Business Processes as Artifacts

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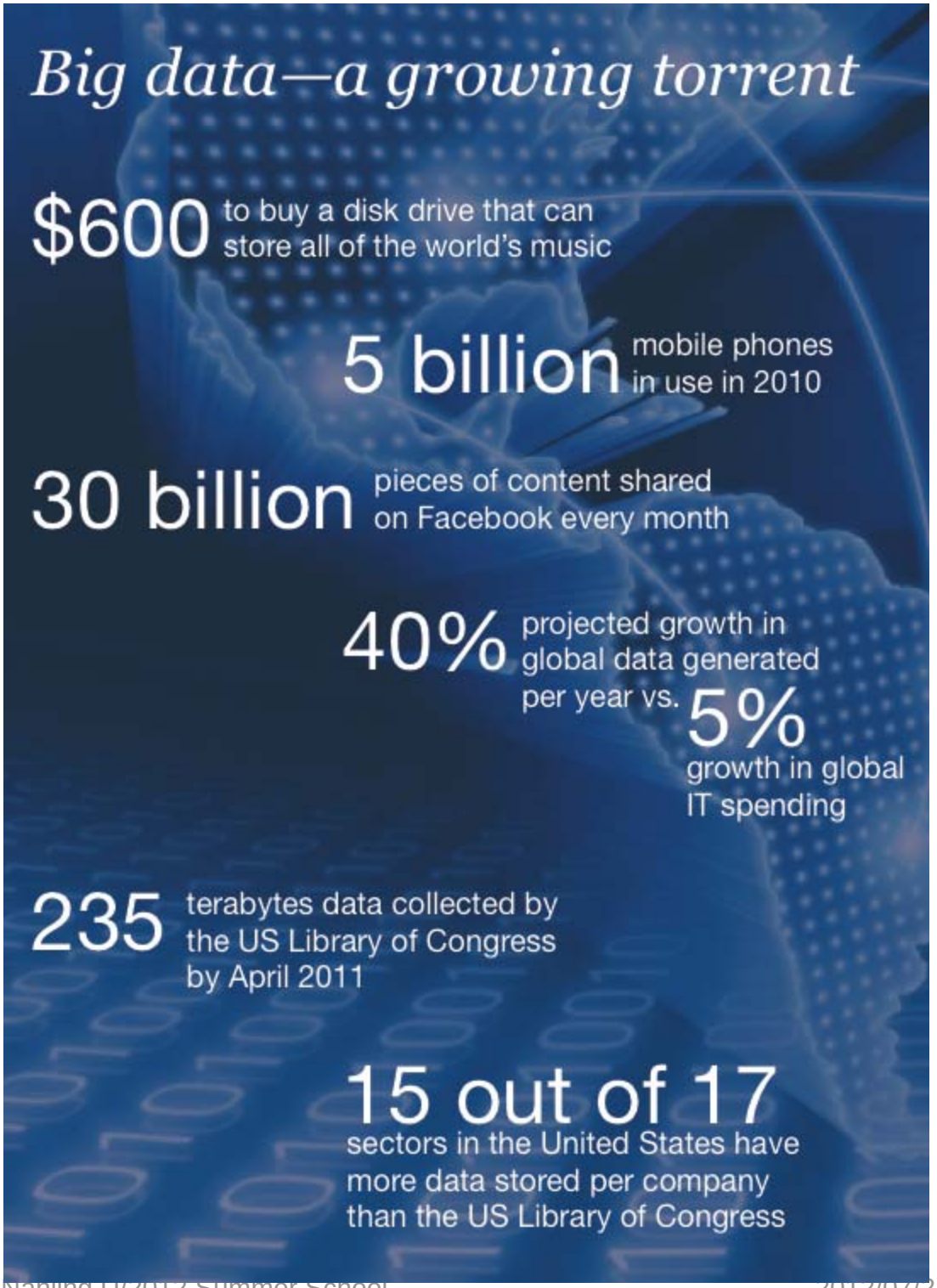
The "Big Data" Report

- Mckinsey Global Institute, June 2011:
  Big data: The next frontier for innovation, competition, and productivity

- MGI: established in 1990 to develop deeper understanding of the evolving global economy
  Mission:
  To provide leaders in the commercial, public, and social sectors with the facts and insights on which to base management and policy decisions



From EXECUTIVE SUMMARY:

"The United States alone faces a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts to analyze big data and make decisions based on their findings."

What big data can generate:

US health care

- $300 billion value per year
- ~0.7 percent annual productivity growth

Europe public sector administration

- €250 billion value per year
- ~0.5 percent annual productivity growth

Global personal location data

- $100 billion+ revenue for service providers
- Up to $700 billion value to end users

US retail

- 60+% increase in net margin possible
- 0.5–1.0 percent annual productivity growth

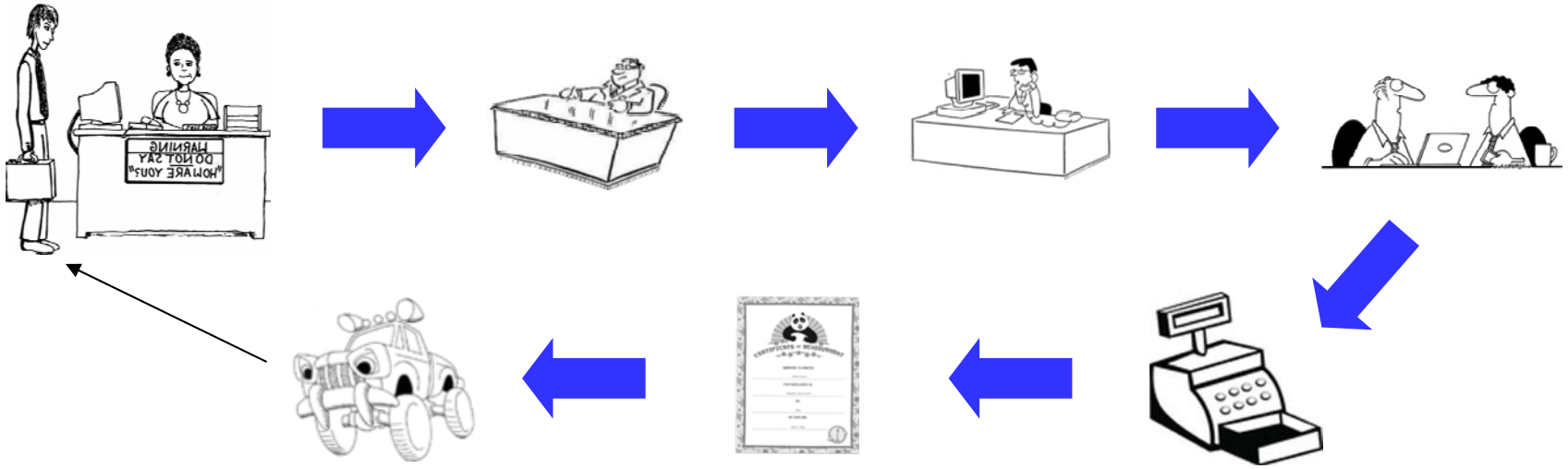
Manufacturing

- Up to 50 percent decrease in product development, assembly costs
- Up to 7 percent reduction in working capital

SOURCE: McKinsey Global Institute analysis

Business (Biz) Processes

- A biz process is a set of one or more linked activities (automated or manual) that collectively realize a business objective or policy goal,
  normally within the context of an organizational structure defining functional roles and relationships

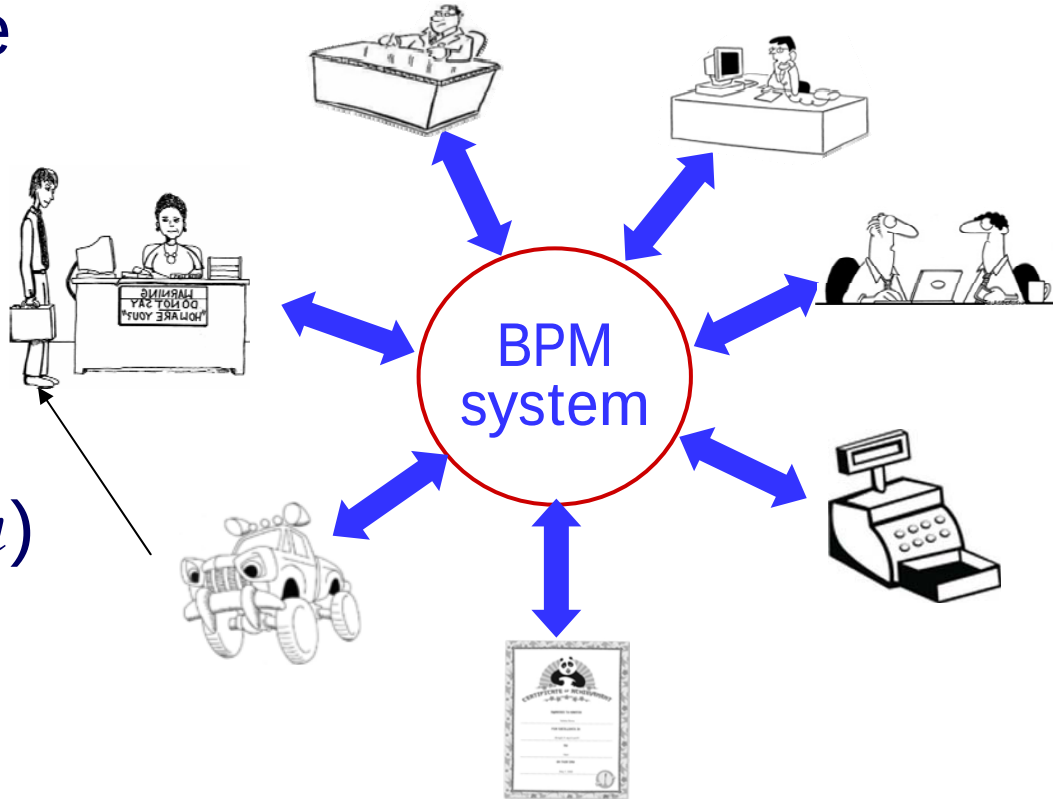


Obtaining a Permit

BP Management Systems (BPMSs)

Software systems to manage and support (and control)

- biz models
- data (*documents, files, …*)
- enactments
- resources (*including human*)
- others (*e.g. auditing*)



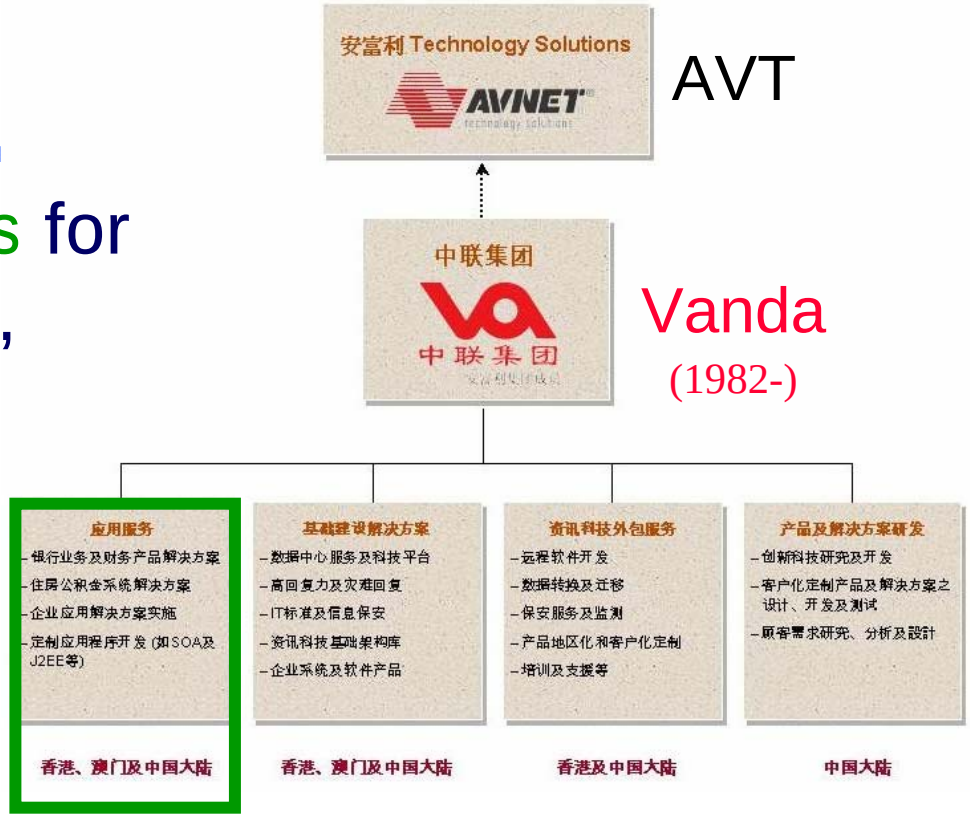
BP "=" workflow in the wider sense

Traditional meaning of workflow in 80's to early 90's means task sequencing

Outline

- Challenges in Business Process Management
- Artifact-centric Modeling Approach
- EZ-Flow and Selected Technical Issues
- Conclusions

Vanda Group



- Developing workflow systems for regional banks, credit unions, provident funds, ...
- Est. 60% of the market excluding national banks

Key obstacles:

- Training (engineer liquidity)
- Repetition of work, labor intensive (could make more $$ or ¥¥ and be more competitive)
- High maintenance cost

developed workflow application domains

Hangzhou Housing Management Bureau

- Population: 8.7 millions

One division (~400 SMEs) deals with all real estate licenses, permits, titles, etc.

- 300,000 cases each year,
  ~500 workflow (types), 35% 1 day, 30% 7-9 days

developing workflow application domains

Hangzhou Housing Management Bureau

杭州市住房保障和房产管理局
www.hzfc.gov.cn

- Population: 8.7m

One division (~400 SMEs) deals with all real estate licenses, permits, titles, etc.

- 300,000 cases each year,
  ~500 workflow (types), 35% 1 day, 30% 7-9 days

[Jin-Wen-Wang CoopIS 2011]

SAP reference models: 600+

Haier CHINA 3,000+

SUNCORP 6,000+

CNR 中国北车股份有限公司 China CNR Corporation Limited 200,000+

Hangzhou Housing Management Bureau

- Population: 8.7m

One division (~400 SMEs) deals with all real estate licenses, permits, titles, etc.

- 300,000 cases each year,
  ~500 workflow (types), 35% 1 day, 30% 7-9 days
- Contractor/in-house development of workflow system(s)
  (¥¥ millions for in-house only)

Challenges:

- Manage changes (policy, environment, ...)
- Serious lack of automation for design-development-maintenance

developing workflow application domains

Hospitals: RuiJin & Cottage

上海瑞金医院

- Health care delivery:
  much of the $300 billion could be gained
- Treatment workflows can fundamentally improve health care quality

Falling far behind:

new IT divide?

- No workflows, conflicting “workflows”
- “Shaky” IT infrastructures

- RuiJin has the largest IT team (40+FTEs) among all hospitals in Shanghai

wishful workflow application domains

Application and Research Challenges

- Lack of clear ways to combine various factors of workflows
- Lack of workflow technology to support a variety of essential functions
- Long tail phenomenon is a “holy grail”
- Application domains work in isolation
- Unifying holistic conceptual models
- Design and runtime support
- Reasoning, business “informatics”, process mining
- Interoperation

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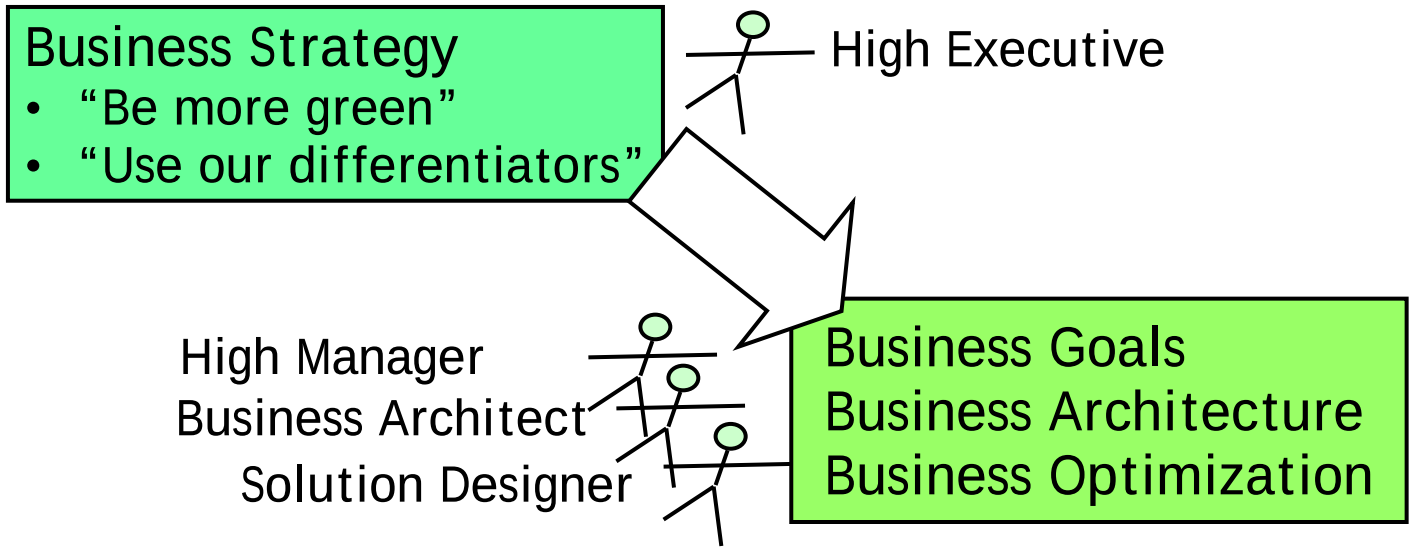
The Challenge of BPM



A Representative "Model" at Biz Manager Level

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

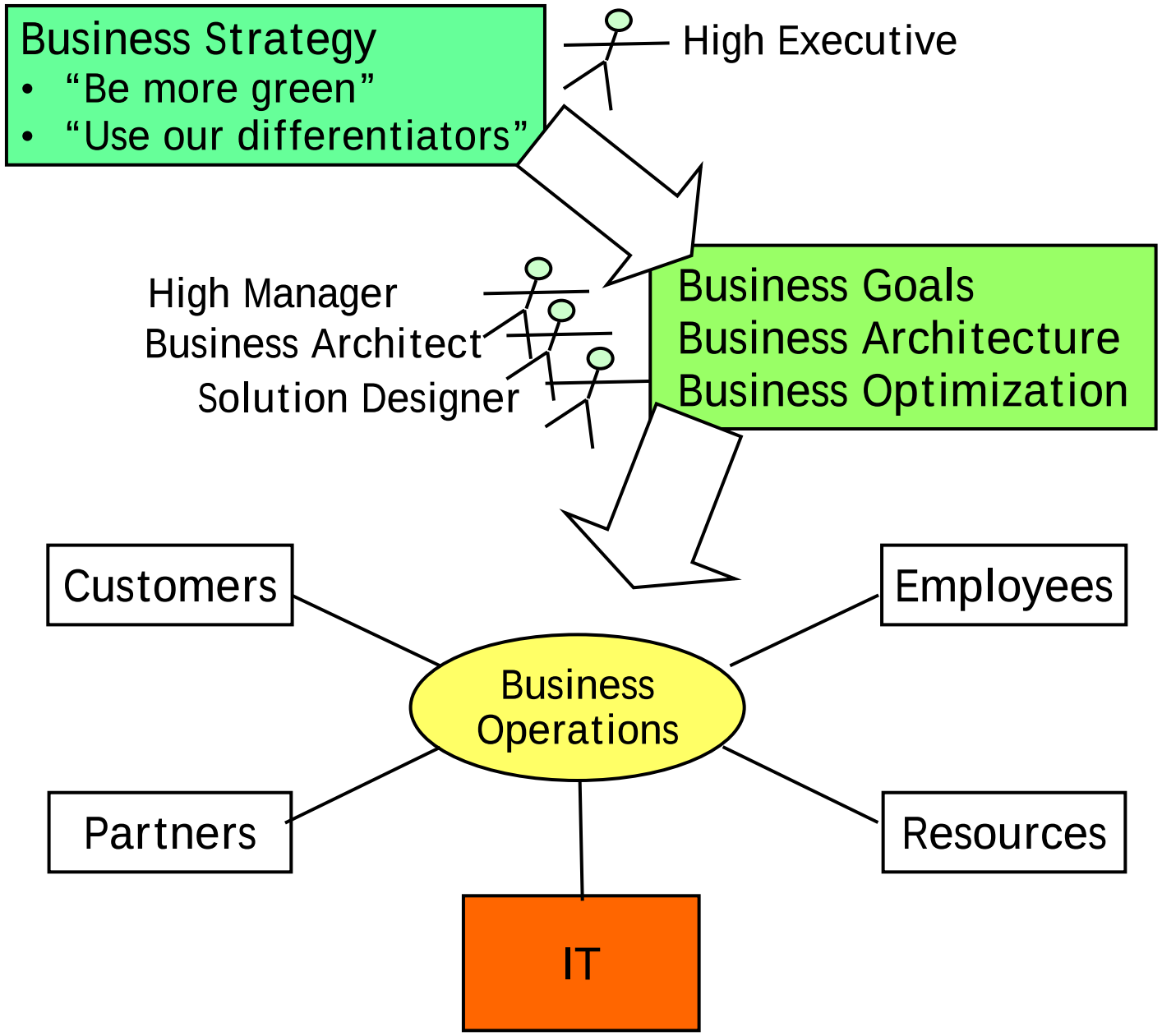
"Business Component": part of enterprise that has potential to operate independently

"Business Competencies": large biz area with characteristic skills and capabilities

"Accountability Level": scope and intent of activity and decision-making

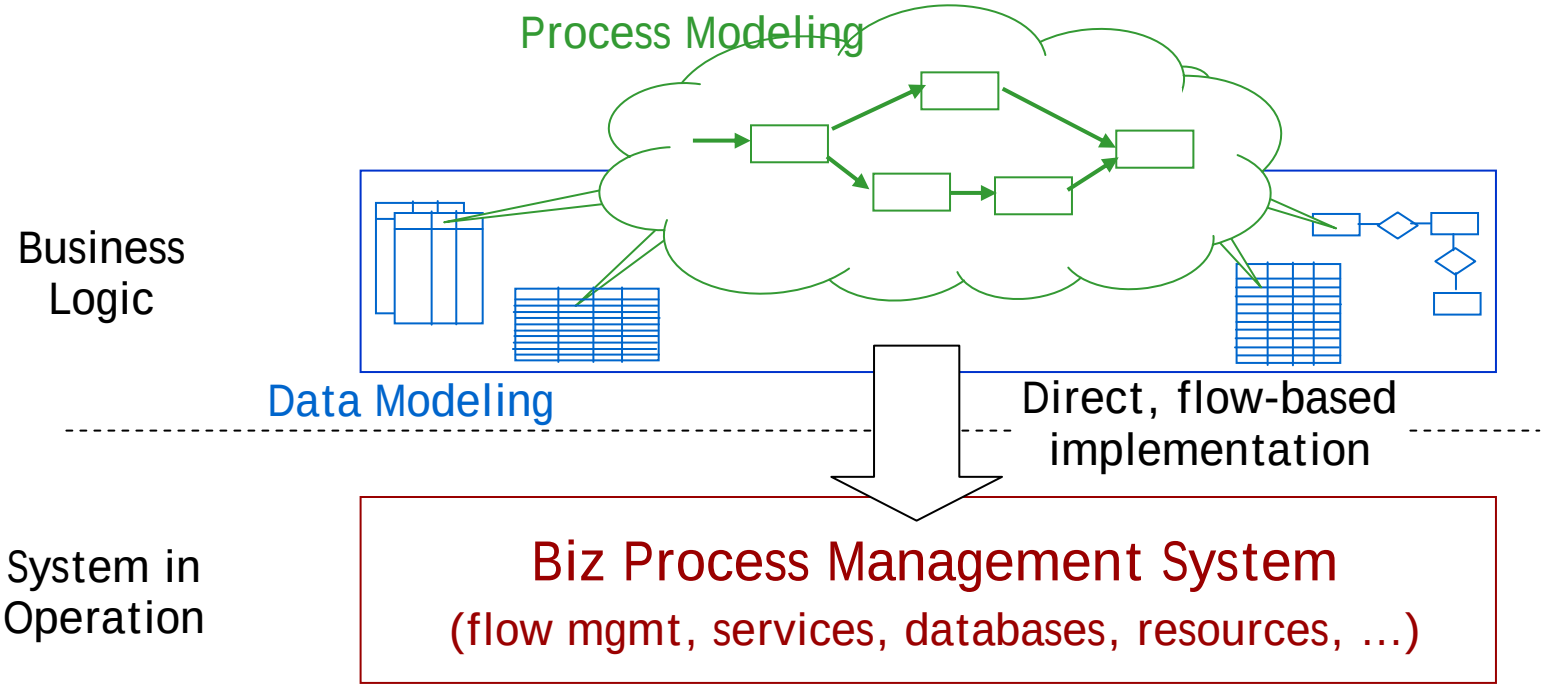
	Business Administration	New Business Development	Relationship Management	Servicing & Sales	Product Fulfillment	Financial Control and Accounting
directing	Business Planning	Sector Planning	Account Planning	Sales Planning	Fulfillment Planning	Portfolio Planning
controlling	Business Unit Tracking	Sector 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		

The Challenge of BPM

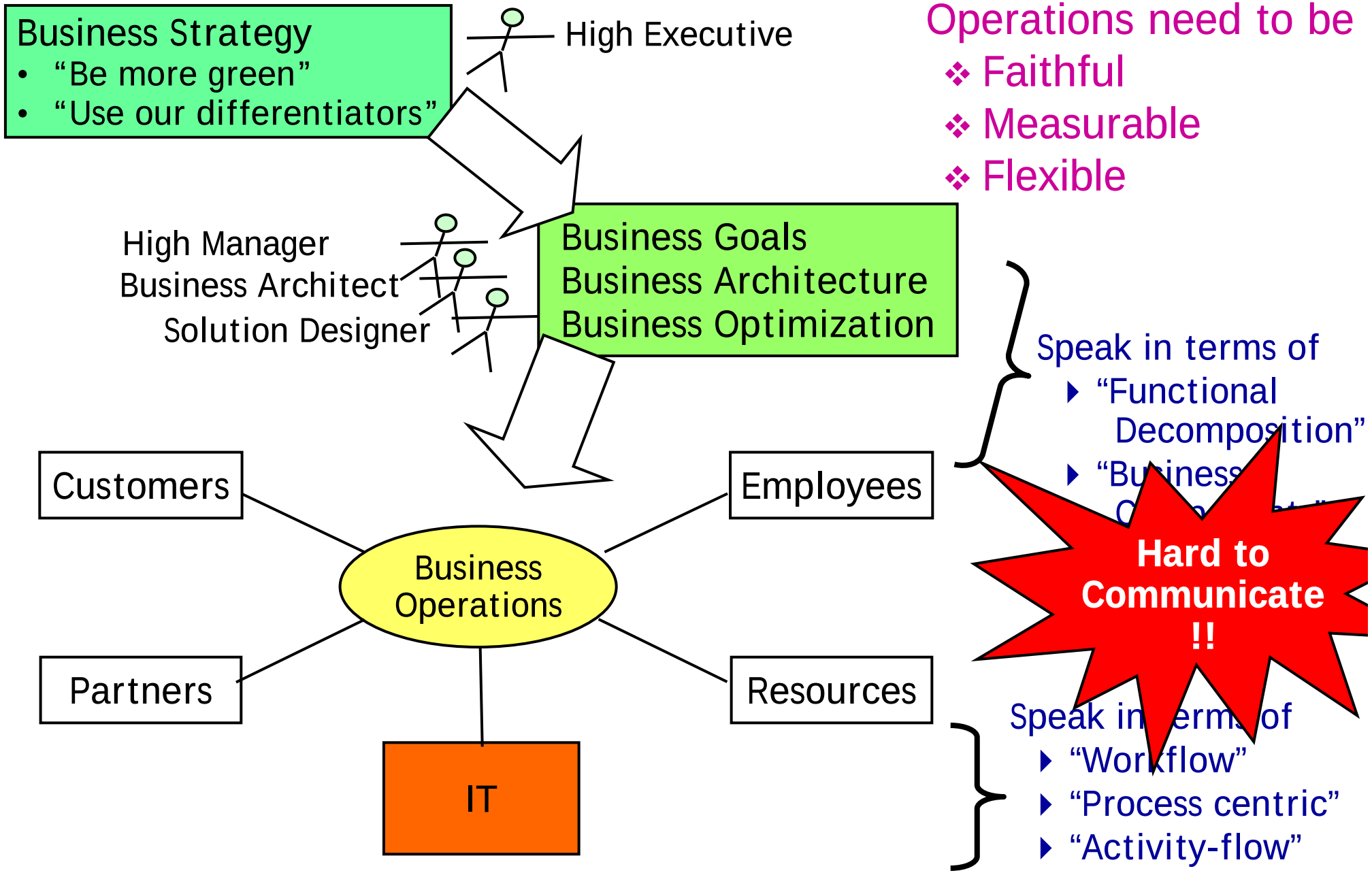


Common Model at IT Level:

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



The Challenge of BPM



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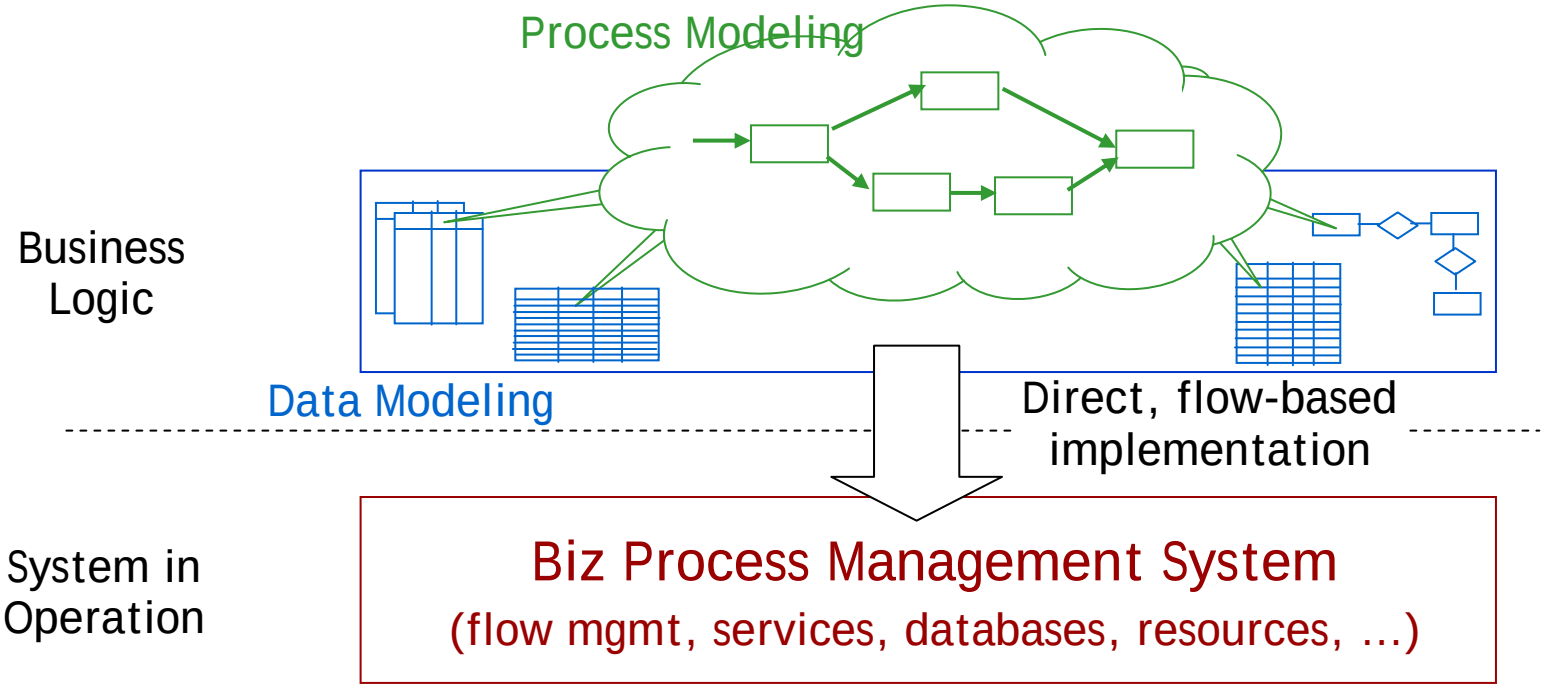
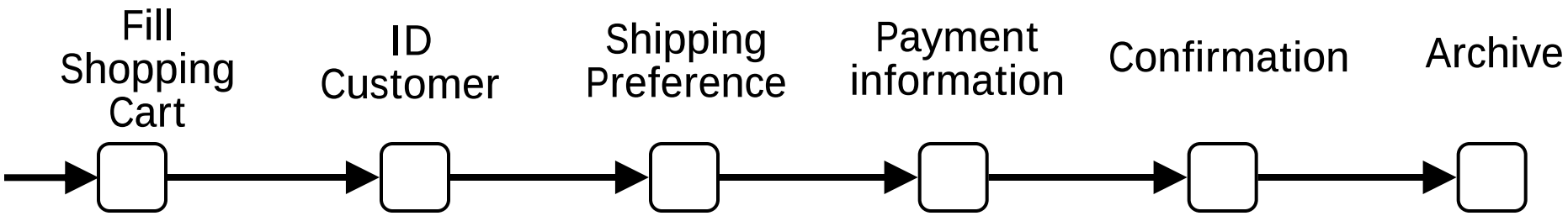


- Data and business objects are typically an afterthought
- Hard for stake-holders to communicate about the big picture
  - People "see the trees but not the forest"
  - Overall process can be chaotic – Cf. "staple yourself to a customer order"
- Hard to manage versions
  - E.g., evolution, re-use, generic workflow with numerous specializations

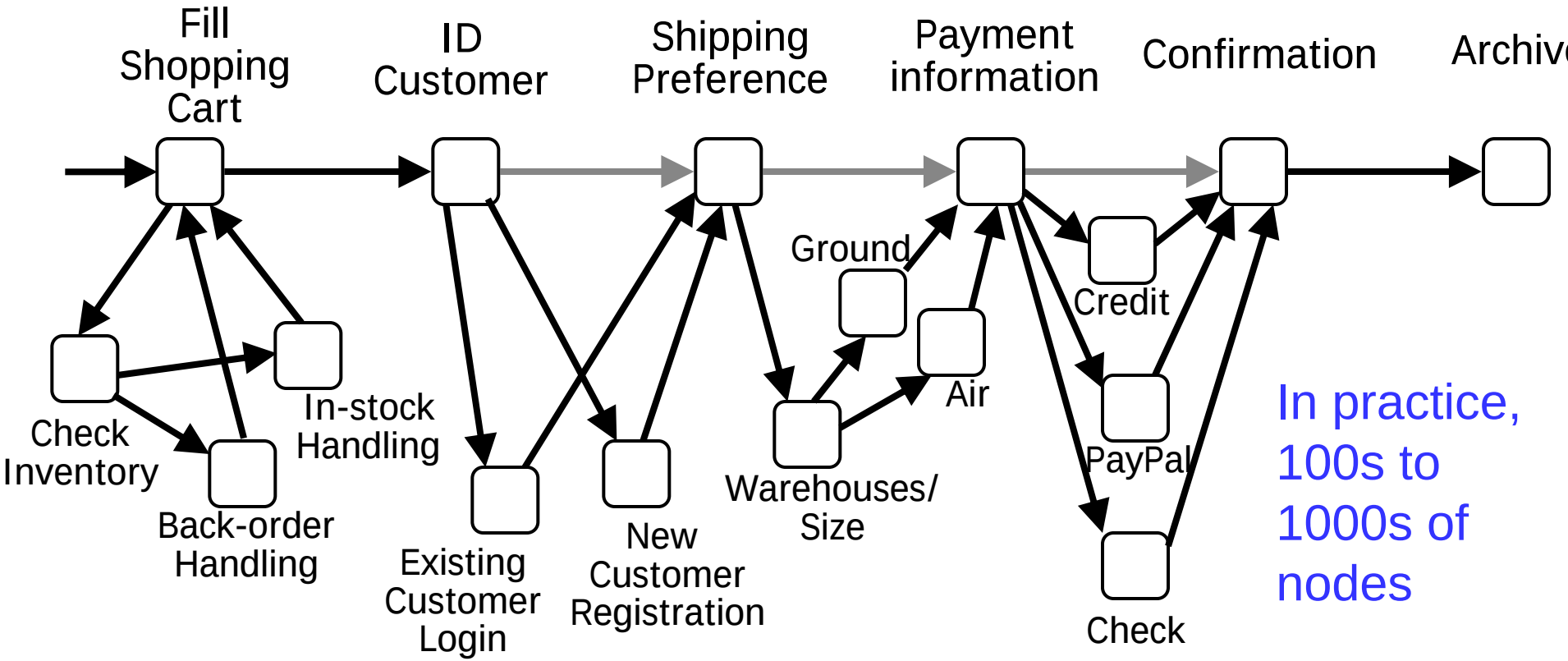
Typical Biz Process Modeling

- A bookseller example: Traditional control-centric models



Typical Biz Process Modeling

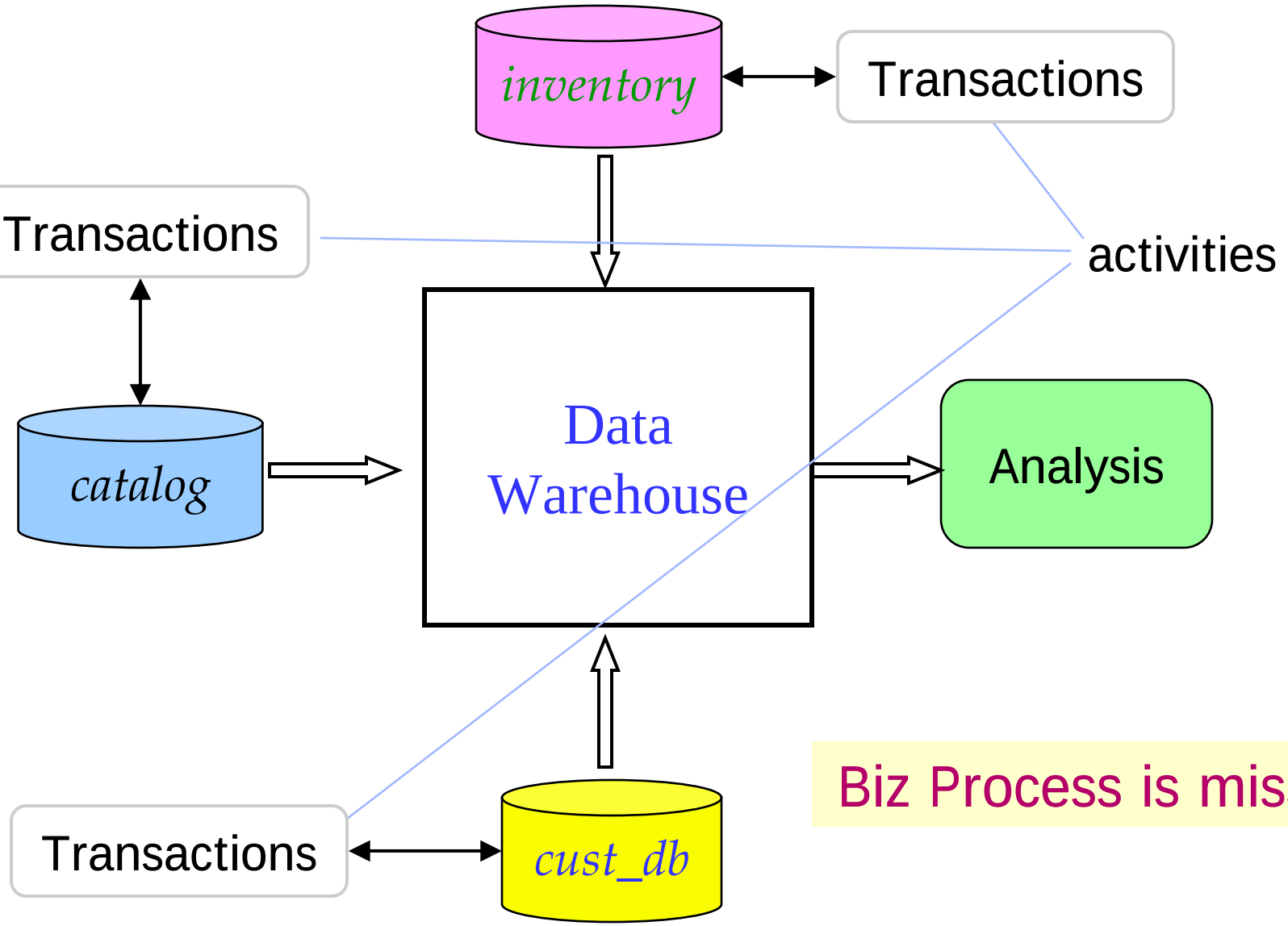
- A bookseller example: Traditional control-centric models
- Multiple steps needed for each activity



Hard to reason, find useful views: missing data

BP Analytics (Biz Intelligence)

- Extract-Transform-Load



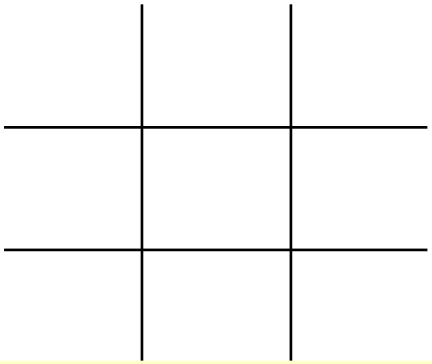
Why We Should Look for a Unifying Model

Good models go beyond description – they support action

- Selecting the right model for the job matters

Example: "Game of 15"
Winner: First one to reach exactly 15 with any 3 chips

First model – A is  and B is – what is B's move?

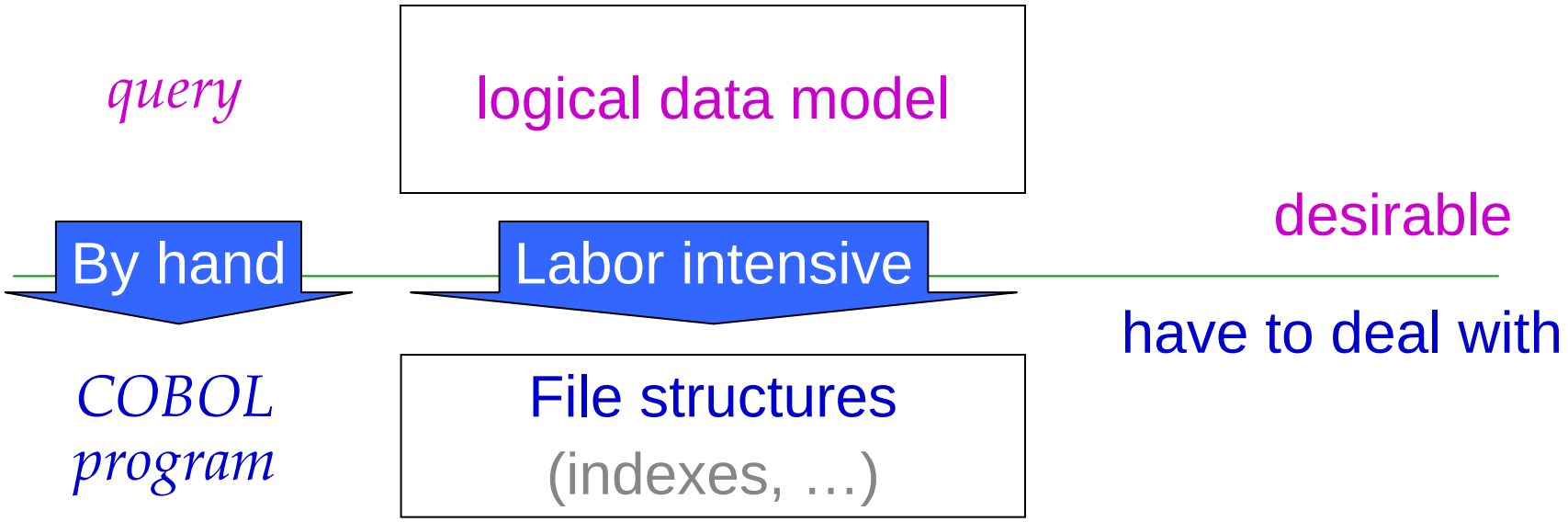
Second model –  – B's move is 6!

Can we find a "model" of business operations that is

- Useful & natural for the business level stake-holders to use
- Useful & natural for mapping to the IT infrastructure

Data Management In the Infancy (60's)

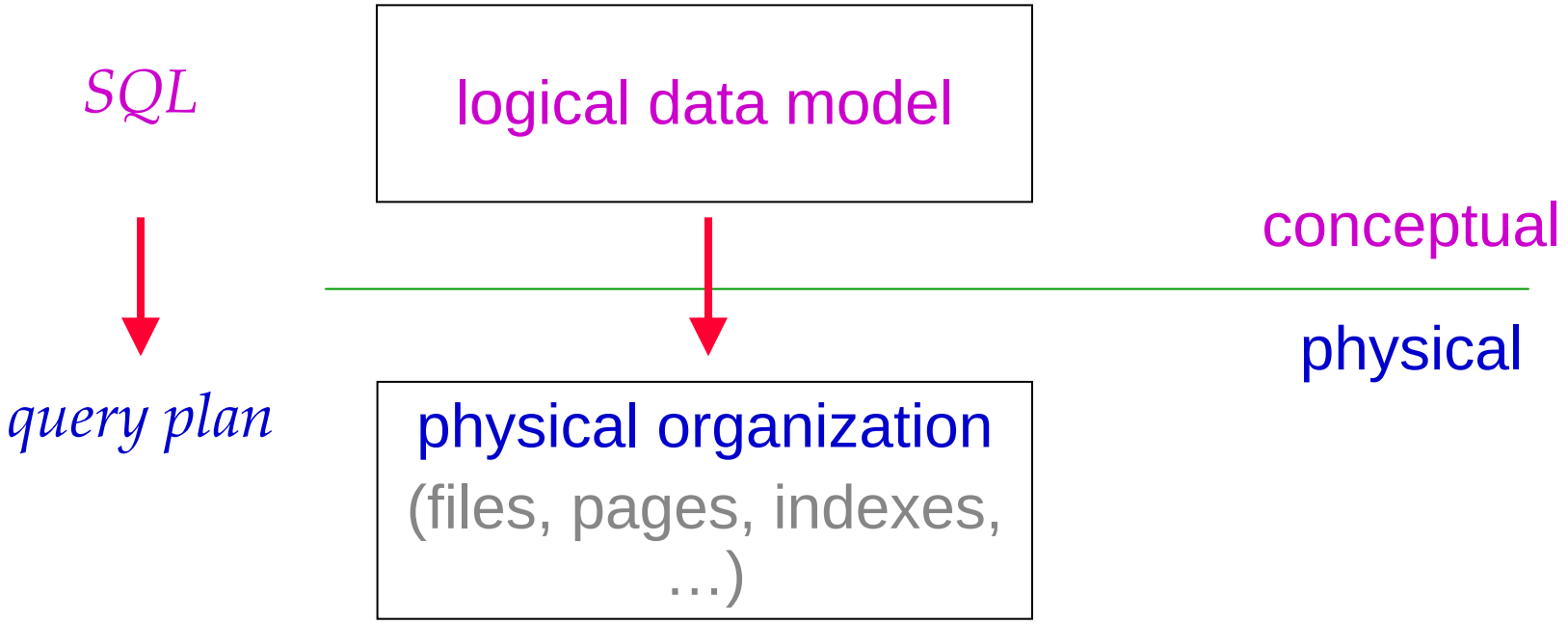
- Driving applications: inventory control, financial data management



- The key to the success: automation

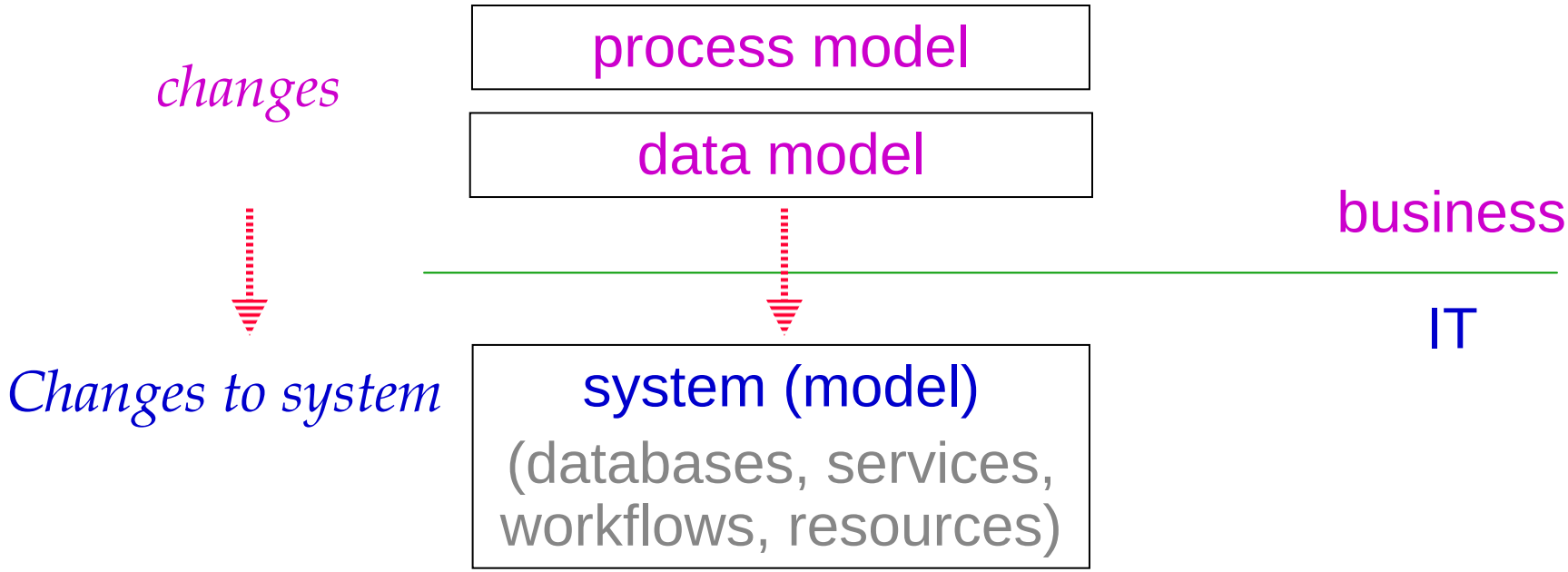
A Fundamental "Theorem" of Databases

- Physical data independence allows us to focus only data management issues



Future of BPM?

- Automate ⟿ 's



- Reuse concepts, tools, techniques developed in CS
- First step: a single conceptual model for biz processes
  - both data and processes are 1st class citizens

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BP Modeling: Data Exclusion to Data Centricity

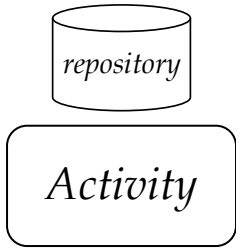
- Data exclusive models focus on activity flow and management
  - WfMC, BPMN, ...
- Incorporating data as views complements well (but separate from) activity views
  - UML (object modeling and activity diagrams)
- Executable models integrate data and activities with low level of abstraction
  - BPEL
- Recent data-centric approaches treat both data and activities “equally” in a more uniformed manner
  - Biz artifact-centric, form-based, spreadsheet-based

Business Artifacts

- A business artifact is a key conceptual business entity that is used in guiding the operation of the business
  - *fedex package delivery*, *patient visit*, *application form*, *insurance claim*, *order*, *financial deal*, *registration*, ...
  - both "information carrier" and "road-maps"

- Very natural to business managers and BP modelers
- Includes two parts:
  - Information model:
    data needed to move through workflow
  - Lifecycle:
    possible ways to evolve

Example: Restaurant



Artifacts

Guest Check

Kitchen Order

Receipt

Cash Balance

Create Guest Check

Open GCs

Add Item

Prepare Receipt

Pending KOs

Pending Receipts

Closed GCs

Prepare & Test Quality

Payment

Paid Receipts

Update Cash Balance

Ready KOs

Disagreed Receipts

Deliver

Archived Receipts

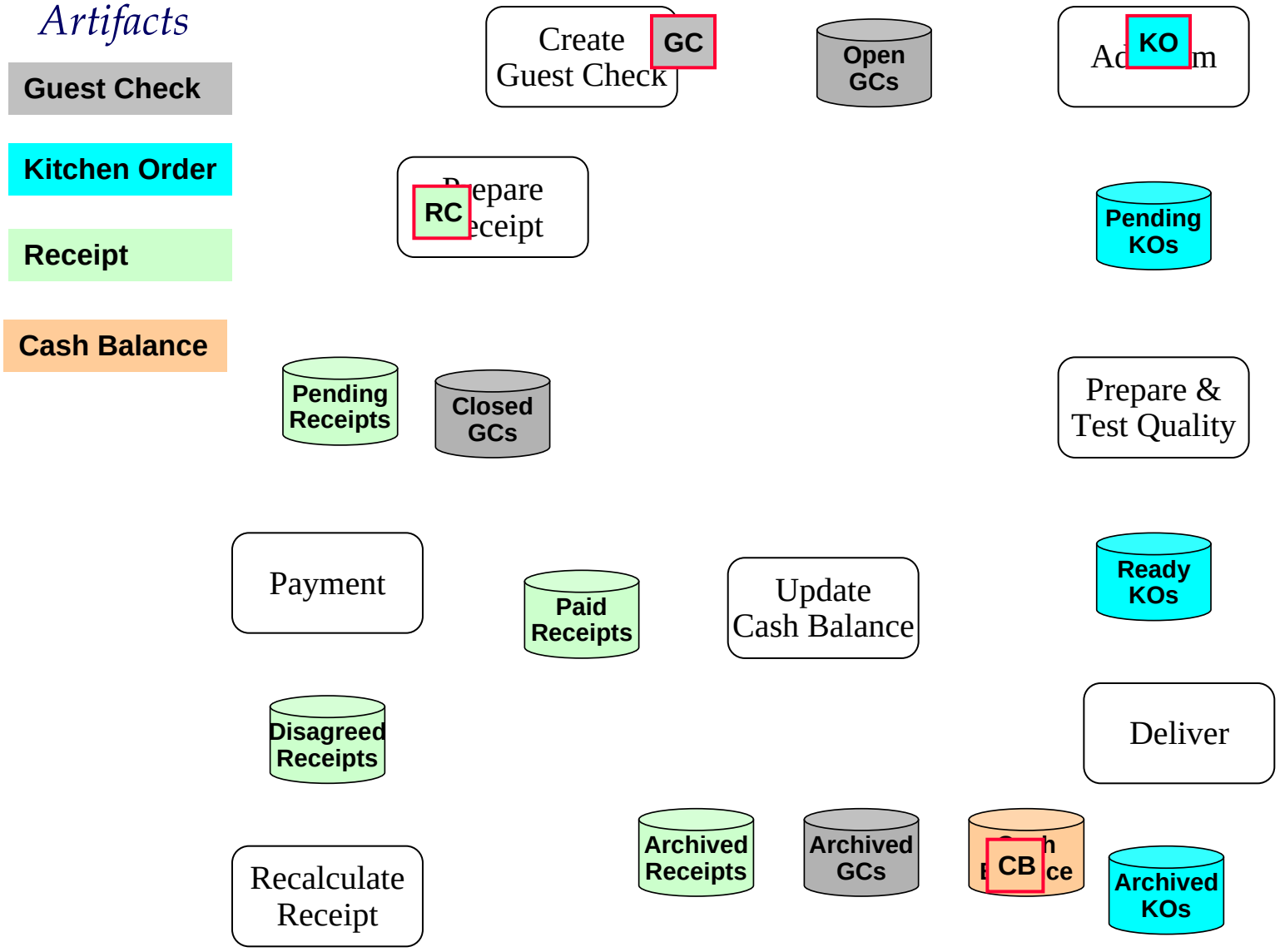
Archived GCs

Cash Balance

Archived KOs

Recalculate Receipt

Example: Restaurant



Case Study : IBM Global Financing

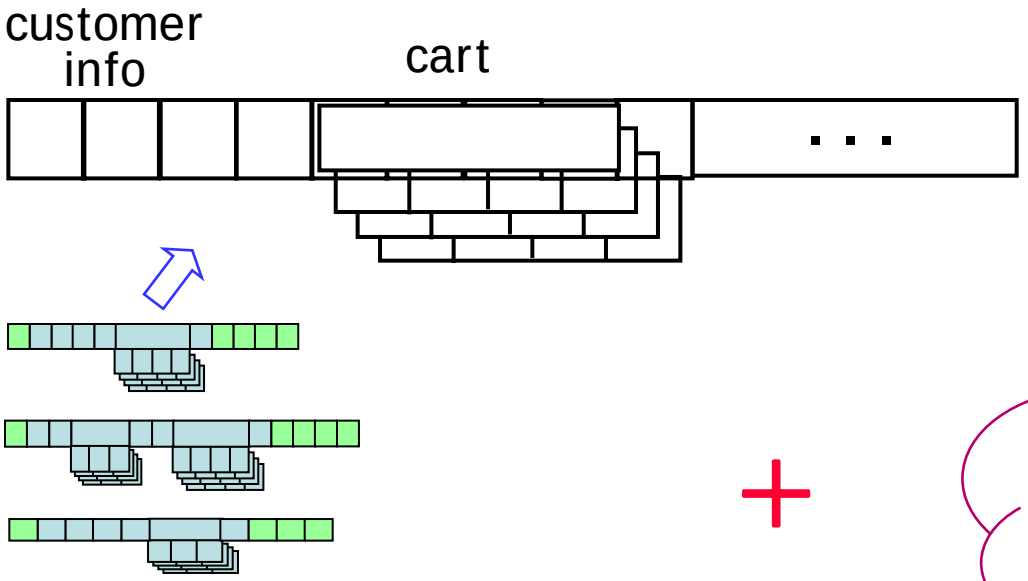
[Chao, Cohn, et al BPM 2009]

- Finance HW, SW & services from IBM & others for clients
- IBM internal financing business w/ global reach
  - World's largest IT financier w/ $38B asset base
  - Financing >$40B IT assets / year for last 3 years
  - 125K clients across >50 countries (9% of IBM profit)
- Business challenges
  - Operations tailored to mega-deals becoming too costly
  - Efficiency & cost control required global performance metrics
  - Country "silos" inhibited integration & annoyed clients
  - Current methods failed to produce end-to-end "tangible model"
  - Needed globally standard process w/ local variations

How the Artifact-Centric Approach Helped

- In a 3-day workshop with 15 business SMEs from IGF, a preliminary artifact design was created
  - Already useful to stakeholders from different regions as a common vocabulary
- 6 weeks of design refinements lead to final design
  - Enabled visibility into the global process and the regional variations: not possible before
  - A blueprint for transformation of IGF operations
    - VP roles assigned to pieces of top-level artifact model
- Current plan: automate the global-level artifact model
  - Anticipate significant improvement in efficiency
  - Plan to substantially augment the sales staff

Emerging Artifact-Centric BPs



Artifacts (Info models)

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Specification of artifact lifecycles

- Informal model [Nigam-Caswell IBM Sys J 03]
- Systems: BELA (IBM 2005), Siena (IBM 2007), ArtiFlow (Fudan-UCSB 2010), Barcelona (IBM 2010)
- Formal models
  - State machines [Bhattacharya-Gerede-S. SOCA 07][Gerede-S. ICSOC 07]
  - Rules [Bhattacharya-Gerede-Hull-Liu-S. BPM 07][Hull et al WSFM 2010]

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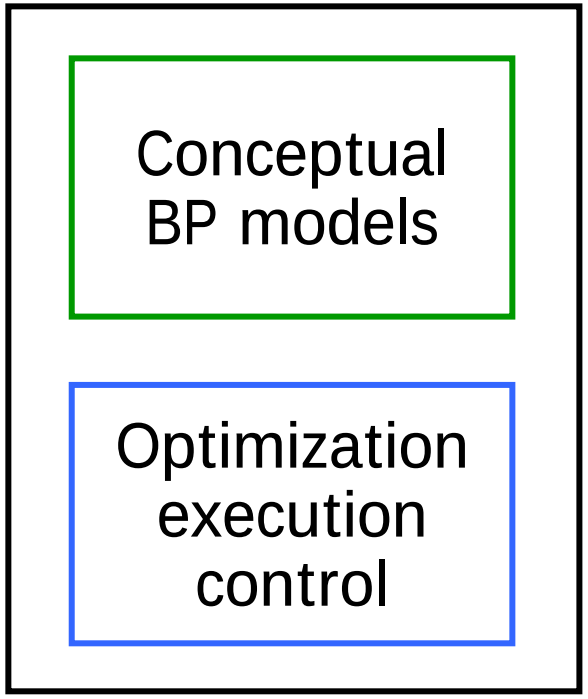
Artifact-Centric BPMSs

@IBM:

- Declarative models
- Semantics (U Rome)
- Analysis (UCSD)
- Workflow views (lenses)

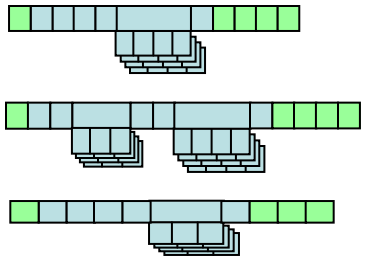
@UCSB

in collaboration with
IBM, U Rome, Fudan, ...



BPMS components

Declarative Biz Processes



Artifacts
(info models)

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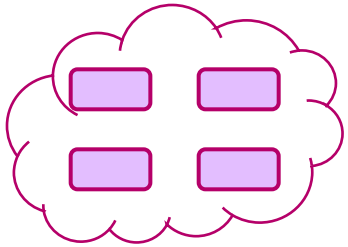

Semantic services
(IOPEs)

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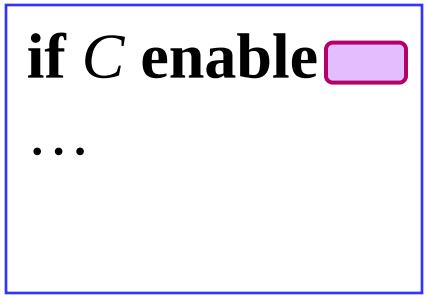
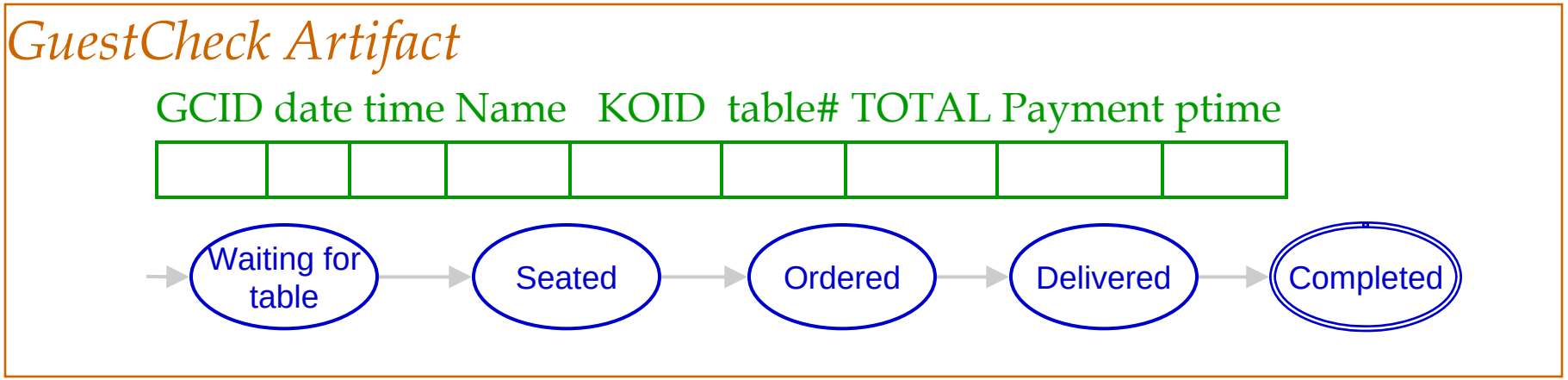


Condition-
action rules

- Variation of [Bhattacharya-Gerede-Hull-Liu-S. BPM 07]

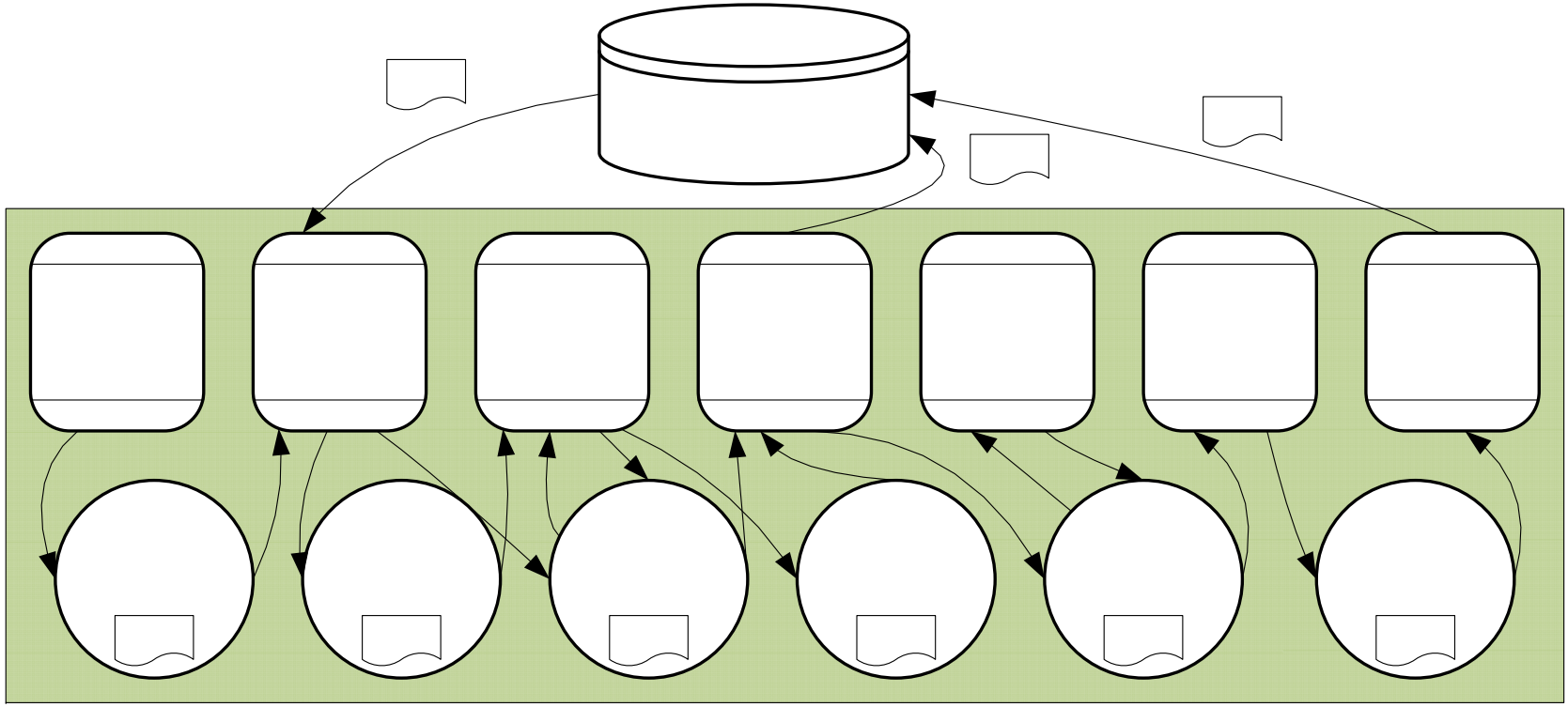
Artifact Classes

- An artifact class consists of
  - a finite set of attributes, of type U or artifacts IDs
  - a finite set of states, initial and final states (transitions not defined)
- An artifact is a pair:
  - a mapping from attributes to $U \cup$ IDs $\cup \{\perp\}$
  - a state



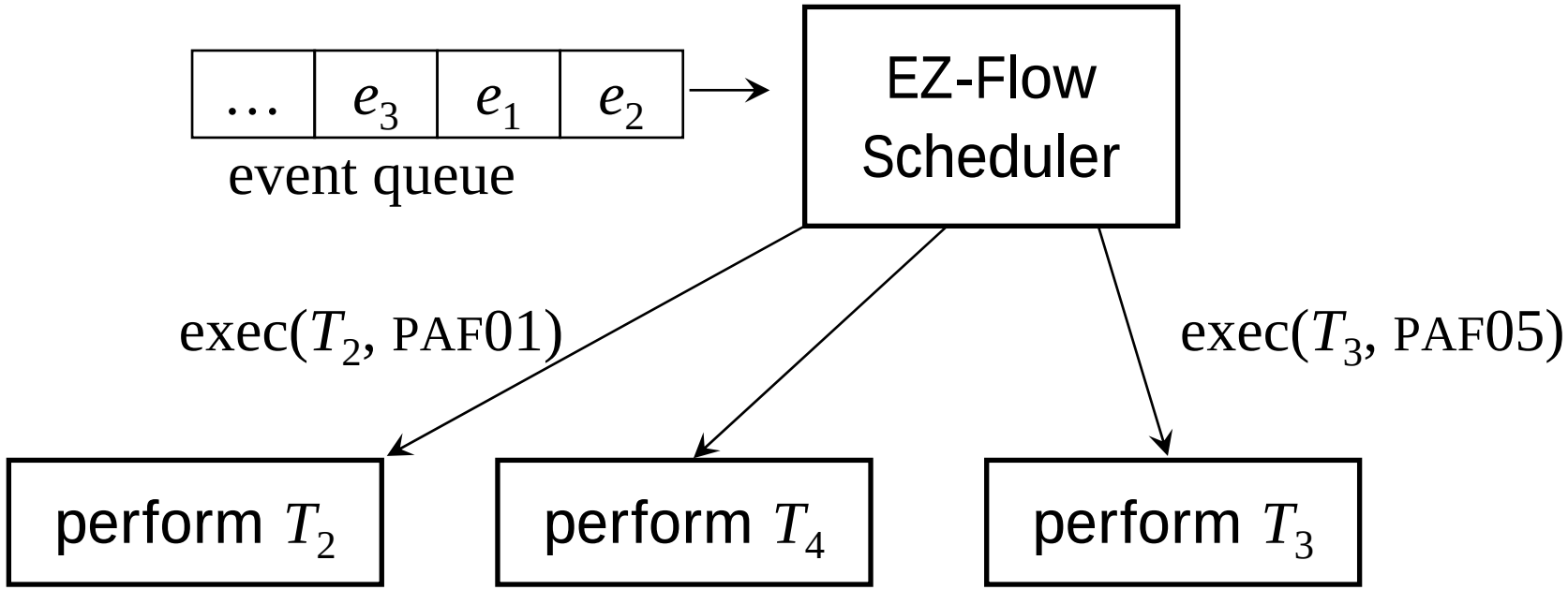
EZ-Flow: Procedural Biz Processes

- Each biz process has a core artifact (class)
  - Business data (object) + enactment
  - Event driven
  - Similar notion in recent GSM model from IBM



[EZ-Flow or ArtiFlow, 2009, 2010]

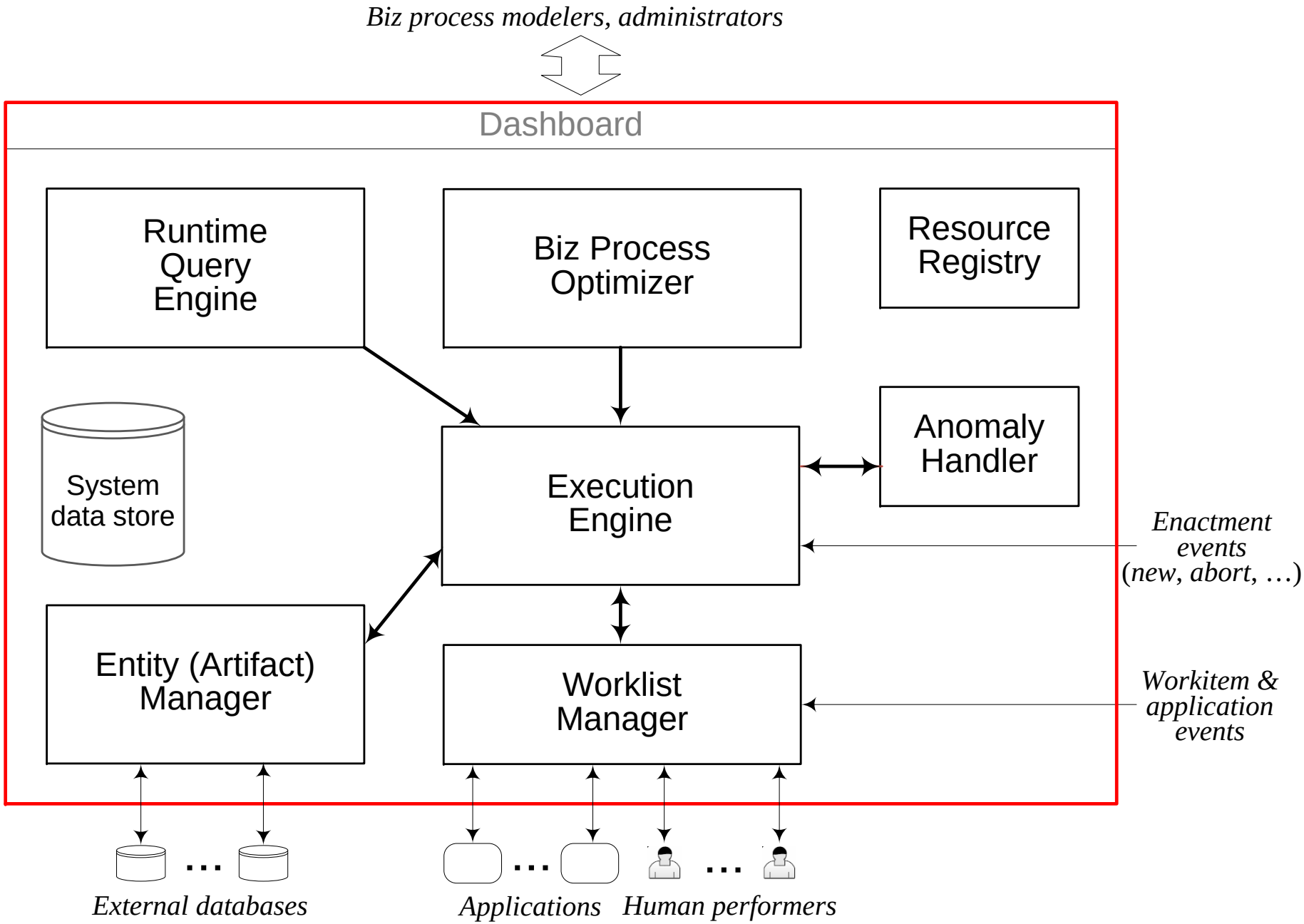
EZ-Flow Engine



task performer:

handles data wrapping and service wrapping

EZ-Flow and Research Problems



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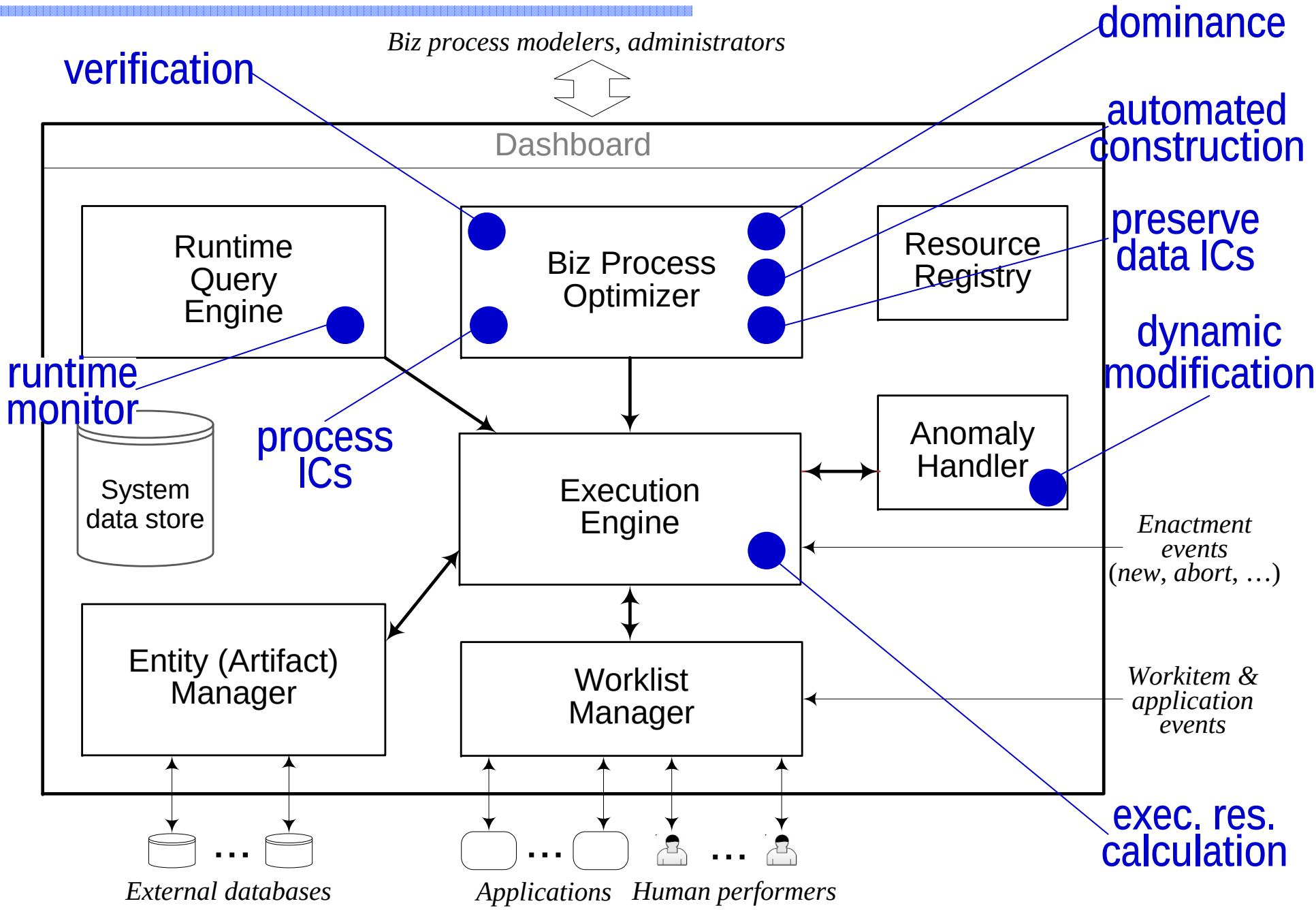
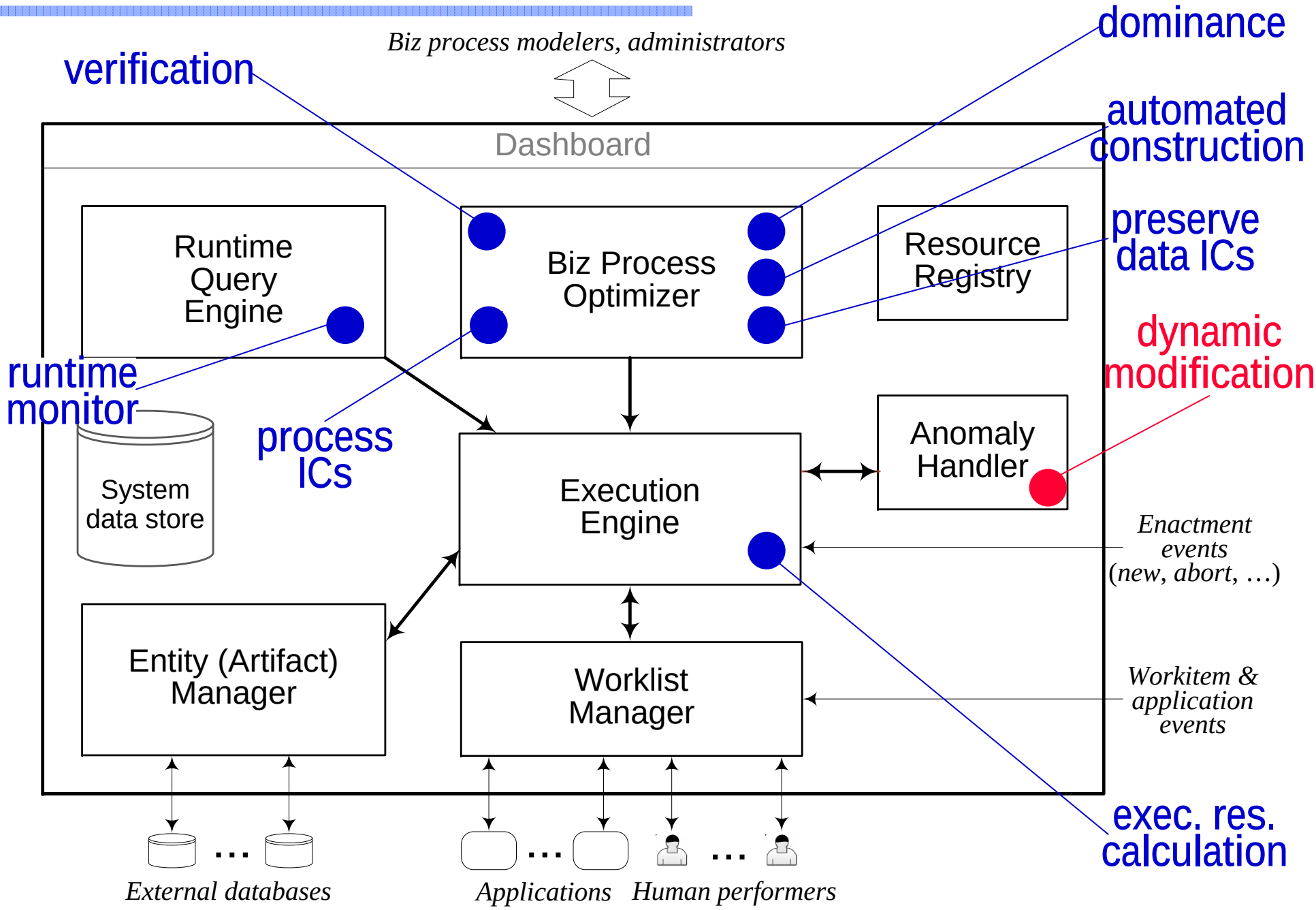


EZ-Flow and Research Problems



Changes in Biz Processes

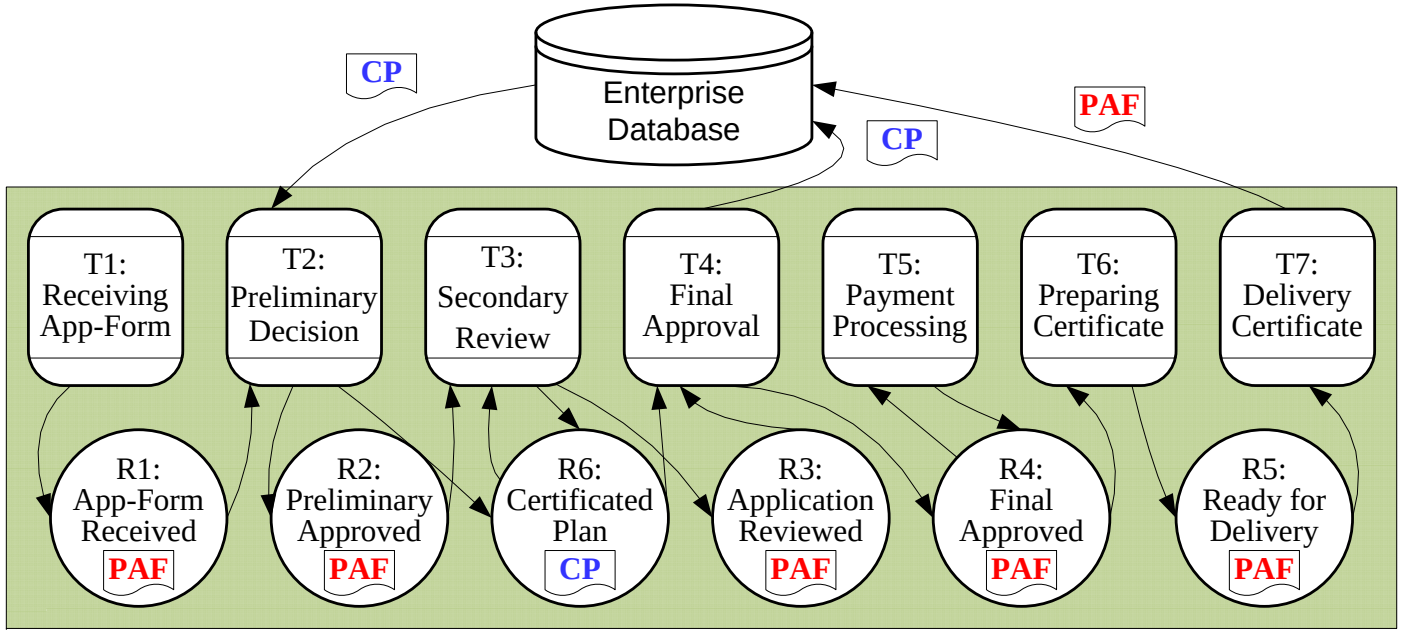
- Reason for changes:
  - Policy/regulation change
  - Technology change
  - Environment change
  - User demand change
  - ...
- The long tail phenomenon:
  large number of cases of a small number of patterns
  a small number of cases are mostly different
- BPMSs must handle the latter more efficiently

Manage Changes

- Modify biz process model: time consuming, big effort
- Anticipate change at design time, and build flexibility in schema, e.g., [Gottschalk-van der Aalst-Jansen-Vullers-La Rosa 2008] [Hallerbach-Bauer-Reichert 2008]
  - limited options
- Declarative models: worklet [Adams-ter Hofstede-Edmond-van der Aalst 2006], LTL-based [van der Aalst-Pesic-Schonenberg 2009]
  - Data not included
- Runtime dynamic execution mechanism based on objects (task wrappers) [Redding-Dumas 2010]
  - Detached from process model, low abstraction
- Our approach: procedural process model with declarative changes, conservative extension [Xu-S.-Yan-Yang-Zhang 2011]

Technical Approach

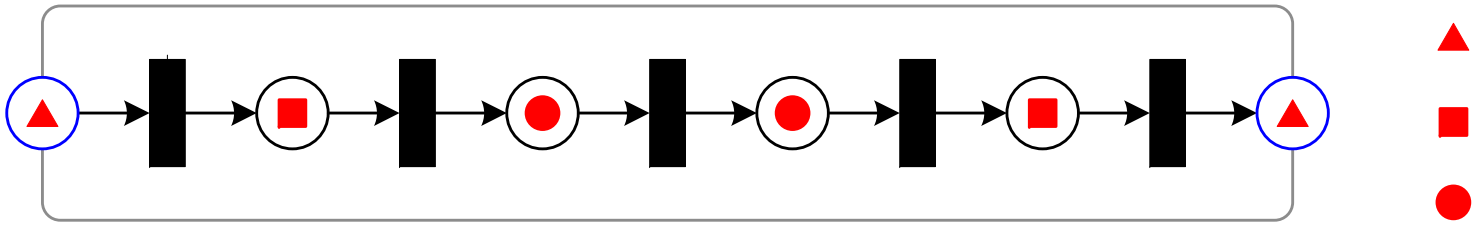
- Ingredient 1: artifact-centricity



- Each biz process has a core artifact (class)

Technical Approach

- Ingredient 2: formal model (semantics) for execution



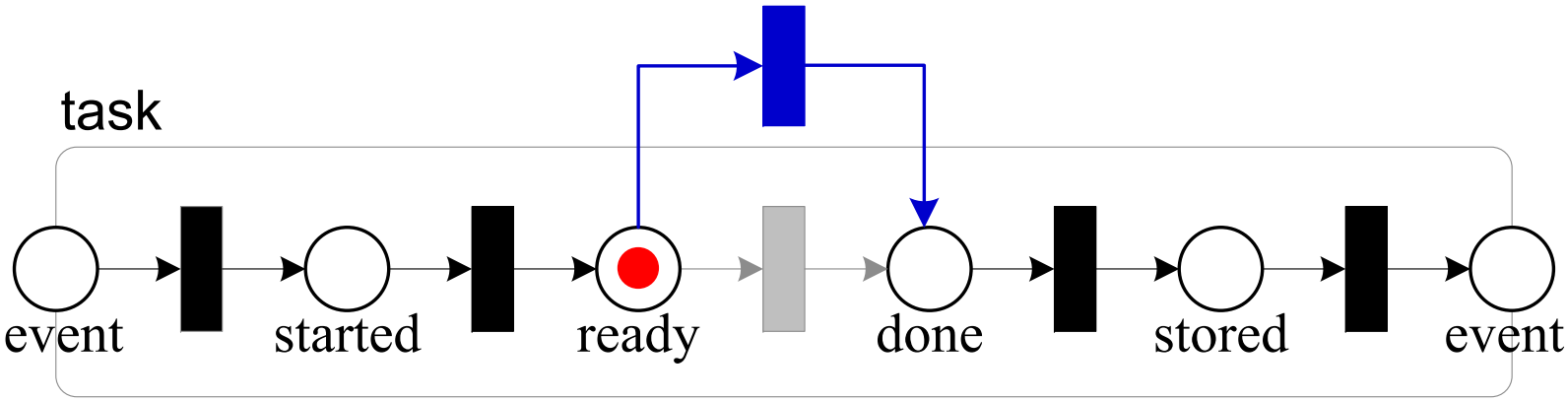
- Ingredient 3: declarative change specification
  - Four execution altering operators
  - Rules for applying the operators based on conditions

start *fetch* *invoke*

$event_s$ started ready done

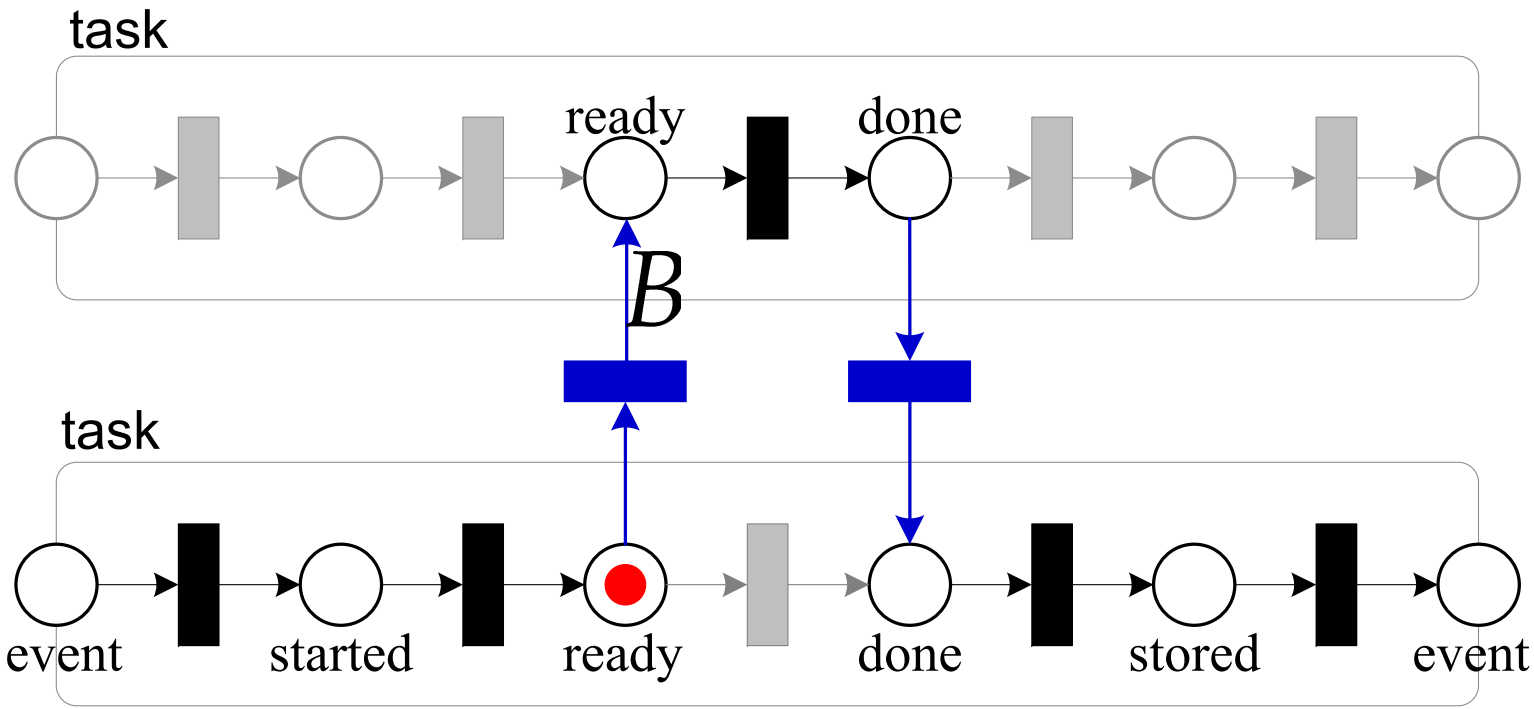
(1) (2) (3) (4)

Natural Disaster Victims on Green Channel




```
Express-SR:
  MAY skip SecondaryReview ON PAF
  WHERE projectType="reset"
```

New Fee Schedule for Low Incoming Housing



invoi

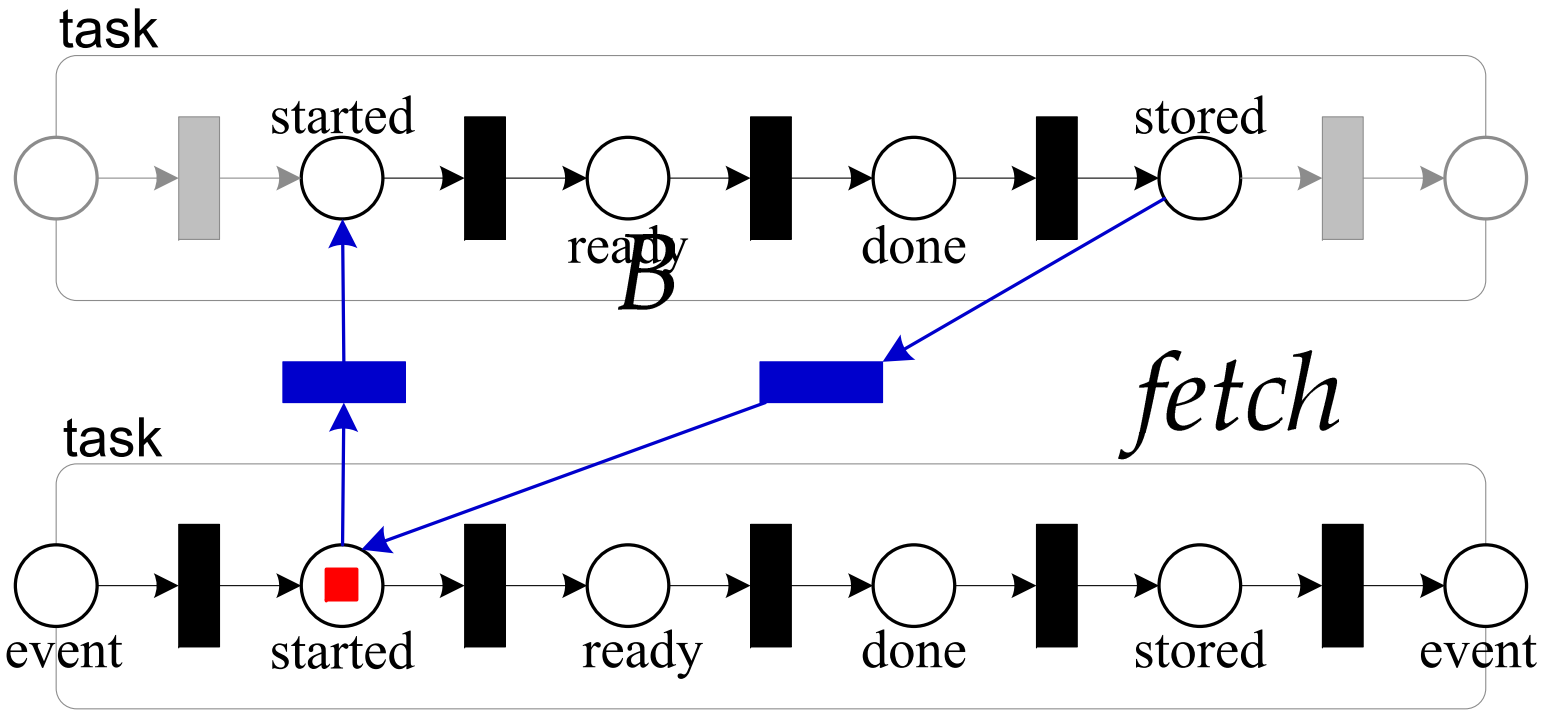
```
Affordable-Fee:
  MUST REPLACE PaymentProcessing
               BY AffordablePaymentProcessing ON PAF
WHERE SELF.projectType="affordable"
```

begin-replace

A

start *fetch* *invoi*

New Contractor Needs Prequalification



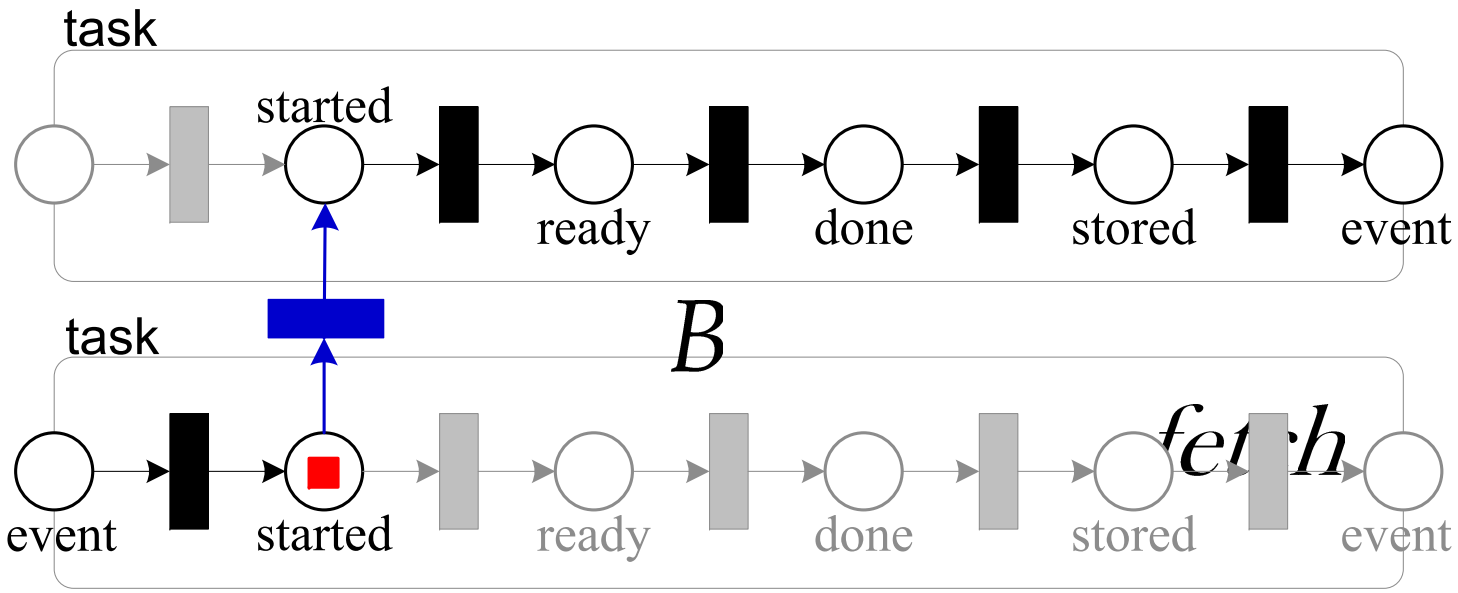

```
First-Timer:
  MUST ADD Prequal BEFORE Prelim_Decision ON PAF
  WHERE projectType="affordable" AND
        developerName NOT IN
           SELECT developerName
           FROM PAF P
           WHERE P.artifactId <> SELF.artifactId
             AND P.projectType="affordable"
```

begin-add

A

start

Insufficient Selling Space Need Re-Check




```
Re-eval:
  MUST RETRACT FROM SecondaryReview
                    TO ReceivingApp-form ON PAF
  WHERE SELF.cp.planArea <
        ( SELECT sum(P1.sellingArea)
          FROM PAF P
          WHERE P.cp=SELF.cp
          GROUP BY p.artifactId )
```

A

retract-to

Start

fetch

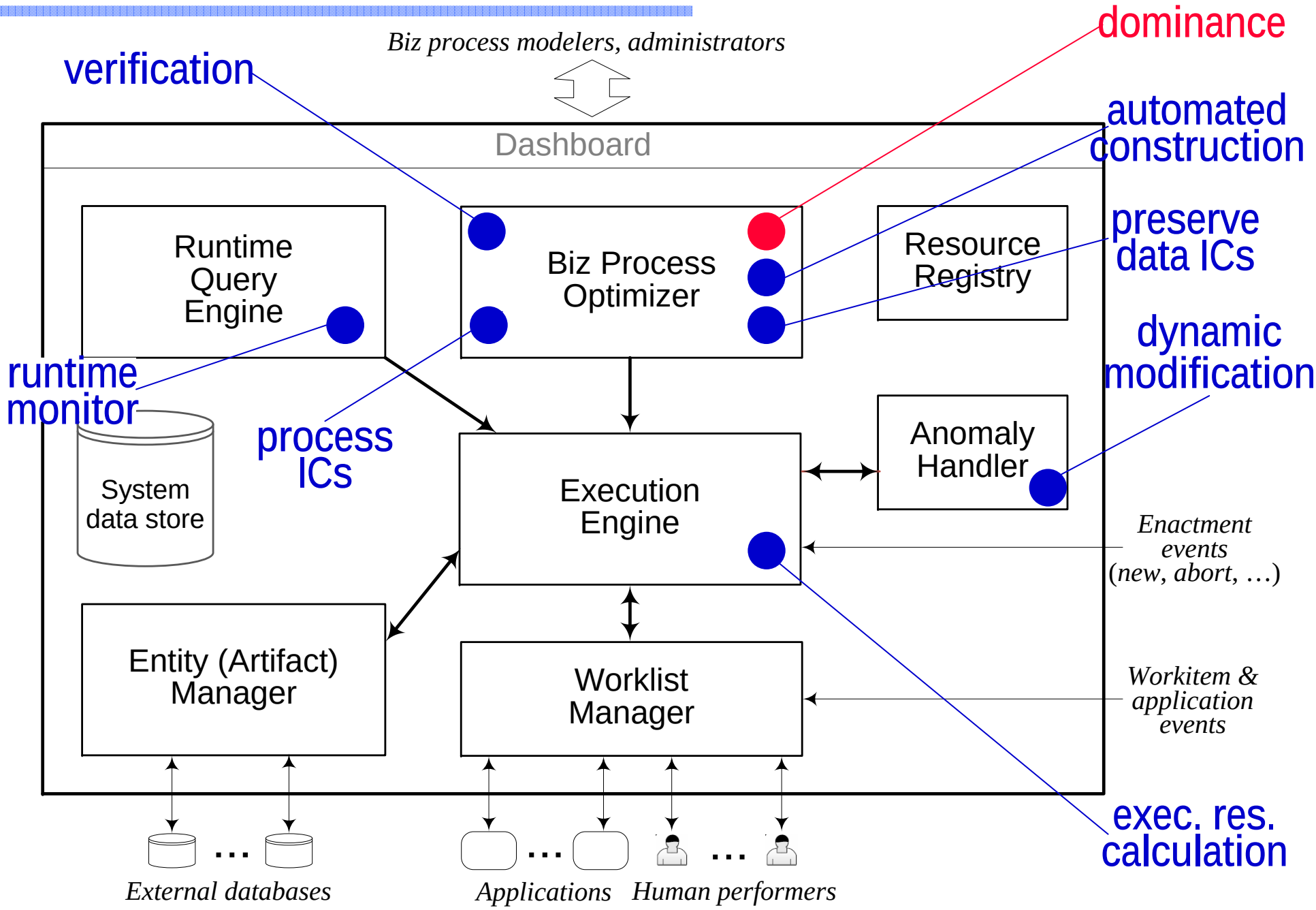
inv

Mixed Procedural and Declarative Pays off

- Biz process = state machine lifecycle + change rules
- Modification rules conservatively extend workflow
  - Could be temporary, non-schematic
- Allows biz process to respond to situations with many more options:
  - # of "trace types" grow exponentially in # rules
- Performance estimates:
  - 9% labor savings for Real Estate Administration of Hangzhou (preliminary study)

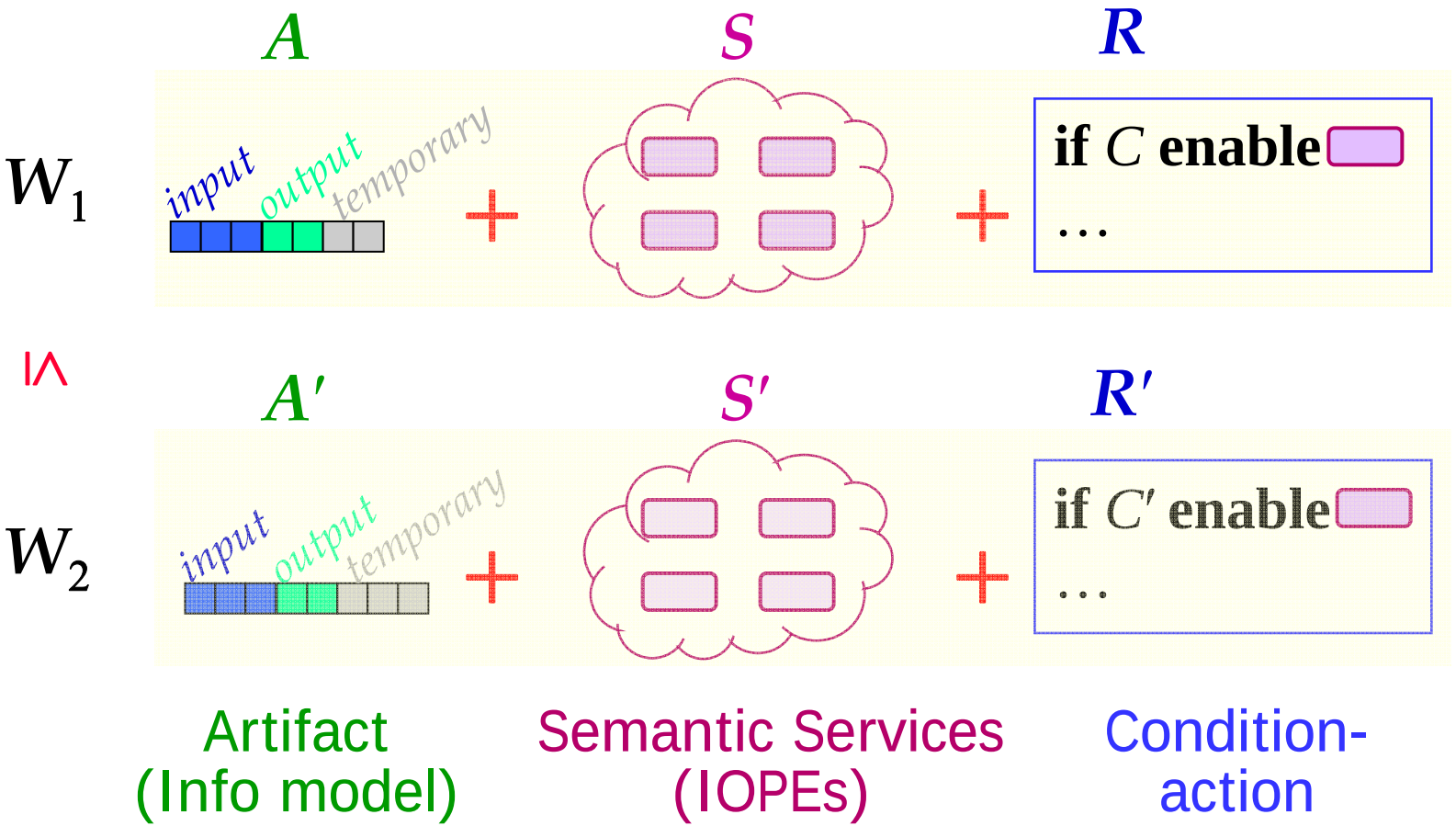
[Xu-S.Yan-Yang-Zhang 2011]

EZ-Flow and Research Problems



Comparing Two Workflows

- Assuming they work on the same input-output (types) Can one workflow "simulate" the other

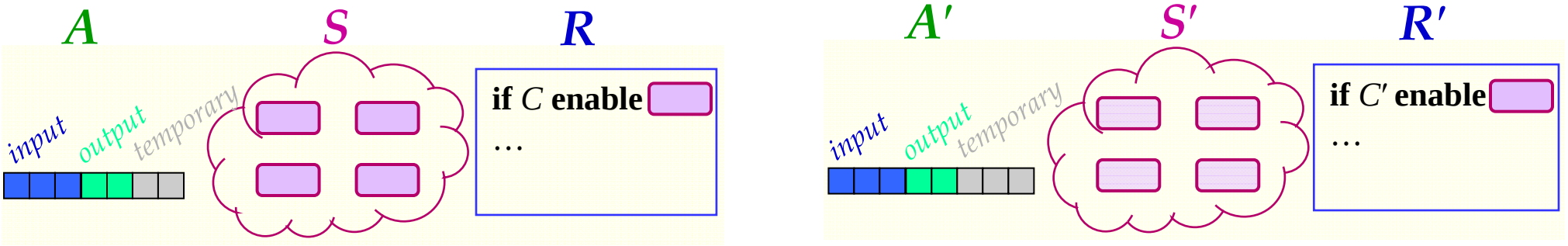


Why Comparison

Many reasons:

- Optimization (similar to comparing queries)
- Replacing part of workflow (reorganization)
- Updating workflow (evolution)
- Reusing workflow
- . . .

Workflow Dominance



$$W_1 \leq W_2$$

if every input-output pair that can be produced by W_1 can also be produced by W_2

- Note:
  - their temporary data can be very different
  - services are different; rule sets are different
  - services may be done by human

Performance Policies

- A performance policy π is a function that assigns each service σ a multi-valued function over U

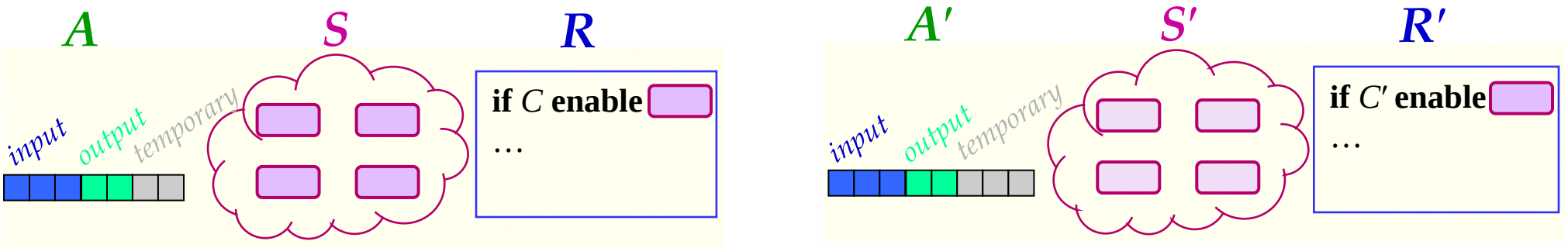
$$\pi(\sigma) : x \rightarrow \{x+1, x+2\}$$

- Since the "flow" is fixed, the choice of a performance policy determines how the workflow would perform
  - E.g., given an input, a workflow can execute and generate an output
- Classes Π of performance policies π
  - Absolute (ABS): $\pi(\sigma) = U \times U$
  - Fixed choice: $\pi(\sigma)$ is some single-valued function

Definition of (k-)Dominance

[Calvanese-De Giacomo-Hull-S. ICSOC 09]

- Fix a class of performance policies Π



$$W_1 \leq_{\Pi}^{k} W_2$$

if for each performance policy π_1, there is a performance policy π_2, such that every *input*-*output* pair produced by $W_1[\pi_1]$ in at most k steps can also be produced by $W_2[\pi_2]$ in at most k steps

Capturing Workflow Under ABS

- Key Lemma:

  $\boldsymbol{W}$: a workflow with service pre- and post-conditions and rule conditions expressed in FOL with equality

  k : a positive integer

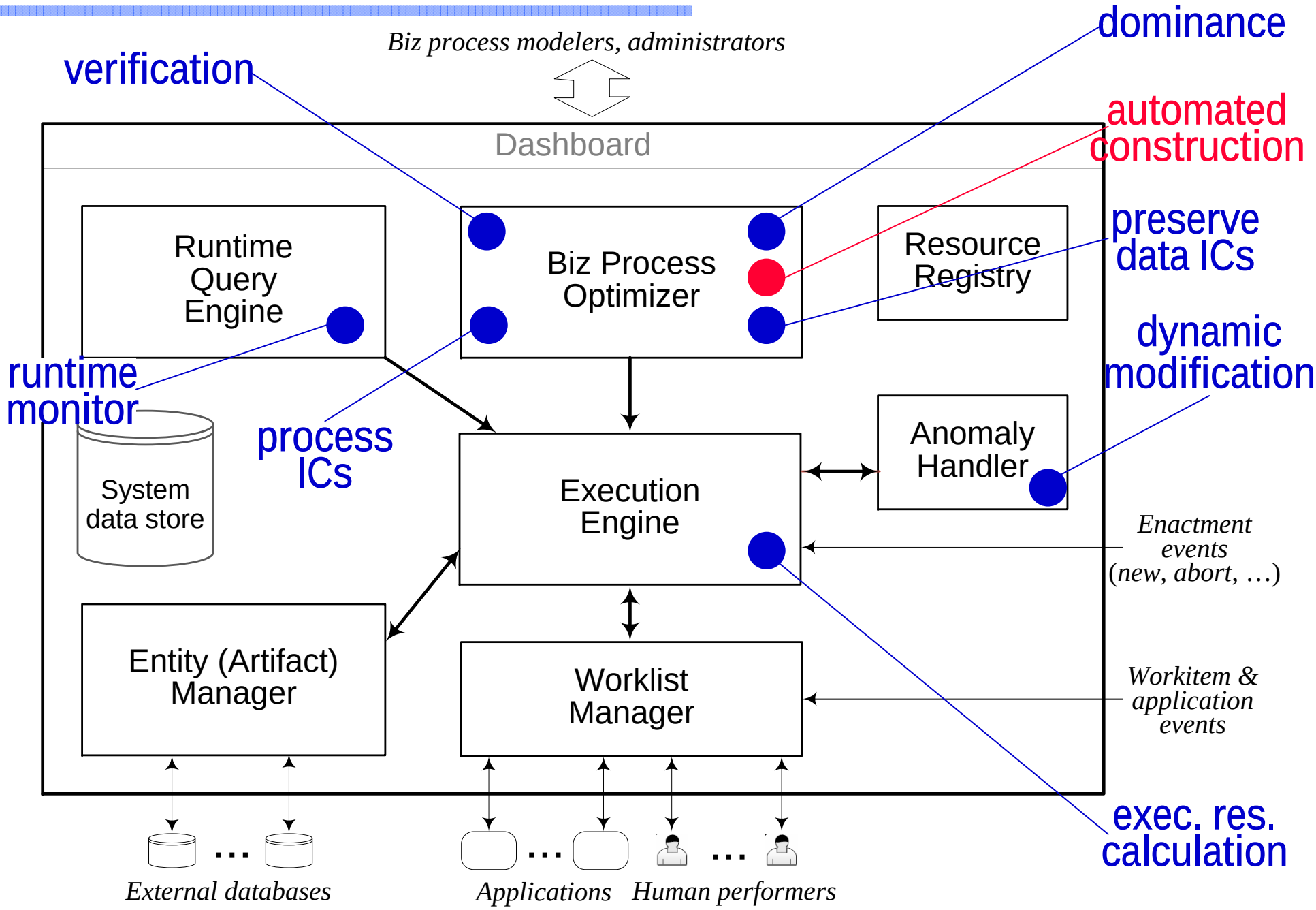
  Then
  there is a FOL formula $\varphi(k, \boldsymbol{W})$ that characterizes the set of all *input*-*output* pairs produced by $\boldsymbol{W}[\mathbf{ABS}]$ in at most k steps

Results on (k)-Dominance

- Absolute k-dominance is decidable but dominance is undecidable:
  1. $(\mathbf{Z}, +, <)$, integers with additions
  2. $(\mathbf{Q}, +, <)$, rational numbers with additions
  3. $(\mathbf{R}, +, \cdot, <)$, real numbers with additions and multiplications (the real closed field)
- Absolute dominance is undecidable:
  1. $(\mathbf{Z}, <)$, integers with discrete order
  2. $(\mathbf{Q}, <)$, rational numbers with dense order
  3. $(\mathbf{R}, <)$, real numbers with dense order

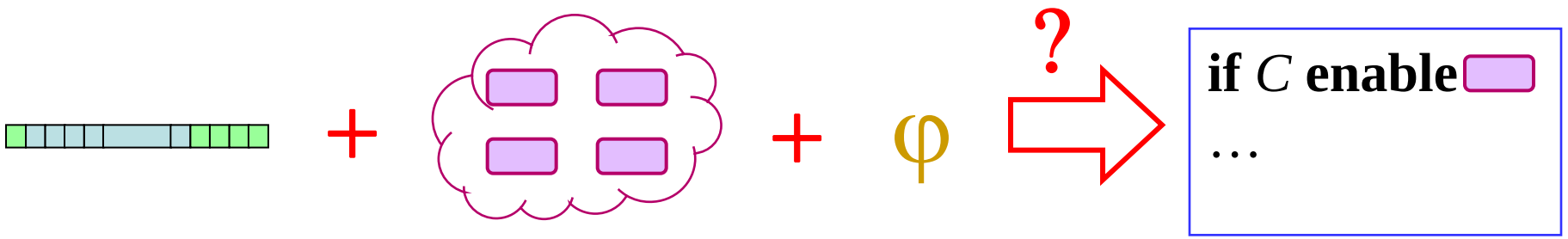
[Calvanese-De Giacomo-Hull-S. ICSOC 09]

EZ-Flow and Research Problems



Synthesis Problem

- Given a goal and a set of services, construct a set of rules so that every execution satisfies the goal



Artifact (Info model) | Semantic services (IOPEs) | Goal (FO) | Condition-action

[Fritz-Hull-S. ICDT 09]

(restricted to single artifact, first-order goals)

Artifact Schema

- An artifact schema is a finite set $\boldsymbol{A}$ of attributes.
  An artifact of $\boldsymbol{A}$ is a mapping from $\boldsymbol{A}$ to $U \cup \{\perp\}$

- Assume a set of initial attributes $\boldsymbol{A}_{\text{init}} \subset \boldsymbol{A}$

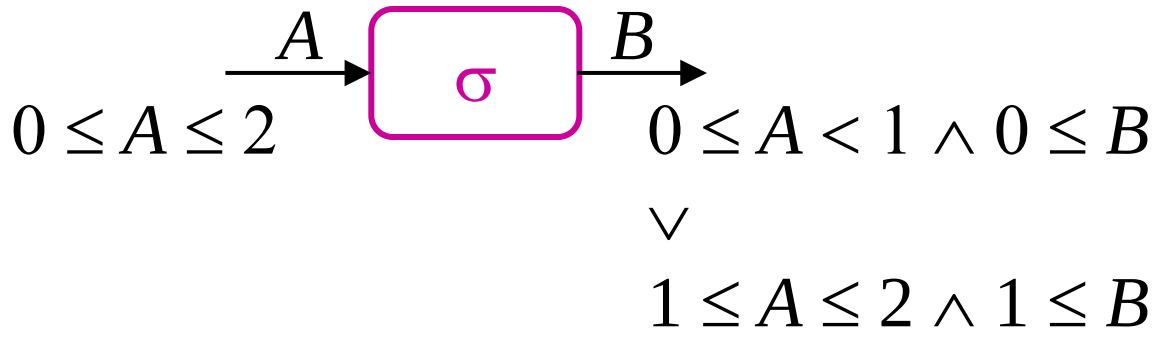
- An artifact is $\boldsymbol{B}$-completed, $\boldsymbol{B} \subset \boldsymbol{A}$, if it is defined on all attributes in $\boldsymbol{B}$
  - "input" artifacts are $\boldsymbol{A}_{\text{init}}$-completed

Semantic Services (Tasks)

- A semantic service over $\boldsymbol{A}$ is a tuple $(\sigma, R, W, \pi, \rho)$, where
  - σ : service name
  - R, W : finite sets of (resp., read, write) attributes
  - π, ρ : quantifier-free formulas (pre- and post-condition, resp.) over R, $R \cup W$, resp.
- allow $\mathrm{DEF}(A)$ for an attribute A

- o' is the result of executing σ on o, $o \xrightarrow{\sigma} o'$, if
  - $(o, o') \models \pi \wedge \rho$, and
  - frame conditions are satisfied

An Example Semantic Service



Condition-Action Rules

- A condition-action rule is an expression "**if** φ **enable** σ" where
  - φ is a (quantifier-free) formula and
  - σ is a semantic service

- o' is the result of executing a rule r : **if** φ **invoke** σ on o, $o \rightarrow_r o'$, if
  - $o \models \varphi$, and
  - $o \rightarrow_\sigma o'$

Workflow Schema

- A workflow schema is a triple $W = (A, S, R)$
  - A : artifact schema
  - S : a finite set of semantic tasks
  - R : a finite set of condition-action rules

- Denote $\overset{*}{\rightarrow}$ the closure of $\bigcup_{r \in R} \rightarrow_r$

The Synthesis Problem

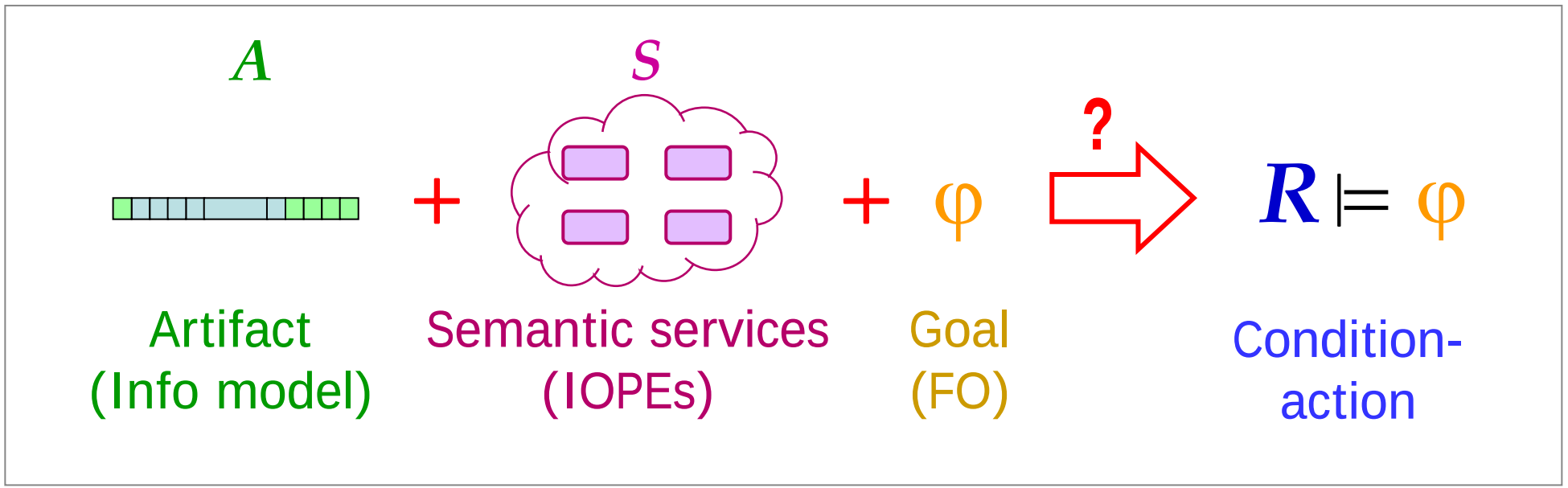
[Fritz-Hull-S. ICDT 2009]

- Given A, A_{init}, a finite set S of semantic tasks, a formula φ over $A_{\text{final}} \subset A$,

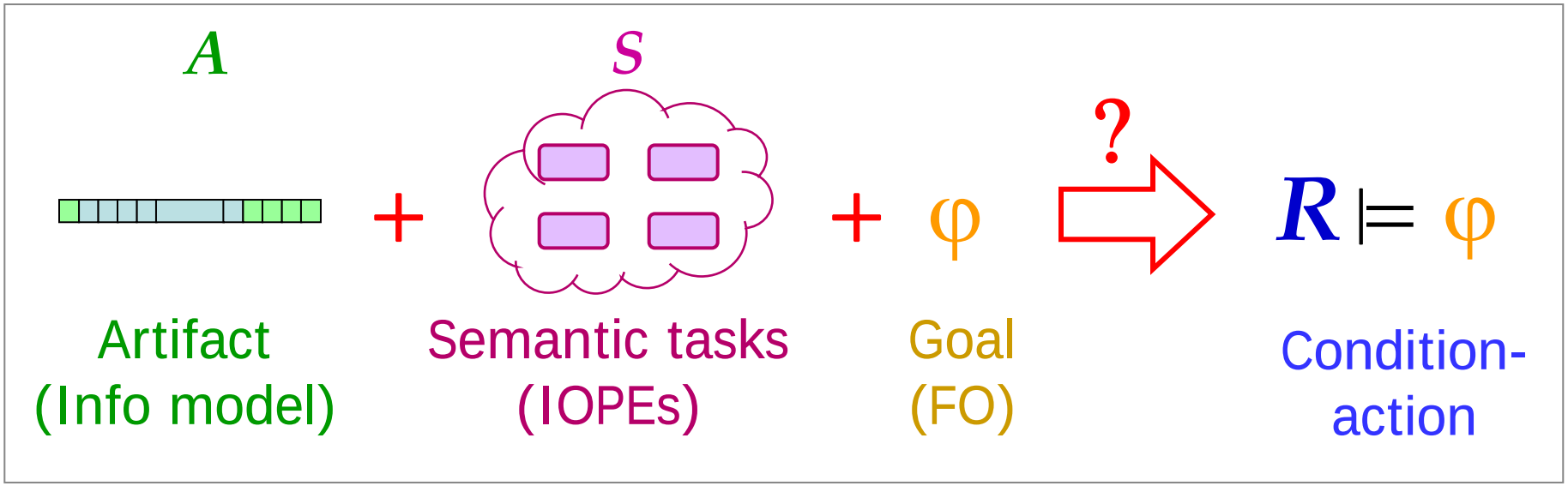
  Find a rule set R such that

$$\text{if } o \xrightarrow{*} o', \text{ then } o' \models \varphi$$

A_{init}-completed A_{final}-completed



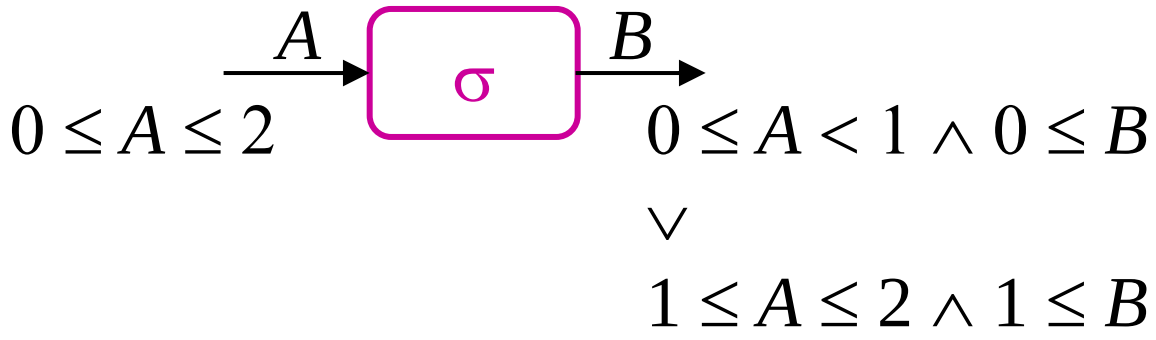
A Trivial Solution



- Just let $R = \varnothing$
- Need to revise the problem statement

Maximally Safe Ruleset

- A ruleset enables all executions that guarantee to satisfy the goal
- Goal: $1 \le B$

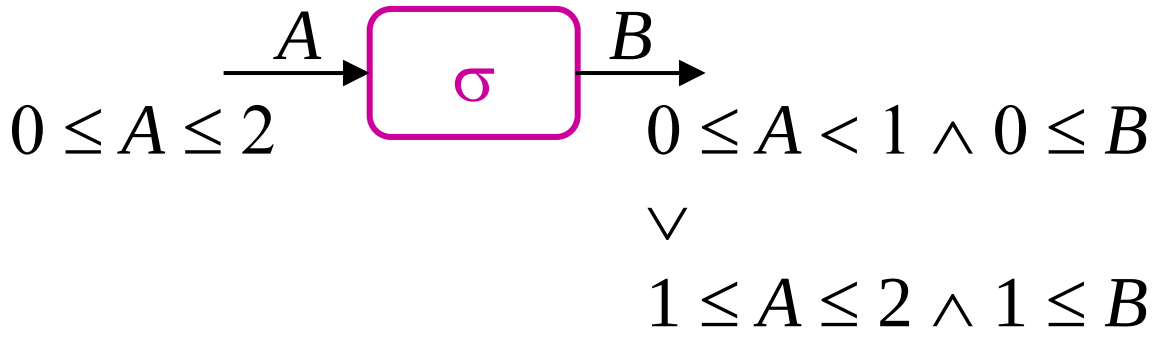


- $1 \le A \le 2$: definitely good
  $0 \le A < 1$: possibly good but can't be sure
- Best we can do

if $1 \le A \le 2$ **enable** σ

Maximally Safe Ruleset With Exception

- A ruleset eagerly move dead-end executions to **EXCEPTION** status
- Goal: $1 \le B$



- $1 \le A \le 2$: definitely good
  $0 \le A < 1$: possibly good but can't be sure
- Be optimistic:

if $0 \le A \le 2$ **enable** σ
if $B < 1$ **goto EXCEPTION**

Pre-Conditions

- Given a semantic task $(\sigma, R, W, \pi(\mathbf{x}), \rho(\mathbf{xy}))$, and a (sub-goal) condition $\delta(\mathbf{xy})$
- A $\forall$-precondition of σ, δ is a formula $\varepsilon(\mathbf{x})$ such that
  - ε logically implies π and
  - $\forall \mathbf{x}\,(\varepsilon(\mathbf{x}) \rightarrow (\forall \mathbf{y}\ \rho(\mathbf{xy}) \rightarrow \delta(\mathbf{xy}))$ holds

$\mathrm{WP}^{\forall}(\sigma, \delta)$: weakest $\forall$-precondition

- A $\exists$-precondition of σ, δ is a formula $\varepsilon(\mathbf{x})$ such that
  - ε logically implies π and
  - $\forall \mathbf{x}\,(\varepsilon(\mathbf{x}) \rightarrow (\exists \mathbf{y}\ \rho(\mathbf{xy}) \wedge \delta(\mathbf{xy}))$ holds

$\mathrm{WP}^{\exists}(\sigma, \delta)$: weakest $\exists$-precondition

Weakest Pre-Conditions

- Given a semantic task $(\sigma, R, W, \pi(\mathbf{x}), \rho(\mathbf{xy}))$, and a (sub-goal) condition $\delta(\mathbf{xy})$
- The weakest $\forall$-precondition

$$\mathrm{WP}^{\forall}(\sigma, \delta) \equiv \pi(\mathbf{x}) \wedge (\forall \mathbf{y}\ \rho(\mathbf{xy}) \rightarrow \delta(\mathbf{xy}))$$

useful for maximally safe ruleset

- The weakest $\exists$-precondition

$$\mathrm{WP}^{\exists}(\sigma, \delta) \equiv \pi(\mathbf{x}) \wedge (\exists \mathbf{y}\ \rho(\mathbf{xy}) \wedge \delta(\mathbf{xy}))$$

useful for maximally safe ruleset with exception

Necessary Condition

Theorem:

If there exists an algorithm to find maximally safe rule sets, the FOL theory is decidable (for the context structure)

The Other Direction

- Invoke-once constraint: each semantic task is allowed to run once

Theorem:

Under the invoke-once constraint, if the FOL theory (of the structure) is decidable and admits quantifier elimination, then the maximally safe rule sets can be computed

A Special Case: Dense Order $(\mathbb{Q}, <)$

- Goal and task conditions are quantifier free formulas
- Acyclic task invocation dependencies
- Each task writes one attribute

Theorem:

Computing Maximal Safe Ruleset is PSPACE-complete

- Key ideas: cell decomposition; reduction from QBF

- Acyclicity condition can be dropped

[Hull-S. 2009] (in preparation)

Further Restrictions

- A constructive EXPTIME algorithm

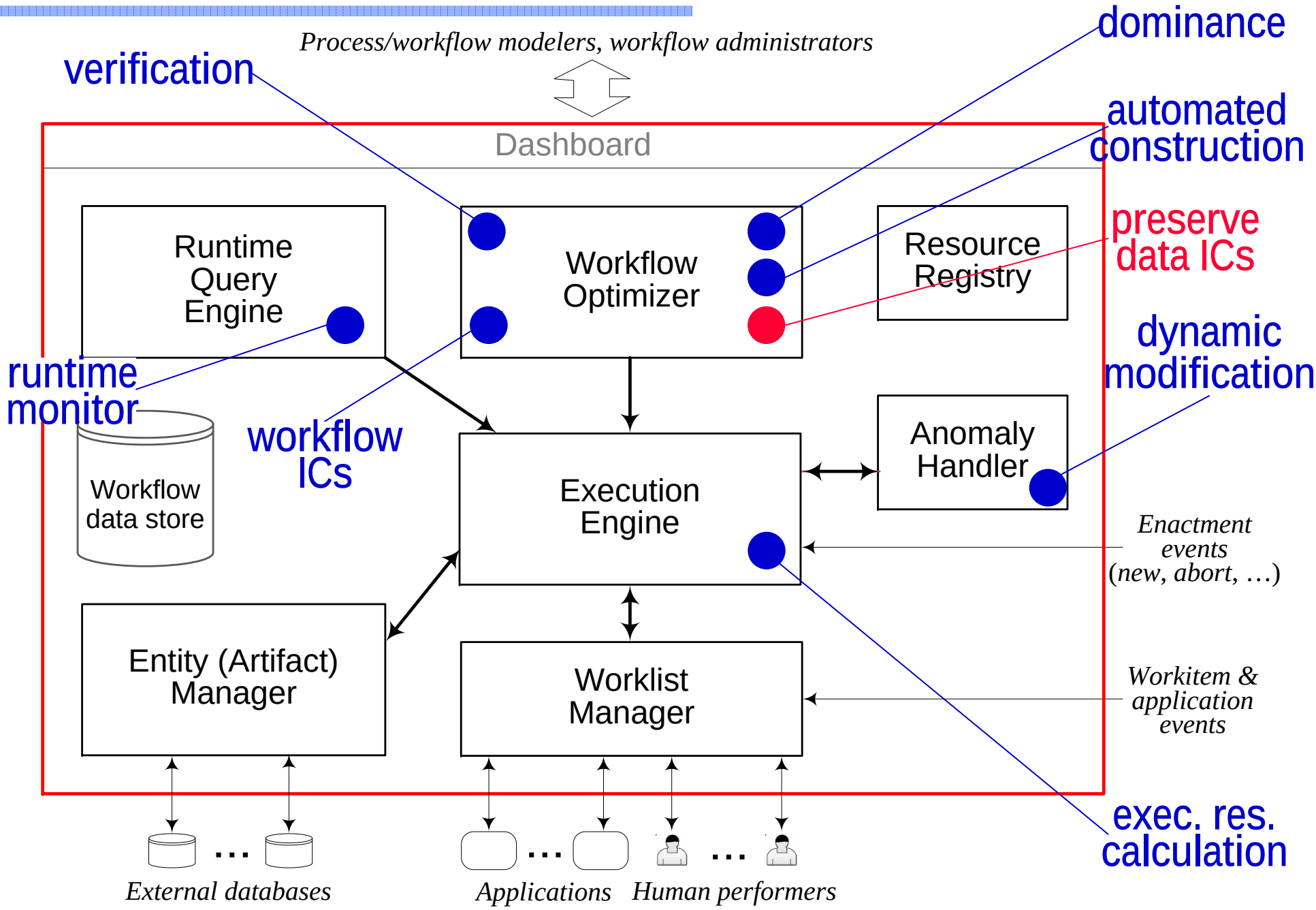
- PTIME if #needed attributes is bounded

Summary of Results

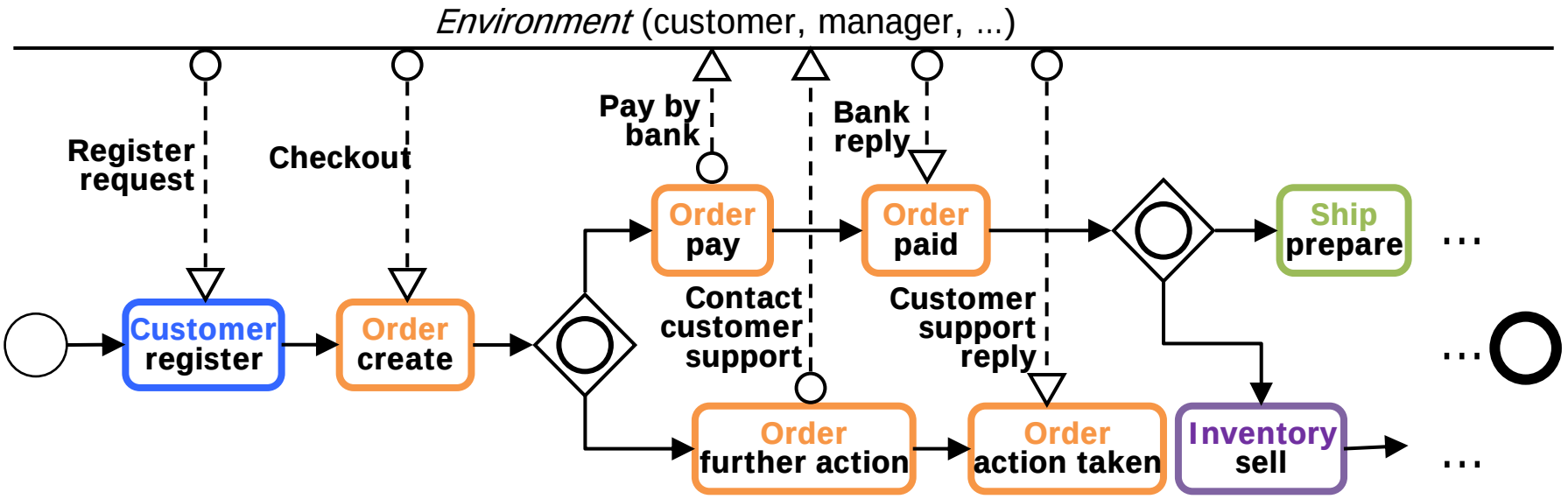
[Fritz-Hull-S. ICDT 2009]

- Synthesis problem is harder than FO logic theory of the underlying structure
- Positive answer for special cases
  - Invoke once
  - Concrete algorithm for dense order domain: PSPACE-complete

EZ-Flow and Research Problems



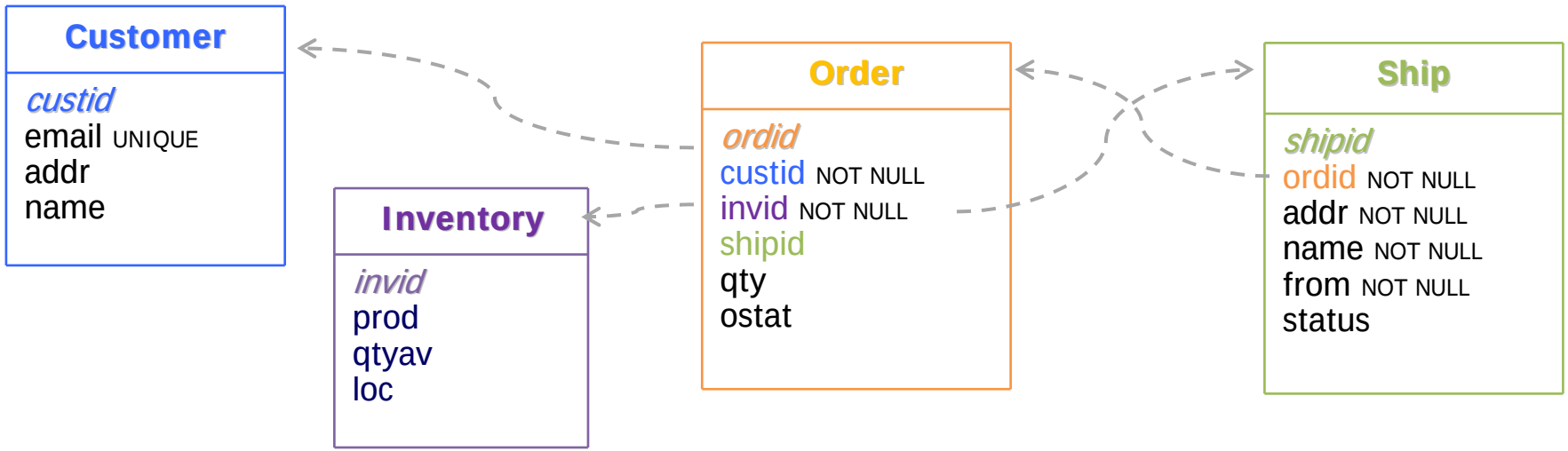
An Example Workflow – EzMart



- Traditional workflow specifications
  - Centered on control flow
  - Data flow is embedded in workflow executions

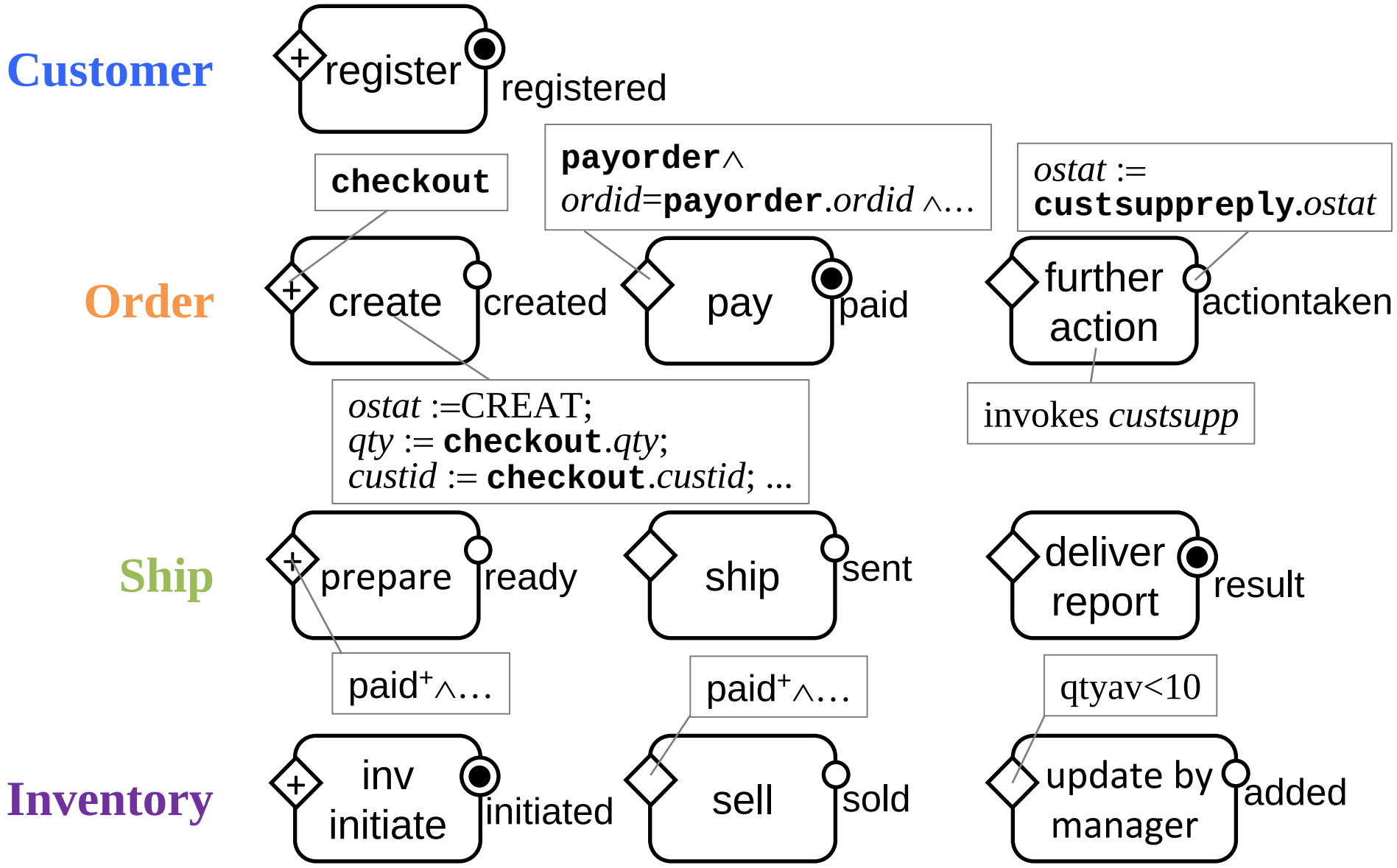
[X. Liu-S.-Yang, 2011]

Data and constraints

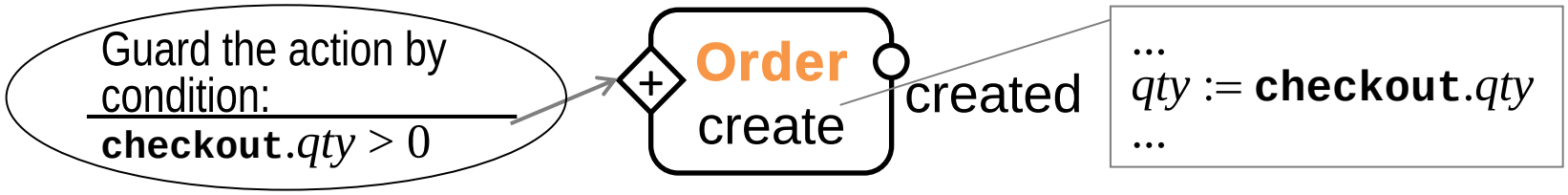


- **Data integrity constraints**
- In data schema
  - *key*, foreign key, candidate key UNIQUE, not-null
- On attribute content
  - Order: qty>0; Ship: from ≠ addr
- Business specific constraints
  - Status: order cannot be canceled or returned when there is an associated shipment not finished
  - …

GSM: A Declarative Workflow Language



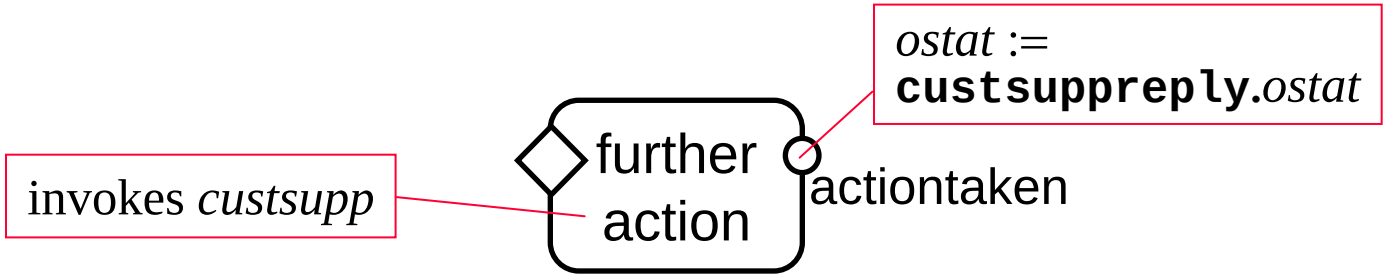
Guard Injection



κ_{attr}=∀oid, ... Order(oid).qty>0

- Intuition: calculate and inject weakest precondition
- GSM: guard-stage-milestone by IBM

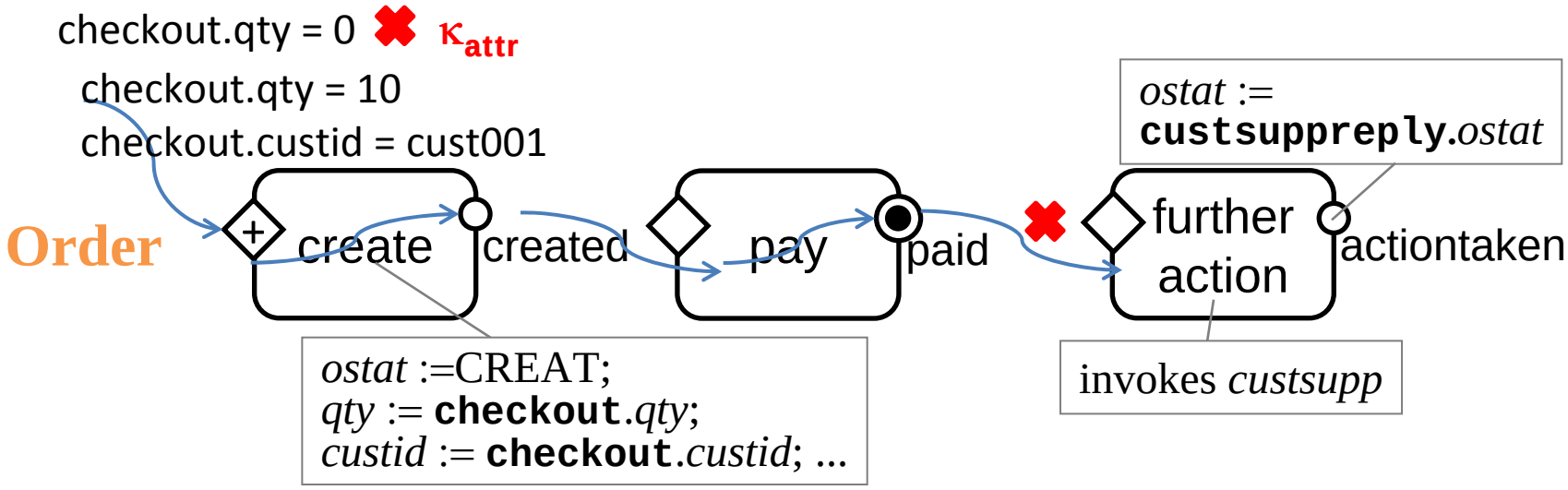
Conservative Injection



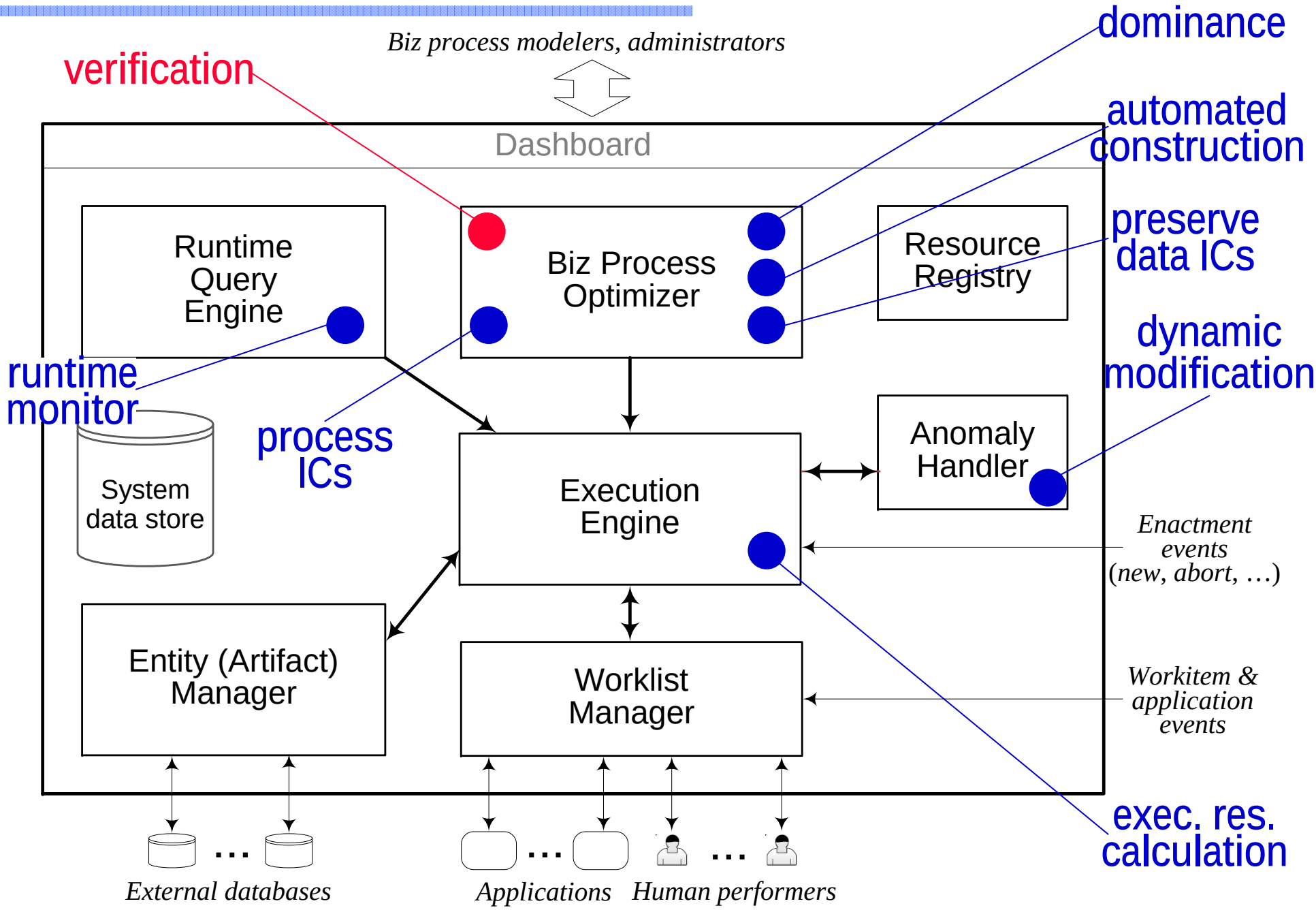
- If there is a shipment associated and is not finished
  - **custsuppreply.***ostat* = CANCEL, **violated**
  - **custsuppreply.***ostat* = CANCEL, **consistent**
- Injection to further_action is **FALSE**

Result

- The injection is
  - Sound: strong enough to block potential violations
  - Conservative complete: weak enough to allow all possible updates that preserves the constraints in conservative manner

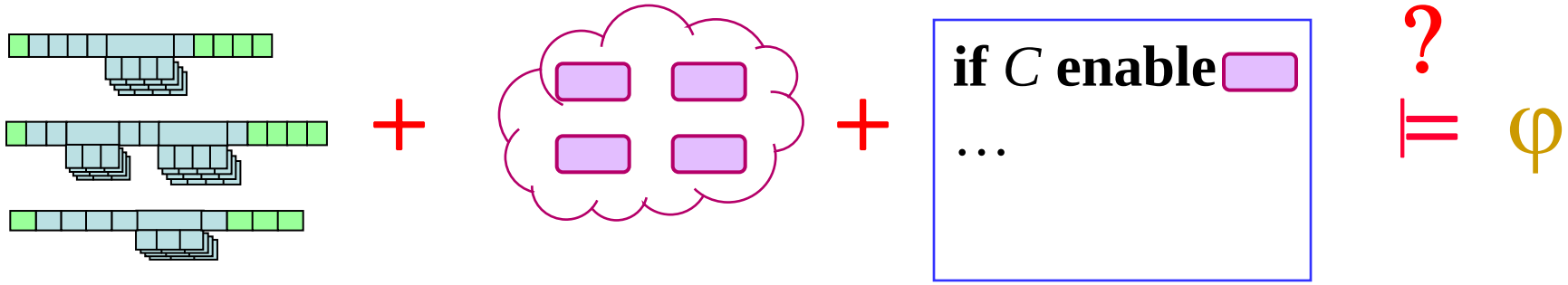


EZ-Flow and Research Problems



Verification Problem

- Given a biz process and a goal, do all executions of the workflow satisfy the goal?



Artifacts (Info models)

Semantic services (IOPEs)

Condition-action

[Bhattacharya-Gerede-S. SOCA 07] [Gerede-S. ICSOC 07]
[Bhattacharya-Gerede-Hull-Liu-S. BPM 07]
[Deutsch-Hull-Patrizi-Vianu ICDT 09]
[Vianu ICDT 09]

Summary of Results

- An artifact system $W = (\Gamma, S, R)$

  artifacts, services, rules

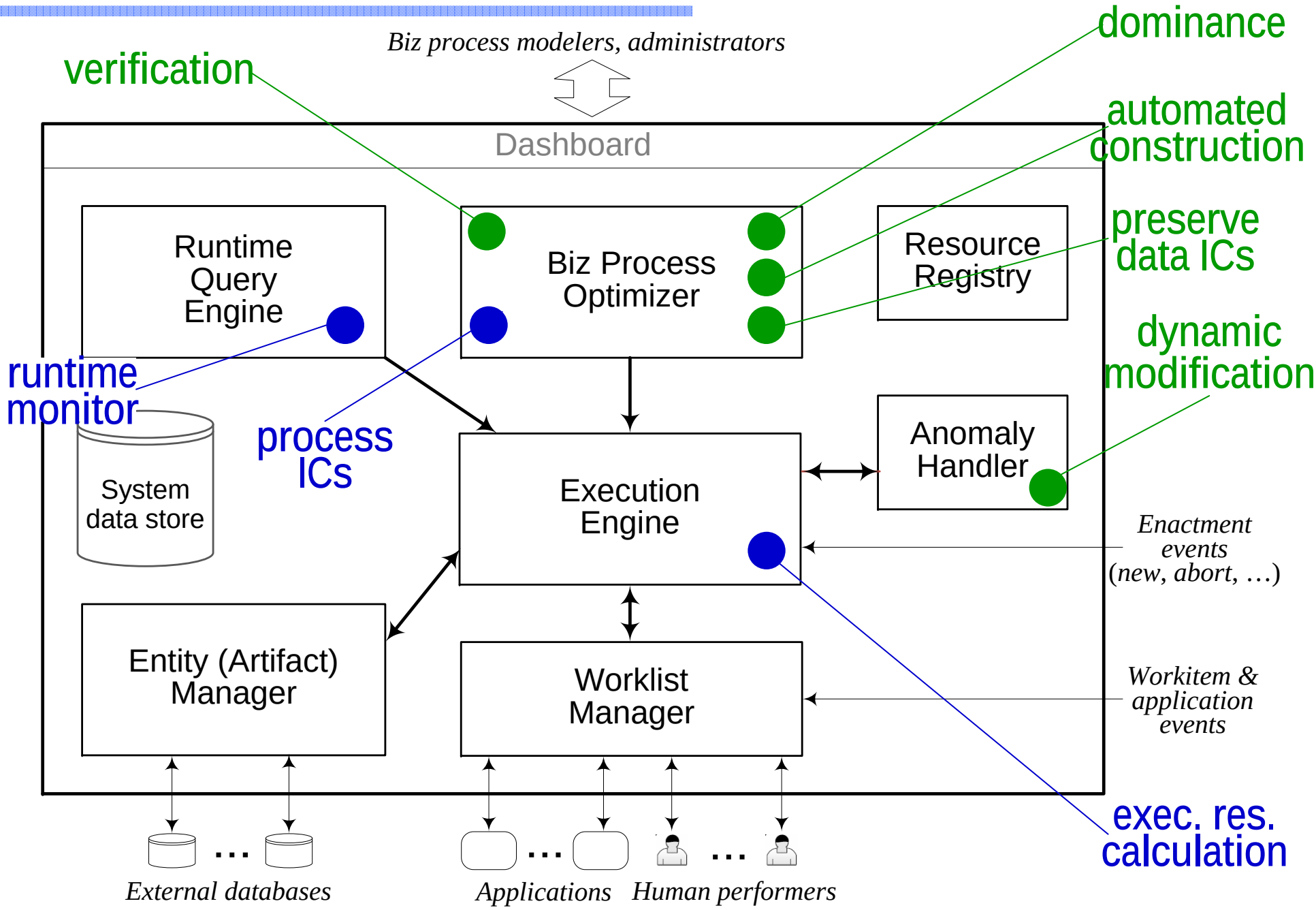
- *Ad hoc properties*, restricted to defined-ness
  - Completion: Does W allow a complete run of an artifact?
  - Dead-end: Does W have a dead-end path?
  - Attribute redundancy: Does W have a redundant attribute?

  Undecidable in general, PSPACE if no artifact creation, intractable for monotonic workflows

  [Bhattacharya-Gerede-Hull-Liu-S. BPM 07]

- *Temporal properties*: LTL(FO) for guarded artifact schema
  - complete in PSPACE [Deutsch-Hull-Patrizi-Vianu ICDT 09]

EZ-Flow and Research Problems



Outline

- Challenges in Business Process Management
- Artifact-centric Modeling Approach
- EZ-Flow and Selected Technical Issues
- Conclusions

Conclusions

- Biz process modeling: a foundation for many BPM issues
  - Many challenges: “old” and new
  - Data-centric or data aware approaches promising
- Systematic exploration provides a good setting for the study
  - First step in a long march
- Similar to mySQL, will “myBPM” be on the horizon?

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