TECHNION
Israel Institute of Technology

# Machine-Assisted Design of Business Processes Using Descriptor Space Analysis

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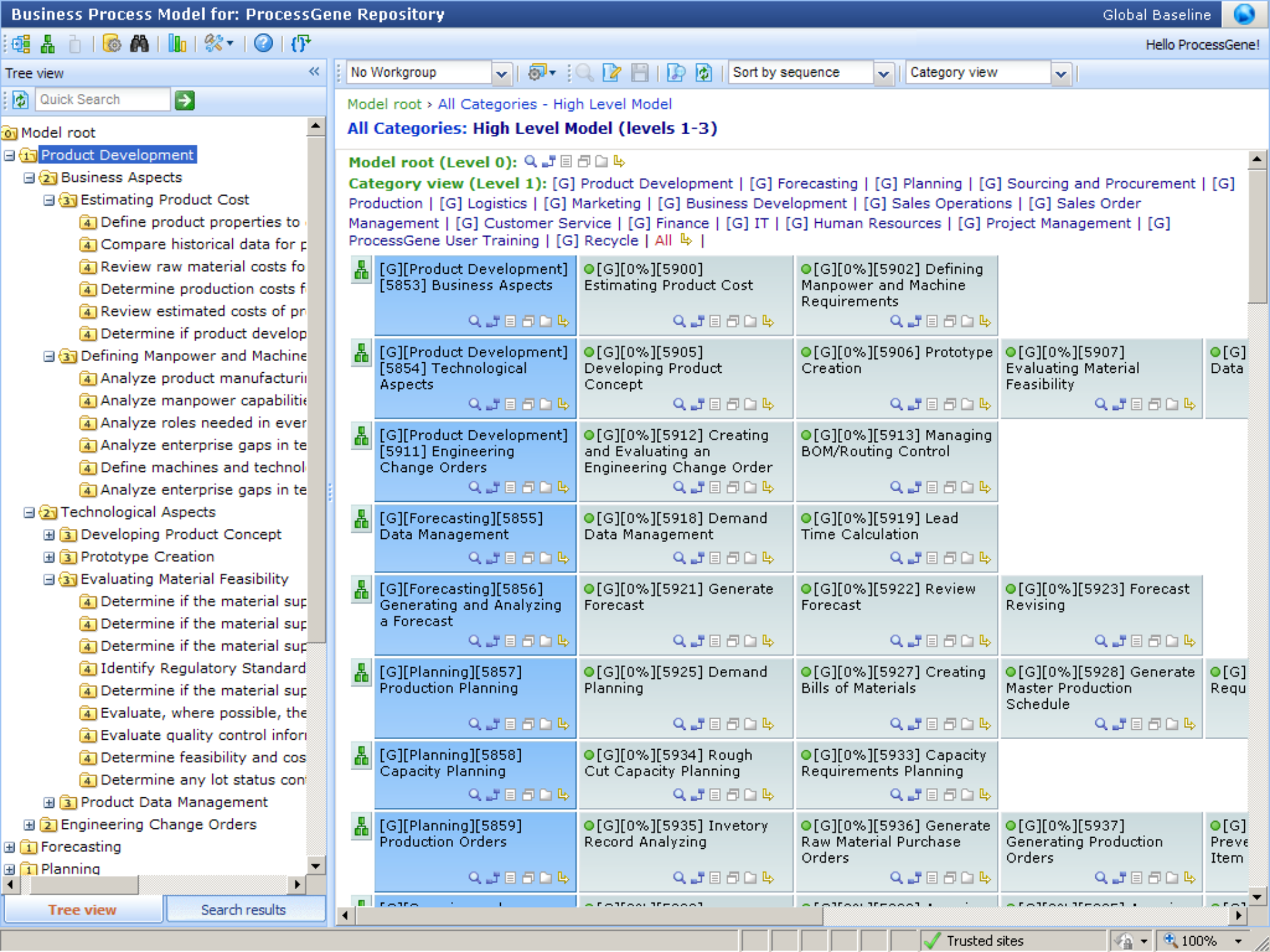
# Background/1

- Business Process Repositories describe the “know-how” of organizations
- Business Process Repositories can be used for:
  - Management of regulations and compliance enforcement
  - Management and control of IT systems
  - Analysis and improvement of processes
  - Documentation and training
  - Mergers and acquisitions planning
  - Performance monitoring


Business Process Model for: ProcessGene Repository
Global Baseline
Hello ProcessGene!
Tree view
Quick Search
Model root
Product Development
Business Aspects
Estimating Product Cost
Define product properties to
Compare historical data for p
Review raw material costs fo
Determine production costs f
Review estimated costs of pr
Determine if product develop
Defining Manpower and Machine
Analyze product manufacturi
Analyze manpower capabilitie
Analyze roles needed in ever
Analyze enterprise gaps in te
Define machines and technol
Analyze enterprise gaps in te
Technological Aspects
Developing Product Concept
Prototype Creation
Evaluating Material Feasibility
Determine if the material sup
Determine if the material sup
Determine if the material sup
Identify Regulatory Standard
Determine if the material sup
Evaluate, where possible, the
Evaluate quality control infor
Determine feasibility and cos
Determine any lot status con
Product Data Management
Engineering Change Orders
Forecasting
Planning
Tree view
Search results
No Workgroup
Sort by sequence
Category view
Model root › All Categories - High Level Model
All Categories: High Level Model (levels 1-3)
Model root (Level 0):
Category view (Level 1): [G] Product Development | [G] Forecasting | [G] Planning | [G] Sourcing and Procurement | [G] Production | [G] Logistics | [G] Marketing | [G] Business Development | [G] Sales Operations | [G] Sales Order Management | [G] Customer Service | [G] Finance | [G] IT | [G] Human Resources | [G] Project Management | [G] ProcessGene User Training | [G] Recycle | All |
[G][Product Development] [5853] Business Aspects
[G][0%][5900] Estimating Product Cost
[G][0%][5902] Defining Manpower and Machine Requirements
[G][Product Development] [5854] Technological Aspects
[G][0%][5905] Developing Product Concept
[G][0%][5906] Prototype Creation
[G][0%][5907] Evaluating Material Feasibility
[G] Data
[G][Product Development] [5911] Engineering Change Orders
[G][0%][5912] Creating and Evaluating an Engineering Change Order
[G][0%][5913] Managing BOM/Routing Control
[G][Forecasting][5855] Data Management
[G][0%][5918] Demand Data Management
[G][0%][5919] Lead Time Calculation
[G][Forecasting][5856] Generating and Analyzing a Forecast
[G][0%][5921] Generate Forecast
[G][0%][5922] Review Forecast
[G][0%][5923] Forecast Revising
[G][Planning][5857] Production Planning
[G][0%][5925] Demand Planning
[G][0%][5927] Creating Bills of Materials
[G][0%][5928] Generate Master Production Schedule
[G] Requ
[G][Planning][5858] Capacity Planning
[G][0%][5934] Rough Cut Capacity Planning
[G][0%][5933] Capacity Requirements Planning
[G][Planning][5859] Production Orders
[G][0%][5935] Invetory Record Analyzing
[G][0%][5936] Generate Raw Material Purchase Orders
[G][0%][5937] Generating Production Orders
[G] Preve Item
Trusted sites
100%

# [G] Production Planning: Decomposition Model

## [G][0%][5925] Demand Planning

Add Process

- [G][0%][6641] Review sales forecast
- [G][0%][6642] Review sales order entries
- [G][0%][6643] Analyze aggregative demand
- [G][0%][6644] Publish aggregative demand to all relevant departments
- [G][0%][6645] Analyze gaps in demand fulfillment
- [G][0%][6646] Consult with relevant function on how to resolve the gaps
- [G][0%][6647] Calculate finished goods provision schedule
- [G][0%][6648] Publish finished goods provision schedule

## [G][0%][5927] Creating Bills of Materials

Add Process

- [G][0%][6650] Determine the type of Bills of Material to create
- [G][0%][6651] BOM is for an engineering prototype item?
- [G][0%][6652] Create the Engineering Bills of Material component list
- [G][0%][6653] Enter a substitute component on the Engineering Bills of Material
- [G][0%][6654] Add Bill Details to the Engineering Bill of Materials
- [G][0%][6655] Create the Bill of Materials component list
- [G][0%][6656] Enter a substitute component on the Bill of Materials
- [G][0%][6657] Add Bill

## [G][0%][5928] Generate Master Production Schedule

Add Process

- [G][0%][6661] Determine External Demand for all Master Schedule Items
- [G][0%][6662] Review BOM
- [G][0%][6663] Establish MPS alternatives
- [G][0%][6664] Check Critical Resources
- [G][0%][6665] Evaluate Manufacturing Ability to meet Demand
- [G][0%][6666] Forecast change required?
- [G][0%][6667] Generate MPS
- [G][0%][6668] Review MPS
- [G][0%][6669] Publish

## [G][0%][5930] Material Requirements Planning

Add Process

- [G][0%][6670] Review MPS
- [G][0%][6671] Review BOM
- [G][0%][6672] Review current stock levels
- [G][0%][6673] Expected receipts
- [G][0%][6674] Quantity of material allocated to previous production orders
- [G][0%][6675] Generate material requirements planning
- [G][0%][6676] Generate MRP purchase orders
- [G][0%][6677] Generate MRP production orders
- [G][0%][6678] Review MRP

## [G][0%][5932] Routing Planning

Add Process

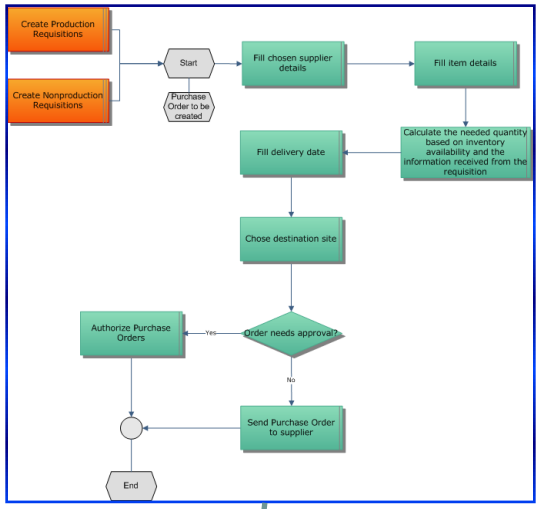
- [G][0%][6682] Define the activities that occur during the production process
- [G][0%][6683] Define the resource used to manufacture the product
- [G][0%][6684] Define the needed information for every step in the manufacturing process
- [G][0%][6685] Assign resource to department
- [G][0%][6686] Notify cost accounting of the resources assigned
- [G][0%][6687] Modify the default routing step dependencies as necessary
- [G][0%][6688] Create the production routing
- [G][0%][6689] Publish

## [G][0%][6001] Manag Labor Requirements

Add Process

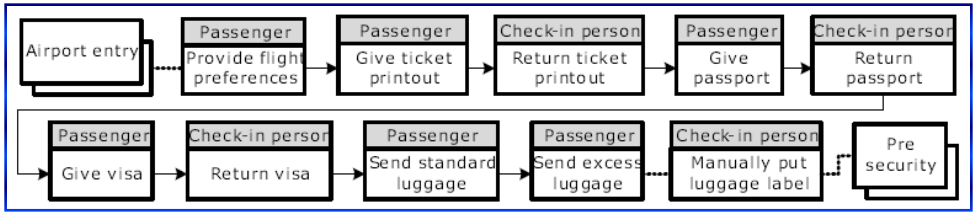
- [G][0%][6691] Review the production schedule identify potential capacit issues
- [G][0%][6692] Review machine loads and labo requirements
- [G][0%][6693] Machir requirements exceed available labor resource
- [G][0%][6694] Adjust start time of batch(es) where necessary to accommodate labor constraints
- [G][0%][6695] Assign the appropriate number personnel per shift to m the workload

# Background/4




A Business Process Model - presented through a flowchart

A Business Process Model - presented through YAWL



# Motivation /1

- Process modeling is considered a manual, labor intensive task
  - The outcome depends on personal domain expertise
  - Errors or inconsistencies can lead to bad process performance and high process costs
- Hence, automating the reuse of constructs, gathered from predefined process models does not only save design time but also supports non-expert designers in creating new business process models

# Motivation /2 – An Example

- Consider an airport process model that incorporates processes related to passengers check-in before boarding an airplane
- Now, suppose that the airport management desires to extend the services provided to its customers by offering a new service: “check-in from home”
- In addition, it is also desired to outline the “check-out” process model as an extension of the current repository
- The existing repository encapsulates know-how and business logic that are relevant and useful for the creation of these new models
  - e.g. passenger check-in policies and procedures regarding security, luggage handling, passenger handling and document validation

# Motivation /3 – An Example

- In the above scenario, it would have been helpful for the process designer to design the new processes using a supporting system that relies on the reuse of previous know-how instead of creating the model manually from scratch
- To illustrate our methodology we use a real-world case study for airport process design
- Based on a "check-in" process that already exists in the repository, we demonstrate how it is possible to design the two, above mentioned, new business processes

# Research objective

- Propose an effective method for designing new business process models related to any functional domain, without limiting the focus to a specified functional area
- Delineate new business process models according to the organization’s specific business logics and business rules

# Related work/1

- Most previous work focused on supporting the design of alternative process steps within existing process models
- Less work has been carried out on the design of new process models
- The few works that addressed the design of new models were limited to a specific domain such as production management

# Related work/2

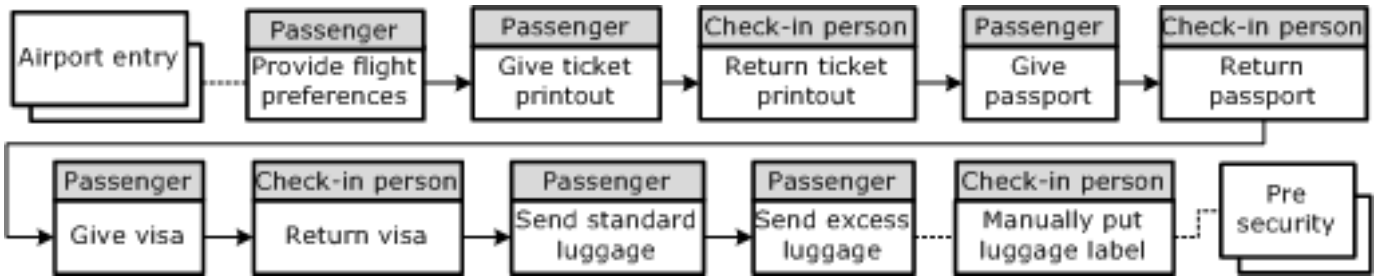

1. K. Bhattacharya, C. Gerede, R. Hull, R. Liu, and J. Su. Towards formal analysis of artifact-centric business process models. Lecture Notes in Computer Science, 4714:288, 2007.
2. T. Gschwind, J. Koehler, and J. Wong. Applying patterns during business process modeling. In BPM, volume 5240, pages 419. Springer, 2008.
3. R. Hull. Artifact-centric business process models: Brief survey of research results and challenges. On the Move to Meaningful Internet Systems: OTM 2008.
4. D. Muller, M. Reichert, and J. Herbst. Data-driven modeling and coordination of large process structures. Lecture Notes in Computer Science, 4803:131, 2007.

# Related work/3

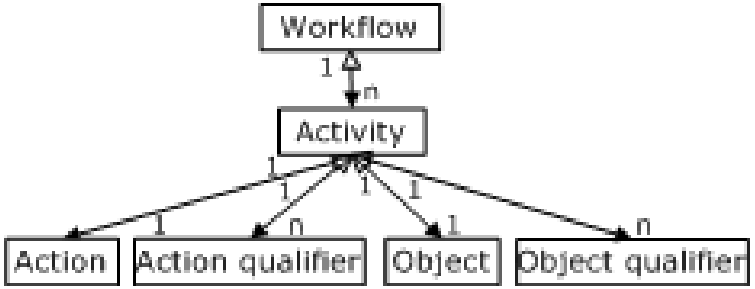

1. H.A. Reijers, S. Limam, and W.M.P. Van Der Aalst. Product-based workow design. Journal of Management Information Systems, 20(1):229262, 2003.
2. H. Schonenberg, B. Weber, B.F. van Dongen, and W.M.P. van der Aalst. Supportting flexible processes through recommendations based on history. (BPM 2008)
3. K. Wahler and J.M. Kuster. Predicting Coupling of Object-Centric Business Process Implementations. (BPM 2008)

# The Descriptor Model /1

An example: the passenger check-in process



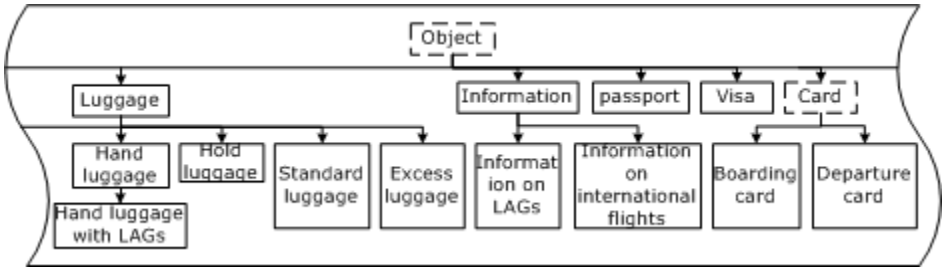

The process descriptor model



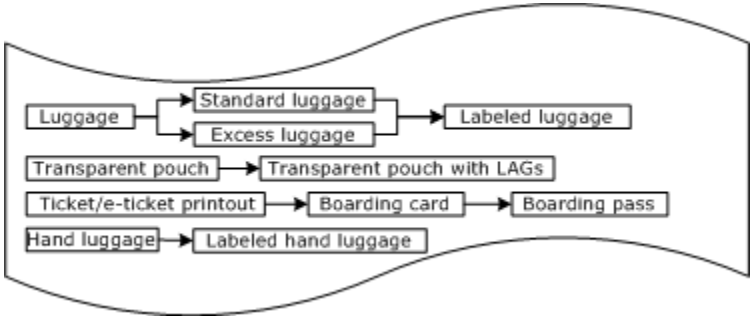
# A Descriptor Model for Process Design /1

## Object taxonomies

- An object hierarchy model



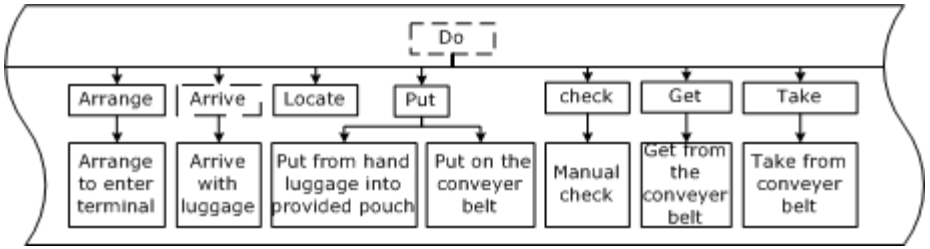

- An object lifecycle model



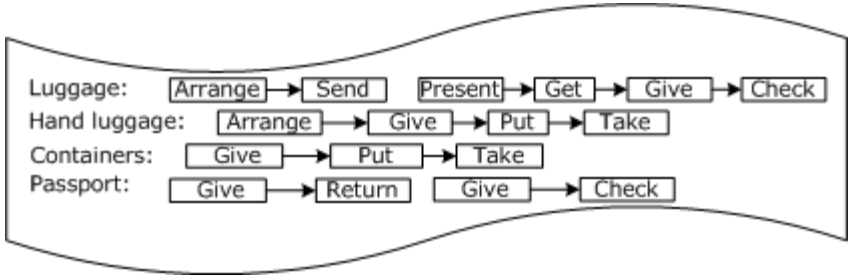
# A Descriptor Model for Process Design /2

## Action taxonomies

- An action hierarchy model




- An action lifecycle model



# The Descriptor Space - Definition

- A quad-dimensional space of activities
  - Each space coordinate represents an activity as a quadruple AC = <O,OQ,A,AQ>
  - Some coordinates represent “real” activities from the process repository, while others represent “virtual” activities
- The distance between every two coordinates

$$Dist\,(AC_i, AC_j) = OD_{ij} + AD_{ij} + OHD_{ij} + AHD_{ij}$$

  - $OD_{ij}$ – the object distance: the minimal number of steps connecting Oi and Oj in the object lifecycle model
  - $AD_{ij}$ - the action distance: the minimal number of steps connecting Ai and Aj in the action sequence model
  - $OHD_{ij}$ - the object hierarchy distance: the minimal number of steps connecting Oi with Oj in the object hierarchy model
  - $AHD_{ij}$ – the action hierarchy distance, defined similarly to $OHD_{ij}$
  - A “no-connection” distance is used when OD/AD are undefined

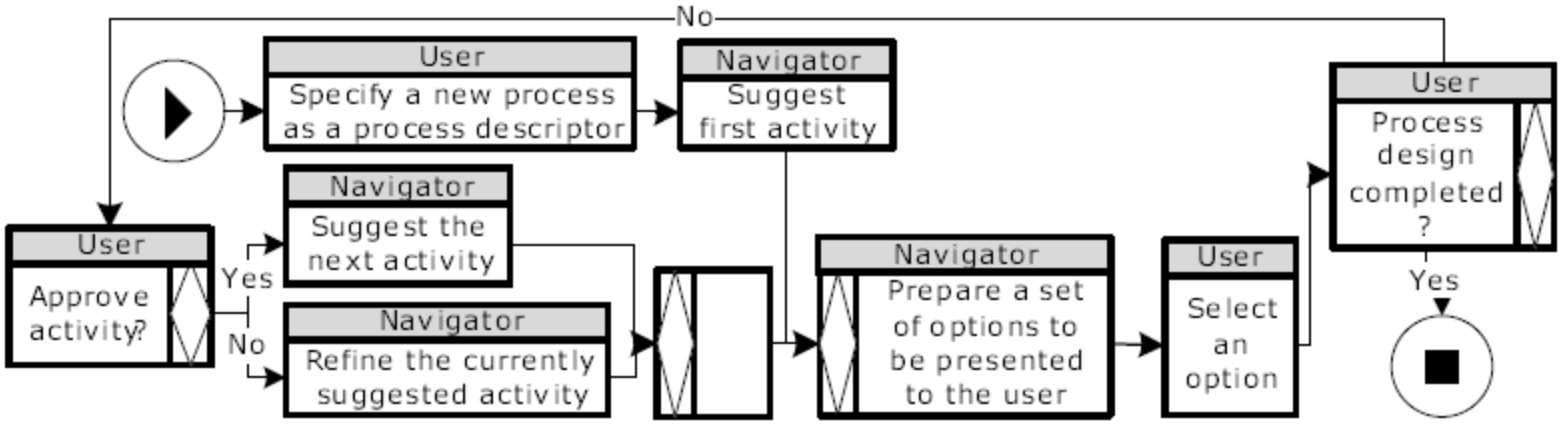
# The Descriptor Space – An Example for Calculating Distances

- Consider the two descriptors:
  - $AC_i$ = (luggage,hand,check,null) and
  - $AC_j$ = (luggage,null,get,from the conveyer belt)
- To navigate from $AC_i$ to $AC_j$:
  - We move one step up in the object hierarchy (OHD = 1) from the object Hand luggage to the object Luggage
  - Then, we recede two steps back from the action Check in the action sequence (AD = 2), resulting with the action “Get”
  - Finally, we drill down one step within the action hierarchy (AHD = 1), and retrieve the action “Get” from the conveyer belt, and by that we reach the target descriptor
  - The total distance between the two above coordinates is 1

# The Descriptor Space - Navigation

- Navigating the Action Dimensions
  - Navigating hierarchaly to more specific or more general actions
  - Navigating longitudinaly to preceding and succeeding actions that act on the descriptor's object
- Navigating the Object Dimensions
  - Drilling down to a more specific object, rolling up to a more general object, or navigating to a sibling object
  - Advancing to a more advanced state of the object processing or receding to a less advanced state

# The Process Navigator /1



# The Process Navigator /2

- Suggesting the First Process Activity
  - Goal
  - Search the target object and its more specific objects within the object hierarchy model
  - Match it with an initial action that can be acted on this object
  - Compose first activity suggestions
    - Retrieved objects and the first action that acts upon them
  - Sort and flag results

# The Process Navigator /3

- Refining the Currently Suggested Process Activity (e.g. “Get luggage”)
  - Action and Object Refinement
    - E.g. “Get luggage from the conveyer belt”, “Get hand luggage”
  - Action and Object Generalization
  - Advance an Object's State or an Action
    - The object “Standard luggage” represents a more advanced state of the object “Luggage”
    - The action “Give” follows “Get” in the action sequence applied on “Luggage”
    - => The following refinement suggestion is constructed: “Get standard luggage”,and “Give luggage”

# The Process Navigator /4

- Refining the Currently Suggested Process Activity (continue)
  - Recede to a Less Processed State of the Object or to a Former Action
    - E.g. the action “Present” is acted on “Luggage” before this object is taken (before the action “Get” is applied), hence creating the refinement option: “Present luggage”
  - Move to a Sibling Action or Object
    - E.g. a navigation to sibling actions to “Get” retrieves a list of activities that includes: “Check luggage” and “Take luggage”
    - In the same manner, a search for sibling objects, retrieves a list of activities, that includes: “Get passport” and “Get visa”

# The Process Navigator /5

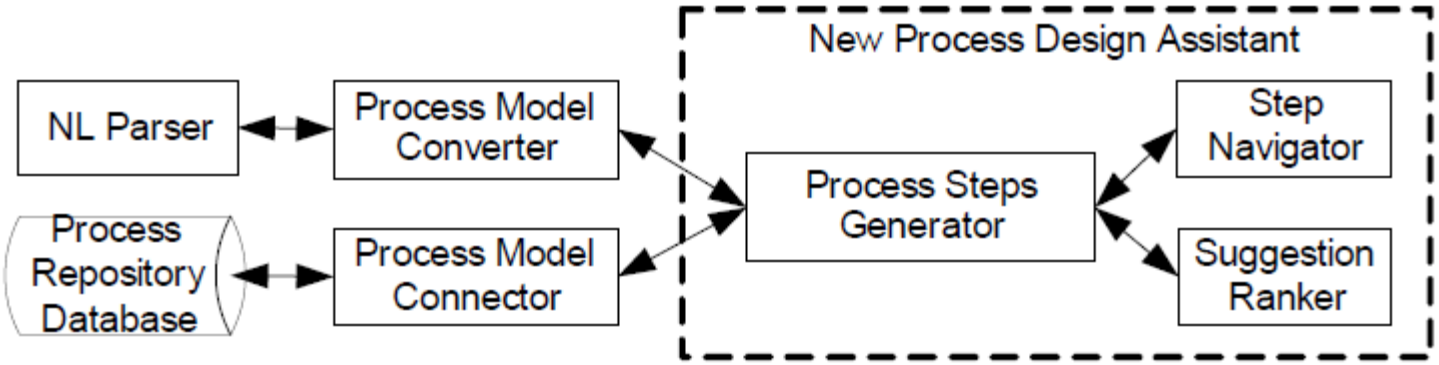
- Suggesting the Next Process Activity
  - Goal: take the process execution flow one step forward
  - Two alternative ways:
    - Advancing to a later action that acts on the currently accepted object
      - E.g. “Give passport”-> “Check passport” / ”Return passport”
    - Proceeding to a sibling object combined with the reference activity's action
      - Rationale: in some process flows the same action is operated on sibling objects in order to fulfill a certain process goal (e.g. Send standard luggage -> Send excess luggage)
      - E.g. “Give passport”-> “Give visa” / ”Give luggage” / ”Give information”

# The Process Navigator /6

- Preparing a Set of Output Options
  - Sort by Proximity to the Reference Activity
    - By calculating distances
  - Internally Sort by Similarity to Processes in the Repository
    - *No change* - the suggested activity is represented “as is” within the underlying business process repository. No mark
    - *Slight modification* - there is an actual activity in the underlying business process repository containing the same object and action with different qualifiers. Marked with “~”
    - *Major change* - the object and action within the suggested activity were not coupled in any of the activities within the underlying business process repository. Marked with “M”.
  - Add a Random Option
  - Flag Each Option
    - E.g. “[1,~]”

# Implementation

- An IT system
  - Server side logic is implemented in PHP using a MySql database
  - The client runs within an Internet browser and is implemented in HTML and JavaScript, with AJAX calls to the server

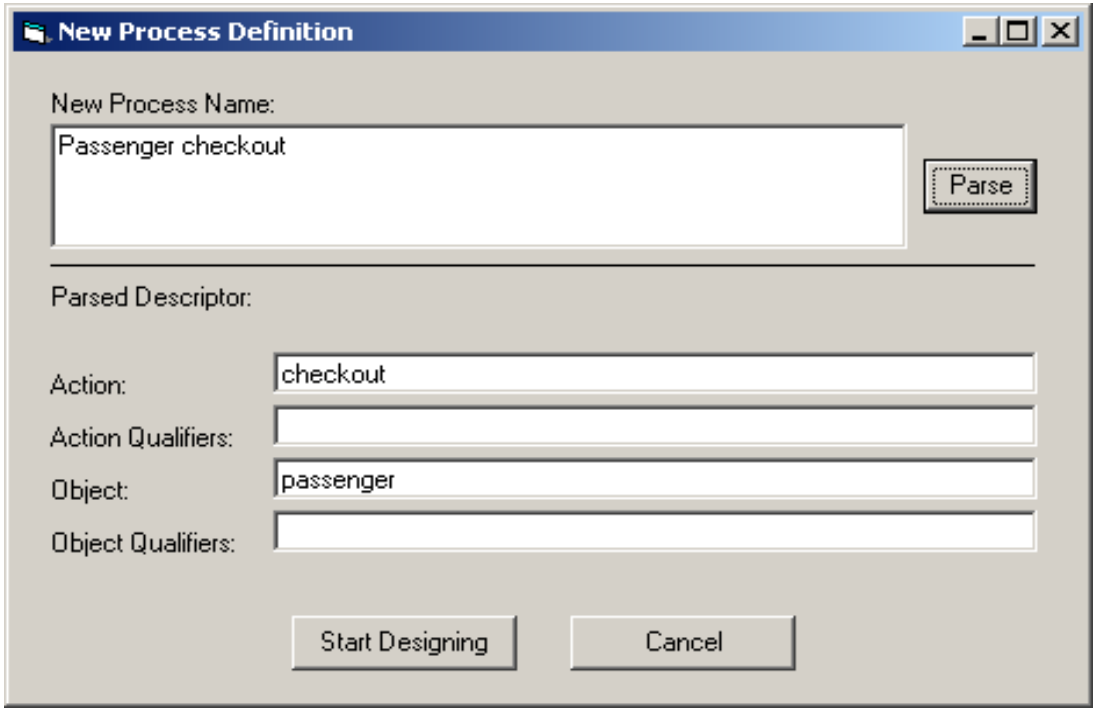


# Case Study /1

- Based on the aviation process repository
- Designing a new process: “Passenger Checkout”
  - Extends the process repository by handling passenger related activities conducted after an airplane arrives at its destination
  - Final design output:

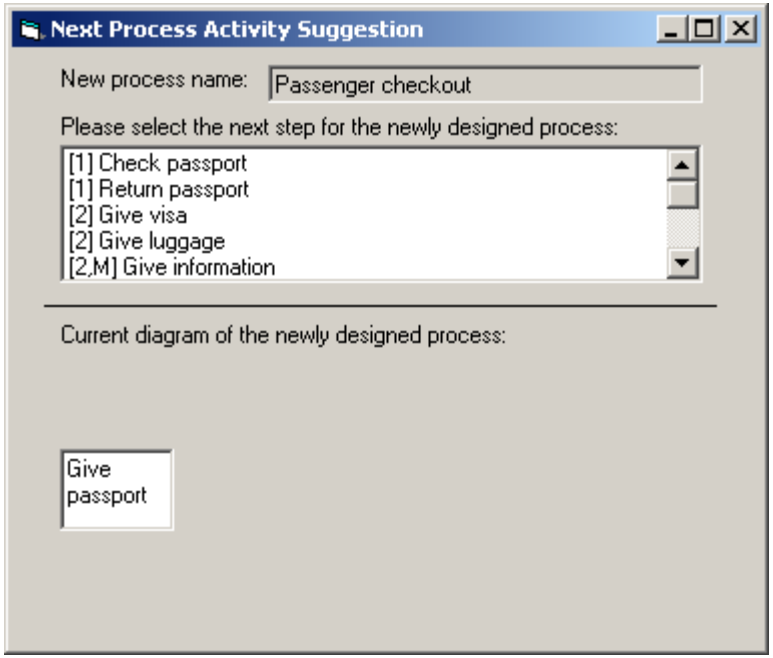
# Case Study – process generation system/2

- Step 1: The process designer's input



# Case Study process generation system/3

- Step 2: First activity (defined by the designer) is: “Give passport”
- Step 3: Next activity suggestions:



# Case Study /4

- Step 4: The designer selects the option “Check passport”
- Step 5: The designer selects the option “Give luggage” as a next future activity (will be required at the customs point)
- Step 6: The designer then asks the process navigator to provide next step options and receives:
  - [1] Check luggage, [2] Give visa, [2,M] Give information
- Step 7: The designer selects the first option, “Check luggage”

# Case Study /5

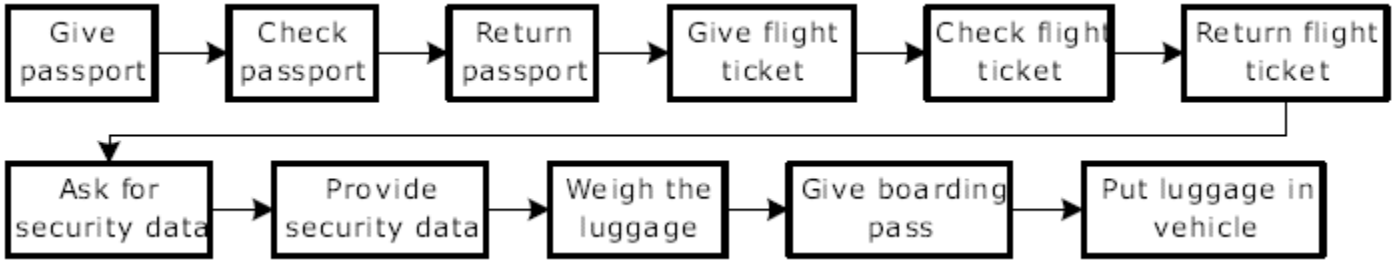
- Step 8: The designer asks for previous activity suggestions to “Give luggage”
  - Rationale: by reviewing the newly designed process, she realizes that an activity may be missing before Give luggage, since the passenger may not have carried his luggage with him to the airplane.
- Step 9: Retrieved previous step suggestions (by navigating backwards in the action sequence)
- Step 10: The designer selects the option: “Get luggage” and asks the process navigator to refine it
  - Reason: it seems to lack sufficient details to express the activity required in this context

# Case Study /6

- Step 11: The process navigator presents refinement suggestions
- Step 12: The designer selects the option: “[1,~] Get luggage from the conveyer belt”
  - Note that this activity was selected although it was not represented “as is” in the business process repository

# Case Study /7

- Designing the new process: “Send luggage from home”
- Output:




- An interesting observation is the usage of the activity “Put luggage in vehicle”
  - While the original business process repository contained the action “Put in vehicle” applied only to the object “Baby carriage”, the terminating activity combines this action with the object: “Luggage”

# Experiments - Data /1

- We chose a set of 14 processes from the Oracle Business Model (OBM)
  - nine business processes from the Procurement category (96 activities)
  - five business processes from the Inventory category (31 activities)
- The Procurement data set contains related, sequential activities and therefore encapsulates a focused operational area
- The Inventory data set encapsulates a loosely coupled business logic regarding an extended business area

# Experiments - Evaluation Methodology /2

- At each experiment, a single process was removed from the database and was reconstructed using the “New Process Design Assistant” software (NPDA)
- This way, the missing process serves as the final design goal, enabling us to measure the method's effectiveness in an objective manner
- Each experiment was conducted according to the following steps:
  - Remove one of the processes from the database so that the database will not contain any of its activities
  - Run the NPDA and select at each phase the option (activity) compatible with the removed process
    - Handle cases in which no option represents the goal activity

# Experiments - Methodology /2

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# Experiment Results/1

- …

**Table 1.** Experiment results.

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Column name | # of total processes in DB | # of total activities in DB | % of goal activities represented in the DB | Avg. # of steps per design phase | Avg. location of correct option in 'next activity' | Avg. location of correct option in 'refine activity' | Avg. location of the correct option per design phase |
| Avg.-all | 14 | 127 | 89.0% | 2.0 | 1.2 | 2.8 | 2.6 |
| Avg.-Procurement | 9 | 96 | 90.6% | 1.9 | 0.8 | 3.0 | 2.8 |
| Avg.-Inventory | 5 | 31 | 83.9% | 2.1 | 1.9 | 2.4 | 2.3 |

# Experiment Results/2

**Table 2.** Distribution of successful predictions vs. the number of required refinements.

| # of refinements | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| % of successful predictions | 12% | 35% | 27% | 12% | 4% | 2% | 2% | 1% | 1% | 3% |
| Cumulative | 12% | 48% | 75% | 88% | 92% | 94% | 96% | 96% | 97% | 100% |

# Conclusions/1

- The proposed method, software tool, and experiments provide a starting point that can alreadybe applied in real-life scenarios, yet several research issues remain open, including:
- (1) an extended empirical study to further examine the quality of newly generated processes;
- (2) an extended activity decomposition model to include
- an elaborated set of business data and logic (e.g., roles and resources); and
- (3) defining a learning mechanism that will take into account previous designer preferences and adjusting (in real time) the process delineator mechanism.

# Conclusions/2

- As a future work we intend to investigate further language semantics by using more advanced natural language processing techniques, as well as semantic distances between words.
- Finally, we intend to apply the techniques we have
- developed to create new methods for workflow validation

# Thank you !