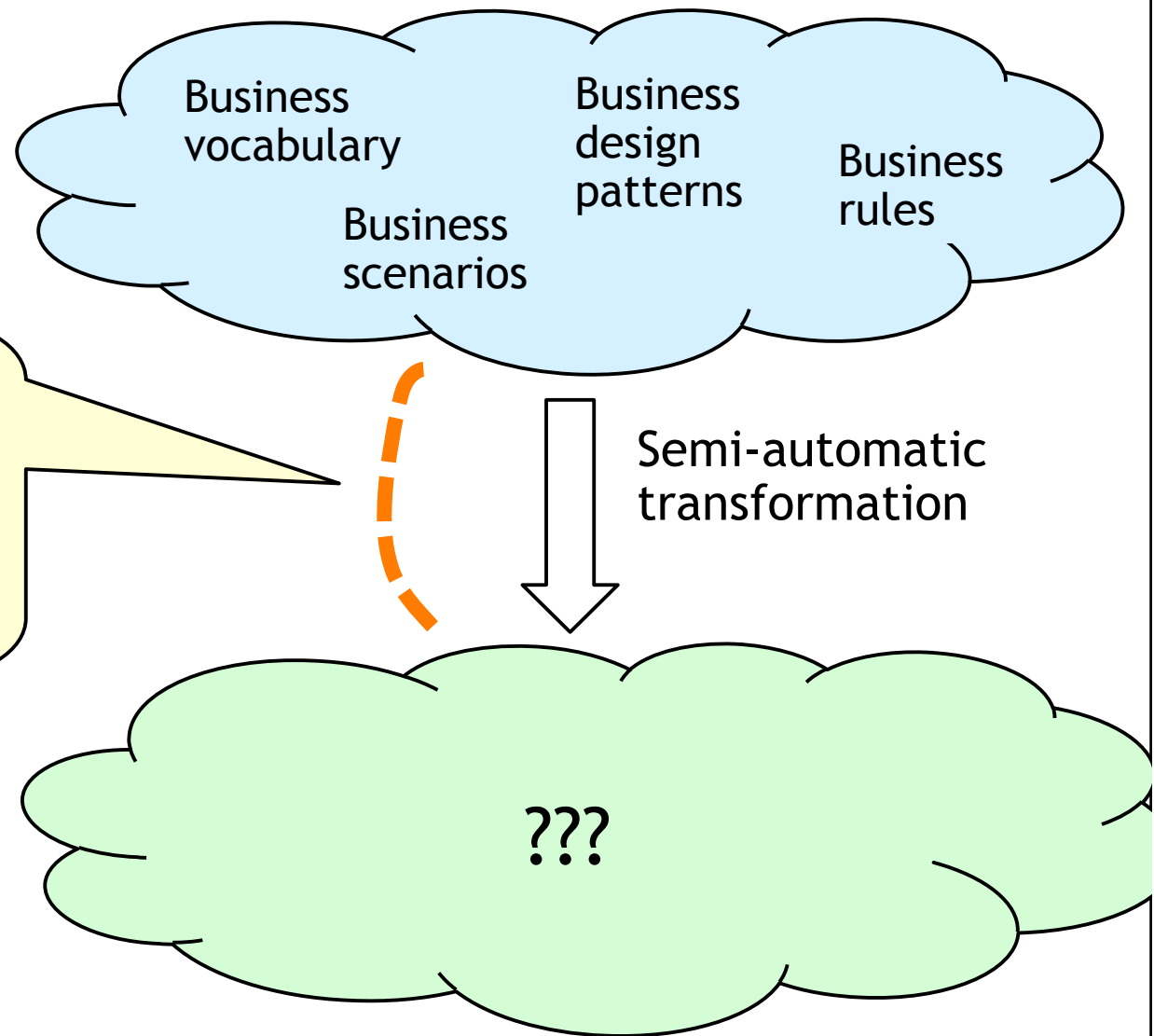
- Data and business objects are typically an afterthought
  - ▶ People “see the trees but not the forest”
  - ▶ Hard for people to communicate across Business Components
  - ▶ Processes often have discontinuities across silos
- Cf. “staple yourself to a customer order”
  - ▶ [Shapiro, Rangan, Sviokla 1992]

# Specifying Biz Operations and Processes, from partial/imprecise to complete/precise

Perspective of Biz  
Architects and Subject  
Matter Experts (SMEs)

The green cloud (formal  
meta-model) will  
provide key building  
blocks for, and  
significantly shape how  
biz architects and SMES  
talk/think in the blue  
cloud

Perspective of  
Solution Designers;  
should have direct map  
to executable workflow  
schema

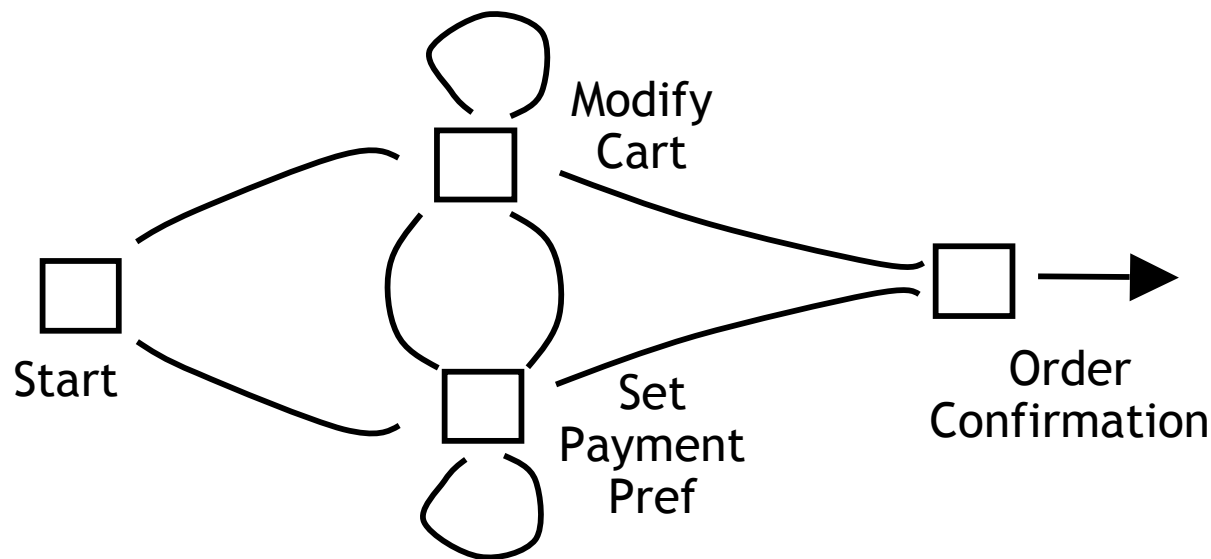


## Examples of Biz Manager level specs

- Some representative “rules” for a BookSeller
  1. “Biz Policy”: Provide as much leeway as possible to gold card customers
  2. “Biz Rule”: For green card customers, get payment before shipping books
  3. “Biz Rule”: If the size of an order changes by > \$50 and customer not paying by AMEX, then confirm with user his payment preference
- Key questions
  - A. How might we accommodate “biz policies” vs. “biz rules”
  - B. What is the underlying language/conceptual model of operations that biz people want to express their rules in?
  - C. Can we simplify everyone’s life by choosing a specific kind of underlying language/conceptual model

# Activity Flows are hard to work with

- This example is exaggerated for Bookseller, but similar things happen in real life scenarios
- Key point: Mapping biz rules to an infrastructure based on activity flows and distributed data sources can be cumbersome



For big cart change and not AMEX, check payment prefs



# The premise of artifact-centric

A “*business artifact*” . . .

- Is a key conceptual business entity that is used in guiding the operation of the business
  - ▶ E.g., fedex package delivery, patient visit, patient encounter
  - ▶ And insurance claim, order, financial deal, ...
  - ▶ These are “schedules” or “road-maps” with memory
- Includes specifications of both
  - ▶ The *information model*, to hold relevant data about the artifact as it moves through the workflow, and
  - ▶ The *possible lifecycles* they might follow

**Business Artifacts provide**

- a “bird’s eye” view of business operations in ways that CBMs and activity flows can not
- “Actionable insight” into a business

## A note on formal foundations

- This talk is focused primarily on motivations for the artifact-centric approach, and modeling at the conceptual level
  - ▶ We describe models that are analogous to the Entity-Relationship model in database management
- Papers presented later today and tomorrow will present some theoretical work, including precise formal models for artifact-centric
- Those models are variations of the formal model introduced in BPM 2007
  - ▶ [Bhattacharya, Gerede, \_\_, Liu, Su 2007]
  - ▶ We are currently working to identify a single, core formal model, close to that of BPM 2007, most likely called the “Logical Artifact Model”, that might become the analog of the relational database model in database management.

# Agenda

- Context and Goals

- “Business Artifacts”

- ▶ Phase I: a state-machine based approach (mature)
- ▶ Phase II: a declarative approach (emerging)

- Status and Related Work

# Key artifacts in bookseller example

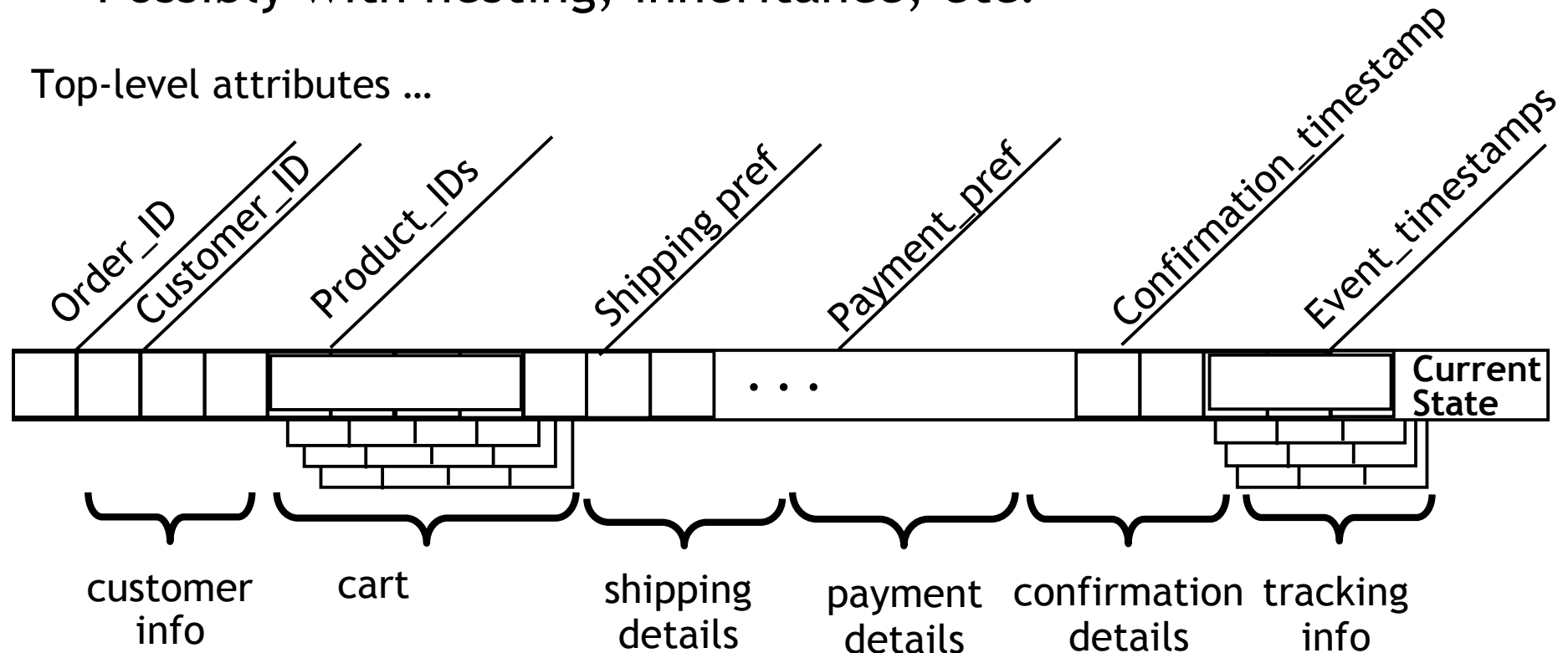
- Order
  - ▶ Info model: all data built up for a single order
  - ▶ Lifecycle: focused on the customer-observable steps
- Customer
  - ▶ Info model: customer info and history
  - ▶ Lifecycle: gathering & updating profile, managing authentication, tracking satisfaction
- Shipment
  - ▶ Info model: Bill of lading, history of steps
  - ▶ Lifecycle: identify goods, group into boxes, monitor shipment
- Title (inventory item)
  - ▶ Info model: Title, author, etc., and availability
  - ▶ Lifecycle: Manage warehouse locations, replenishment, purchasing trends

**In practice, it is typically easy for experts to agree on the key business artifacts, including high-level info model and lifecycle**

# One approach to specify artifact info model: a set of name-value pairs

- Possibly with nesting, inheritance, etc.

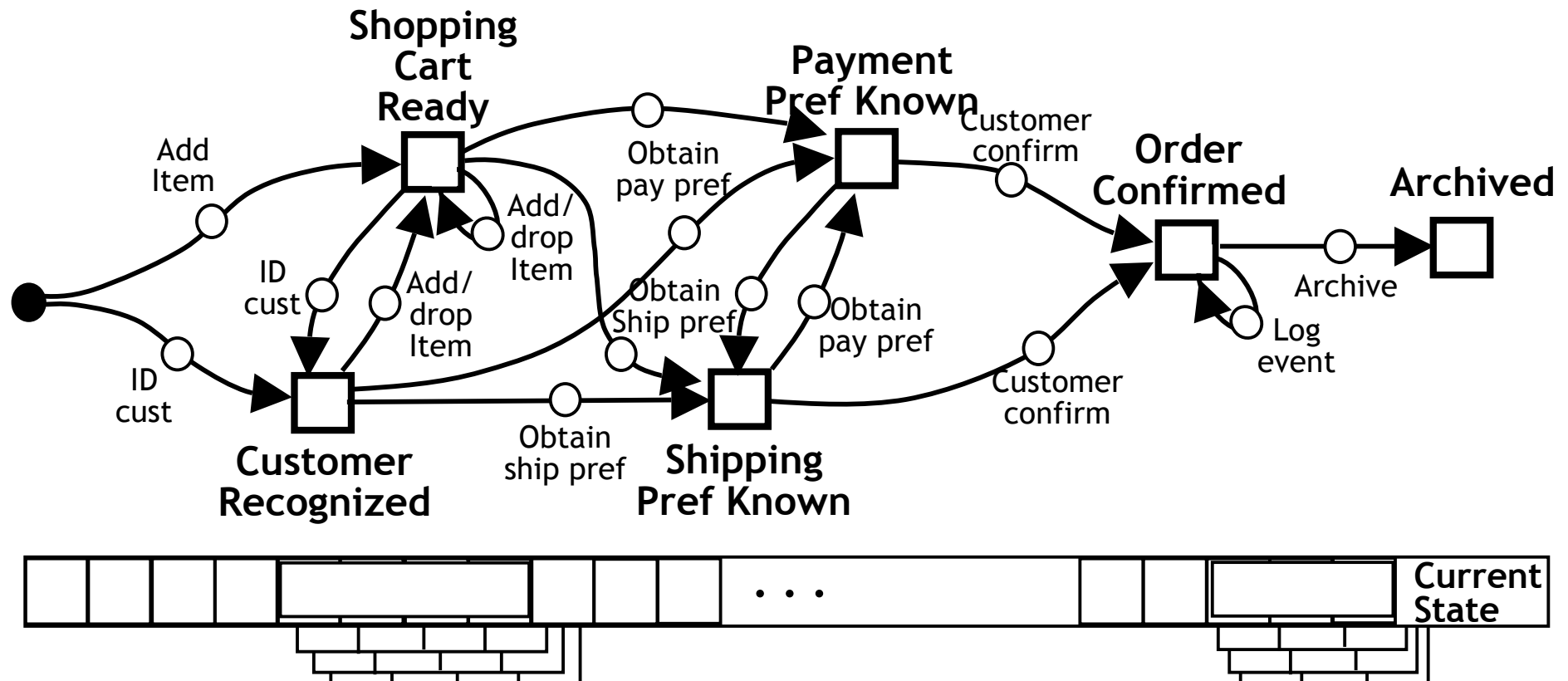
Top-level attributes ...



- Info model provides integrated view of relevant data
- It can be thought of as a “whiteboard” that different people and tasks work on over time
- “Axiom”: All biz relevant info should be in info model

# One approach to model artifact lifecycle: Finite state machines

- States correspond to business-relevant conditions
- Transitions between states (may have guards)
- Tasks move you along a transition



One potential benefit of state machine perspective:  
Typically far fewer states than activities

# Artifact-centric in action (1 of 2): A global financing operation

- Challenge
  - ▶ Global financing/loan organization, with many regional offices, each with different processing
  - ▶ Wanted a unified “global” schema for the biz processing
  - ▶ Tried for 3 years with classical techniques
- Introduction of artifact-centric (June, 2008)
  - ▶ 3-day workshop with 15 SMEs from Finance Org and 5 people from IBM Research artifact group
  - ▶ High-level artifact-centric design created - 3 primary artifacts
  - ▶ All stake-holders agreed on the key artifacts
  - ▶ Instead of bickering, regional teams could cooperate
- Current status
  - ▶ 6-month due-diligence analysis of the artifact-design
  - ▶ Now being rolled out, to manage processes at high manual level
    - Essentially one or two managers per artifact

# Artifact-centric in action (2 of 2): A global Supply Chain application

- **Challenge**
  - ▶ Large scale purchasing operation needed to be re-factored
  - ▶ Has to juggle
    - Requests for goods/services from anywhere within hosting enterprise
    - Enable bids from multiple suppliers
    - Enable selection of best bid, subject to requester needs and legal/procedural requirements
    - About \$1 Billion of outsourcing per year for North America region
- **Introduction of artifact-centric (began 4<sup>th</sup> quarter, 2007)**
  - ▶ Design, implementation, deployment for North America portion within 1 year
  - ▶ Using the artifact toolkit, created in 8 months with 9 developers
  - ▶ Uses “MDHI” tool for auto-generation of web screens/sequences for performing the manual tasks in the workflow
- **Current status**
  - ▶ North America region now deployed
  - ▶ Revised version now being designed/deployed for Asia region



# IBM Research's "Business Entity Lifecycle Analysis (BELA)"

< formally known as "Model-Driven Business Transformation (MDBT)" >

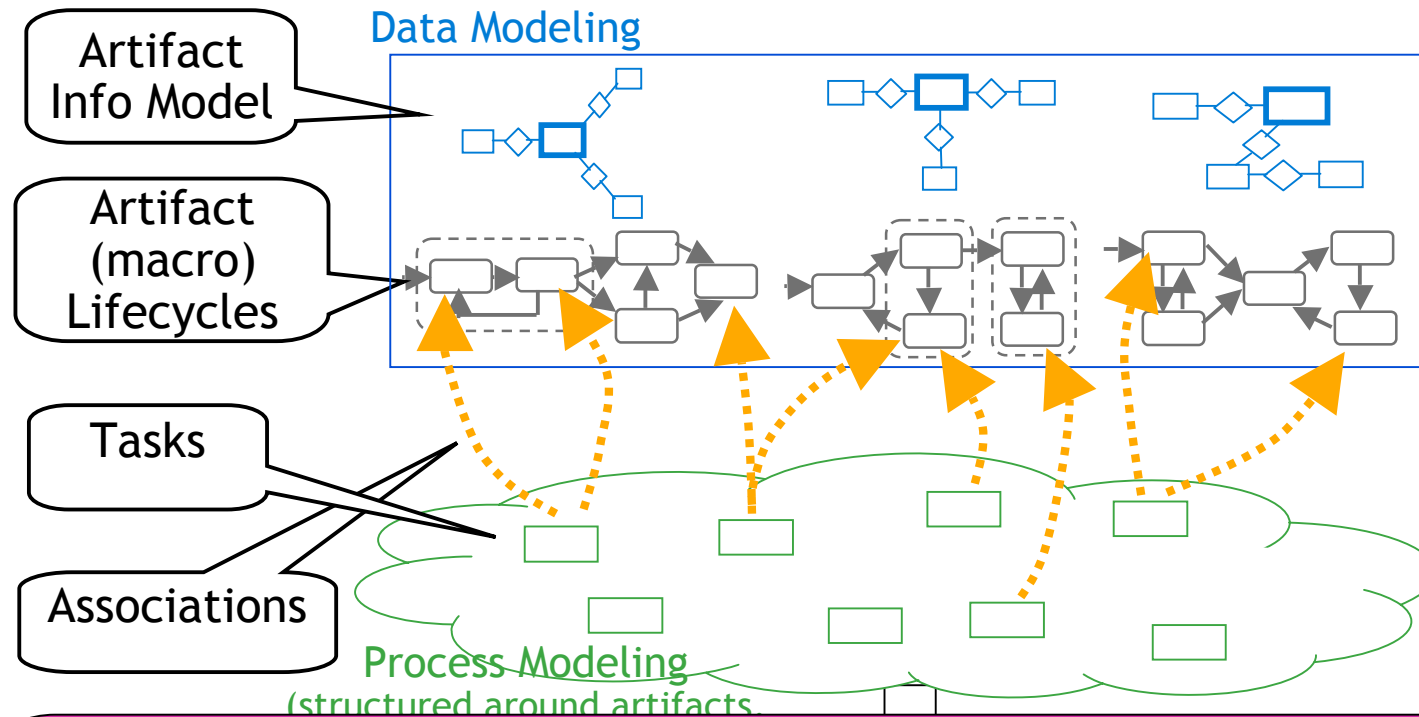
- An effort started in 2001, that has now been used by several internal and external customers
  - ▶ Finance, retail, pharmaceutical, procurement, insurance
- Uses artifact-centric basis
  - ▶ Info models based on nested relations
  - ▶ Lifecycles based on state machines (as illustrated above)
- "Model driven": Once the design is created in the model, it is used to guide the implementation
- Also, provides the basis for auto-generation of the user screens for most of the manual tasks

- Being incorporated into IBM's professional services practice as a component of the SOMA method
- Includes a toolkit for implementing BELA-based BPs on top of WebSphere

# Agenda

- Context and Goals
- “Business Artifacts”
  - ▶ Phase I: a state-machine based approach (mature)
  - ▶ Phase II: a declarative approach (emerging)
- Status and Related Work

# Artifact-centric BP: A framework with many variations



Many different artifact-centric BP meta-models may be considered:

- Different meta-models underlying artifact info models
- Different meta-models for artifact lifecycles (activity-flow, state machine, declarative, ...)
- How services are specified
- How associations are made (including static vs. dynamic)
- Variations on the overall framework, e.g., blur associations and macro lifecycle

## We examine 3 distinct artifact-centric meta-models today and tomorrow

- State-machine based lifecycles (as above)
  - ▶ Demo of Siena prototype environment this morning
  - ▶ See also Marlon Dumas talk tomorrow morning
- “Abstract” “declarative” lifecycle
  - ▶ Essentially, based on forward-chaining rules
  - ▶ Used for preliminary theoretical results
  - ▶ Presented this afternoon and tomorrow morning
- “Practical” “declarative” lifecycle
  - ▶ Again based on forward-chaining rules, but packaged with pragmatic considerations
    - E.g., hierarchy, intuitive macros, side effects, scalability constructs, ...
  - ▶ Briefly overviewed in the next slides

# A current IBM Research endeavor: *Project ArtiFact*<sup>™</sup>

## Building a declarative artifact-centric meta-model

- As with Phase I:
  - ▶ *Actionable Insight*: Provide a representation that can be used by range from high managers, biz arch, solution designers, IT
  - ▶ *Interaction & Collaboration*: Enable multiple stake-holders (both BP designers and BP users) to interact and collaborate effectively
- Addressing emerging challenges
  - ▶ *Flexibility/Variation*: BPs are always changing, and also you may have a generic BP and specializations
  - ▶ *Re-use and composition*: Simplify reusability, composition
  - ▶ *People*: Incorporate a richer model of people and how they interact with the BP - not just roles
- Key enablers:
  - ▶ Shift from procedural to more *declarative/constraint-based*
  - ▶ Support *hierarchy*
  - ▶ Expanded approach to version management
- Also surrounding issues, e.g., user-centric aspects, foundations, optimization, systems, applications, ...

# Benefits of a declarative approach to specifying artifact lifecycles

## ■ *Declarative vs. Procedural*

- ▶ With declarative, you focus more on **what** is to happen . . .  
. . . without worrying about exactly **how** it is to happen

## ■ Flexibility of individual runs

- ▶ Easy to support “ad hoc” procedures, where multiple tasks may be done repeatedly in arbitrary orders
- ▶ Easier to specify rich “points of variation”

## ■ Flexibility of BP evolution

- ▶ When specifying changes to the BP, the details of “fitting things back together” is often handled “under the hood”, not explicitly
- ▶ Easier to support a “generic” BP with numerous specializations

## ■ Potential for automation

- ▶ Easier to do design-time analysis for correctness, deadlock, etc.

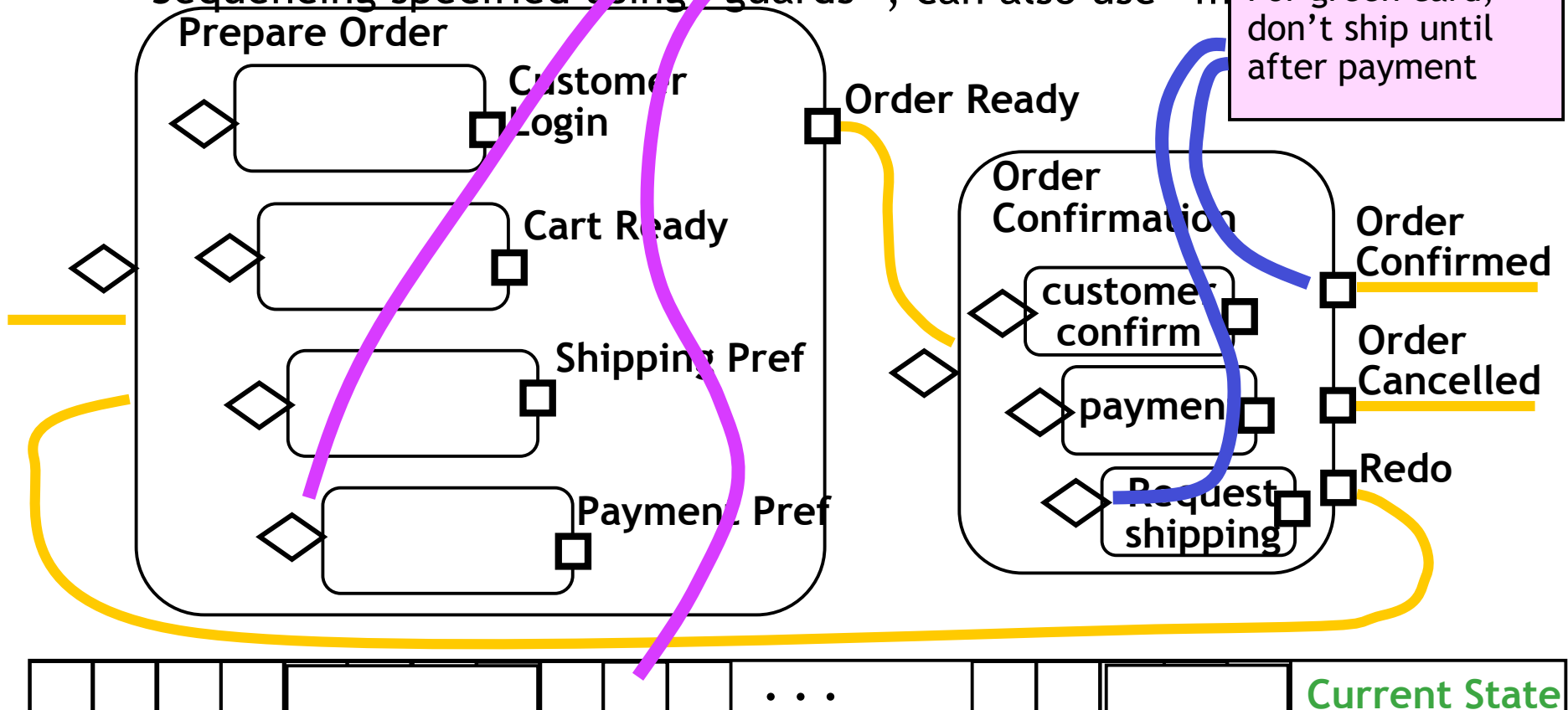
- Perhaps easy for academics to see the advantages
- Challenging to persuade the customers, industry

# Lifecycle Specification in ArtiFact 0.1 (informal)

- Focus on “milestones” (or “goals”)
  - This is a condition on a snapshot of an artifact
- “Stages”: Clusters of tasks that (attempt to) achieve
- There can be hierarchy, to simplify for the designer
- Sequencing specified using “guards”; can also use “m

For big cart change and not AMEX, then check payment prefs

For green card, don't ship until after payment



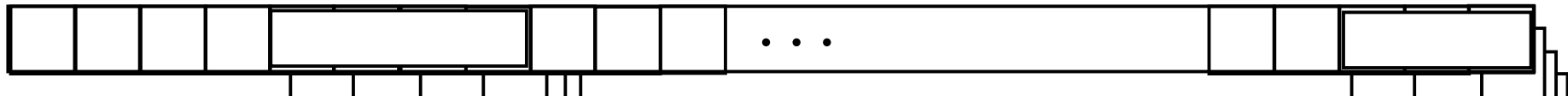
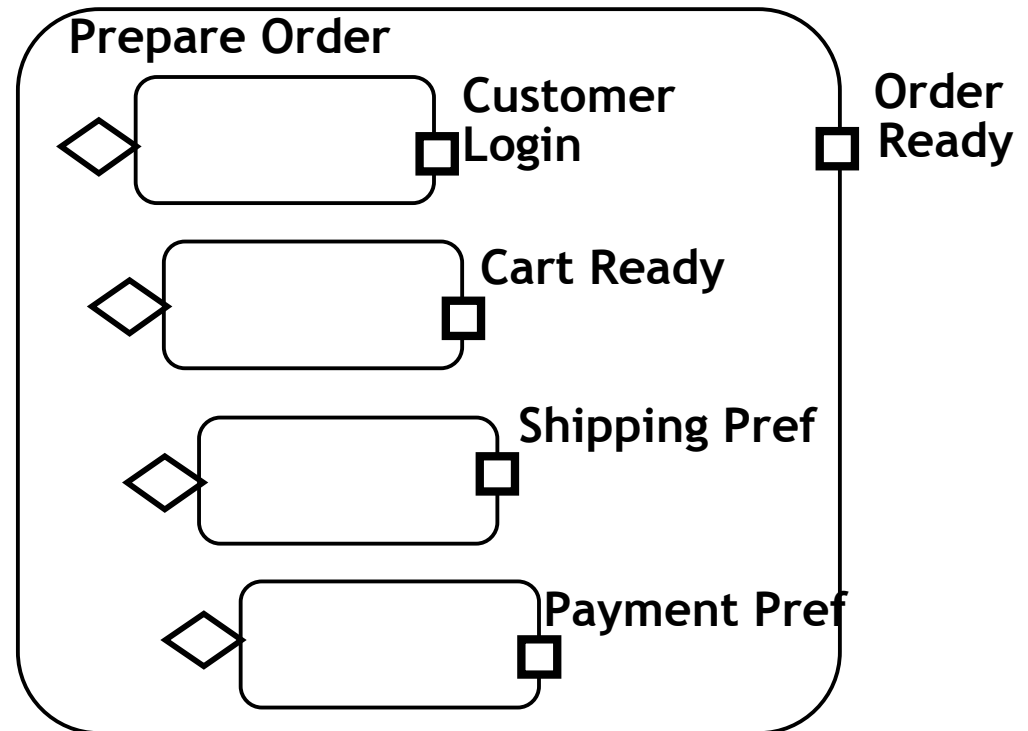
The artifact info model is crucial in providing structure (and traceability) for a potentially free-form lifecycle

## More on the “guarded” style for lifecycle specs

Can put a variety of conditions into the “guards”, e.g.,

- Can only enter Customer login stage once
- If you change Cart you must revisit Shipping Pref
- Cannot enter Payment Pref until either you are logged in or put stuff in Cart

Can support many  
different “patterns” of  
sequencing



**Flow charts and state machines useful in some contexts;  
“Ad hoc” style useful in other contexts**



## Status/plans for ArtiFact 0.1

- First-cut meta-model with operational semantics by May, 2009
- First-cut prototype implementation by September, 2009
  - ▶ Will use Siena as a preliminary “seed”
  - ▶ But shift from Powerpoint to Web-based GUI
- Design GUI
  - ▶ Storyboards and user feedback by June, 2009
  - ▶ First-cut prototype by December, 2009
- Prototype available for open-source extensions by April, 2010
- Current University partners: UCSB, UCSD, U Rome La Sapienza, U Bozen/Bolzano

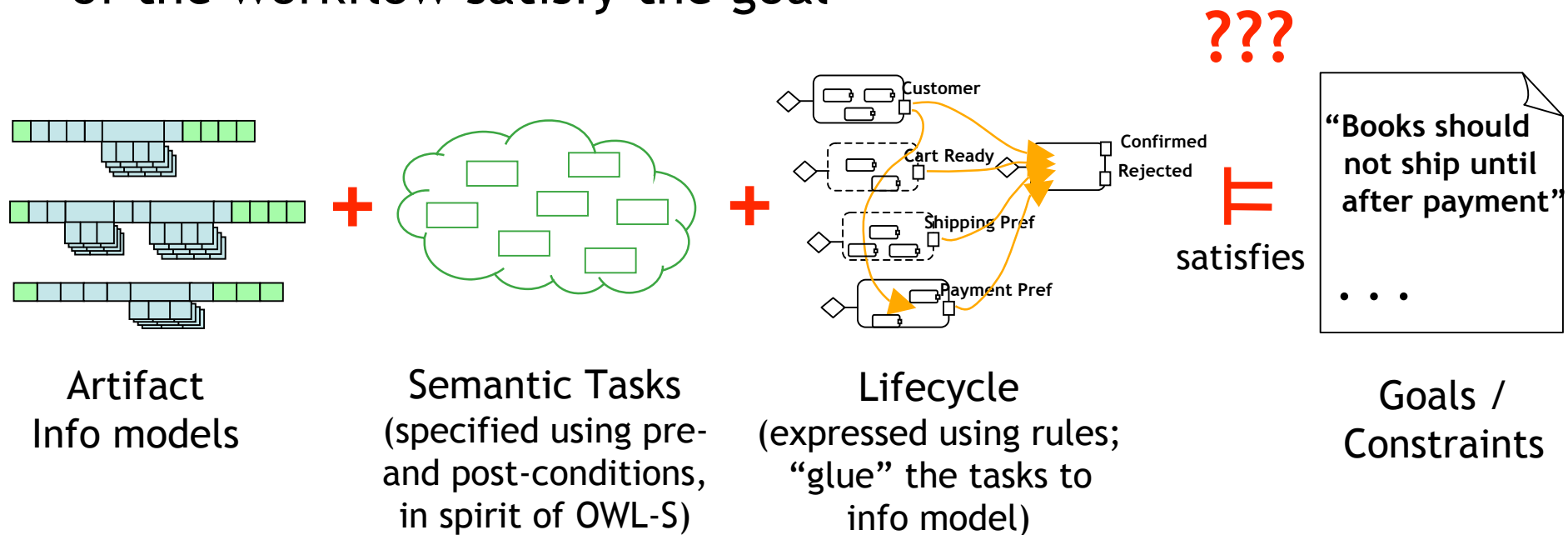
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# Exploiting the declarative nature of artifacts (1 of 2)

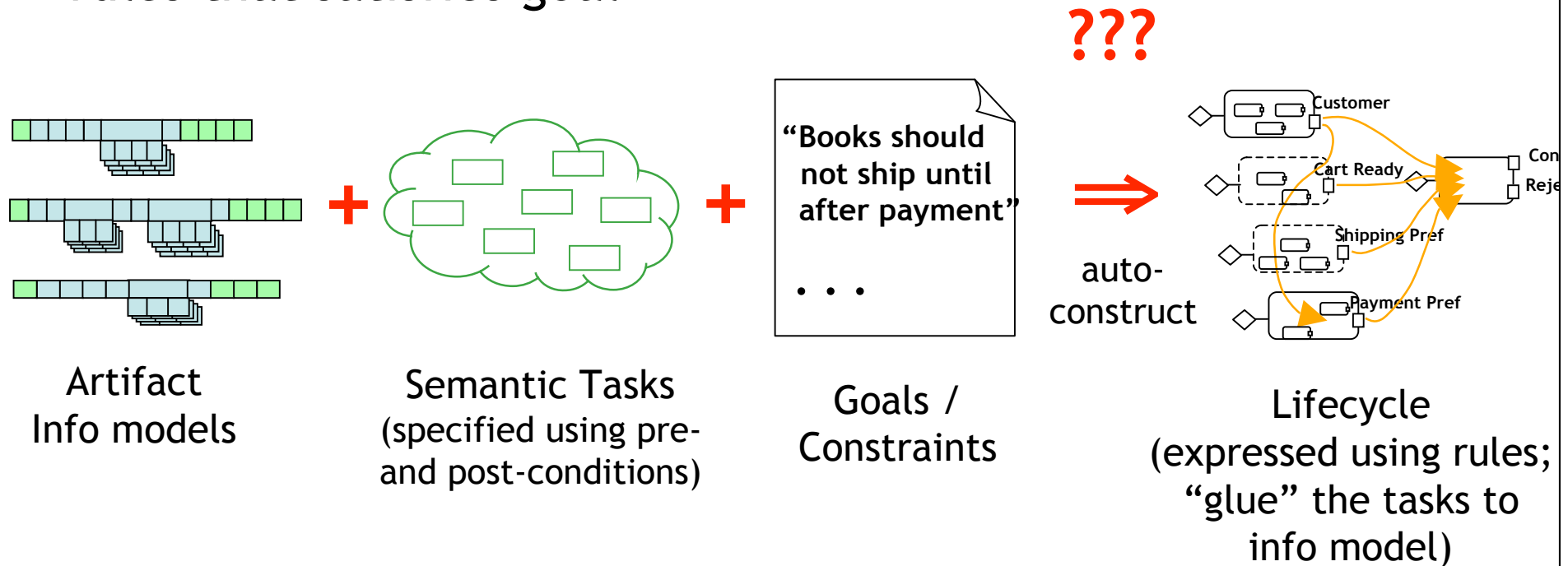
- Analysis: Given a workflow and a goal, do all executions of the workflow satisfy the goal



- ▶ In general, this is undecidable (e.g., if “new”, if set-valued attributes)
- ▶ Boolean attributes, no quantifiers, goal/constraint on final snapshot  
⇒ PSPACE-complete [Bhattacharya, Gerede, Liu, Su 07]
- ▶ Dense linear order, no quantifiers, limited use of set-valued attributes, goals from LTL-FO ⇒ PSPACE-complete [Deutsch, Patrizi, Vianu 09]

## Exploiting the declarative nature of artifacts (2 of 2)

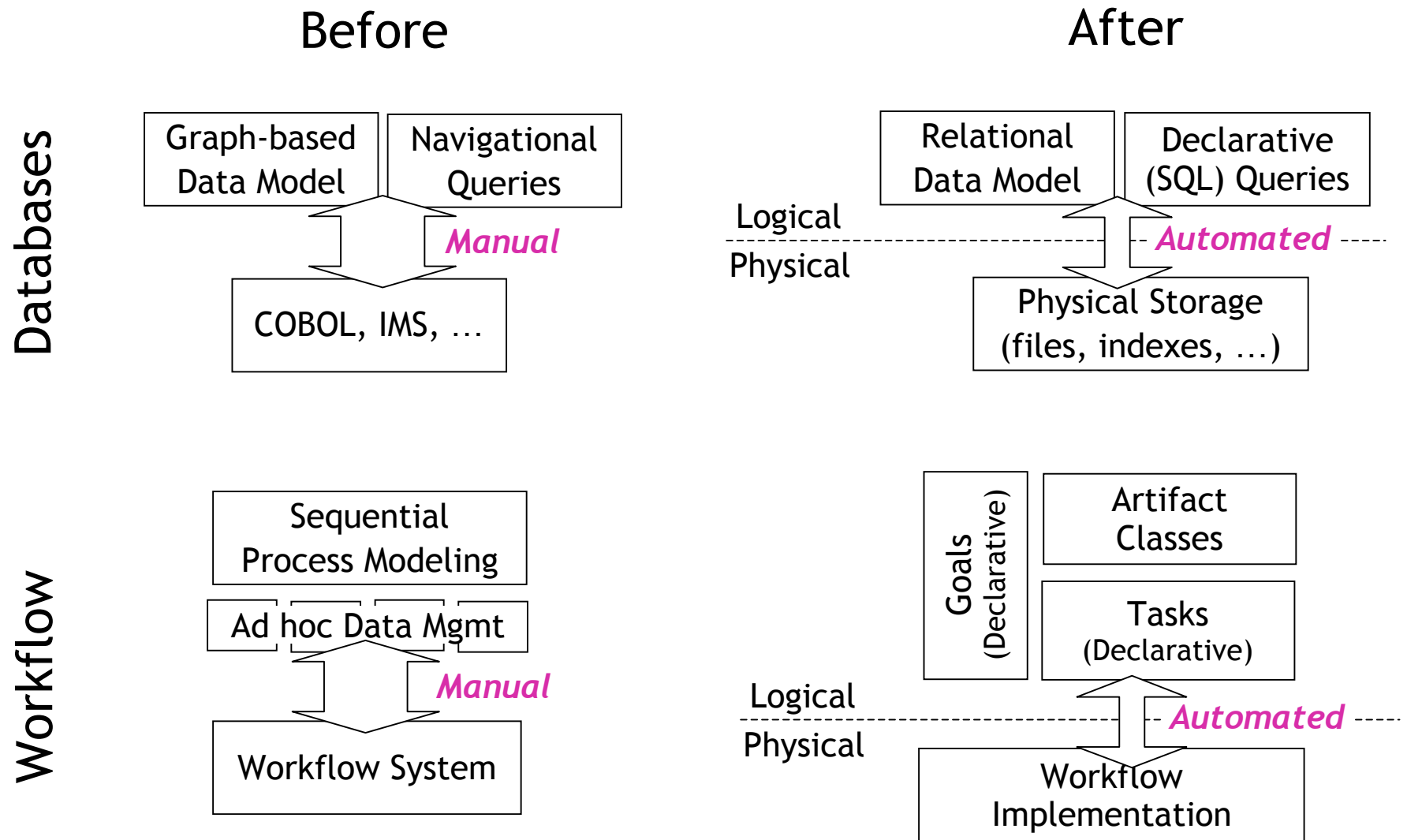
- Synthesis: Given a pre-workflow and goal, find a set of rules that satisfies goal



- ▶ If single artifact, and the goal focuses on final snapshot of artifact
  - ▶ Dense linear order, no quantifiers, no sets  $\Rightarrow$  PSPACE-complete

This investigation is still young, but starts to provide some structure for the formal study of declarative artifact-centric workflow

# An analogy to Relational Databases



## Selected related work (1 of 4)

- Document-based workflow
  - ▶ [Glushko+McGrath 05]: focus mainly on passing documents between components
    - Little focus on the “trace” of how document was arrived at
    - Little focus on the processing of a document “”inside” a component
  - ▶ Document Management Systems
    - Are evolving towards a style of (procedural) artifact-centric
- ECA-based workflow
  - ▶ [Dayal 88], [Hsu et al 88], [Muller et al 04], ...
  - ▶ No prominence for business objects

## Selected related work (2 of 4)

- Declarative workflow specification

- ▶ Vortex [H. et al 99]

- No side-effects
    - Requires write-once semantics

- ▶ DecSerFlow [van der Aalst+Pesic 06]

- No prominence for business objects
    - Subset of LTL with intuitive graphical representation
    - Cannot express synchronization

- Semantic Web Services

- ▶ E.g., OWL-S [McIlraith et al 01]:

- Web services focus on input-output
    - Semantic web services focus on input-output plus pre-conditions and effects on “external world”
    - Artifacts can take the place of “external world”

- ▶ Artifact-centric BP is a “low-hanging fruit” for semantic web service techniques

## Selected related work (3 of 4)

- Artifacts arising implicitly in Digital Government
  - ▶ E.g., Benchmarking Report on Business Process Analysis and Systems Design for Electronic Recordkeeping - by US National Archives and Records Administration
  - ▶ A call to combine Record Management with Biz Process design
- Artifacts arising implicitly in Healthcare Delivery
  - ▶ E.g., Idealized Design of Clinical Office Practice (IDCOP) by the Institute for Healthcare Improvement
  - ▶ Shifting to focus on patients and “patient encounters” (care sequences for them), rather than on individual office visits



## Selected related work (4 of 4)

### Closely related approaches

- “River Fish” perspective (U San Paulo and GTech)
- Object Behavior Models  
[Redding+*Dumas*+ter Hofstede+Iordacheschu]
- Roman Model with “blackboards” [*De Giacomo et. al.*]
- Mapping from XSRL to running service [*Aiello*]
- Object Lifecycle Explorer [IBM Zurich]

# Summary

- “**Business Artifacts**” provide a new way to design and implement Business Processes
  - ▶ Can provide **actionable insight** for businesses
- A business artifact focuses on a conceptual business entity, and includes
  - ▶ Information model for the entity
  - ▶ Lifecycle for the entity
  - ▶ **Breaking traditional separations between data and process**
- There are many possible BP meta-models based on the basic notion of business artifact
- IBM Research’s **Project ArtiFact™** is
  - ▶ Creating a declarative rendition of artifact-centric
  - ▶ Exploring many aspects around the new meta-model, including user-centric, implementation, monitoring and self-adaptation, BP life-cycle, foundations, ...
  - ▶ **Aggressively seeking university collaborators**

# Back-up slides

## Forrester July 2007 market forecast

- \$6.3 Billion by 2011 for BPM sw, services, and maintenance worldwide
- Growth accelerating, and between 17.5% to 35.5% per year over next 5 years
- Rapid growth due to four key trends:
  - ▶ Increased deployment of composite/dynamic applications developed in BPM suites
  - ▶ Continued adoption of BPM to ensure controlled, auditable processes as required by SOX, Basel II, HIPAA and other compliance mandates
  - ▶ Reduced BPM costs, thanks to "a la carte" pricing of

**Business Process Management is an economically important context in which to do research on data and service composition**