Digital Transformation

Business Process Management in the Digital Era: Scenarios, Challenges, Technologies

Manfred Reichert
Motivation

IT Era

1960 Mainframe

1980 PC + Web

2005 Cloud + Mobile

2015 IoT + Analytics + Automation (Machine Learning)

People Centric Digitization

Machine Centric Digitization

Drivers of Innovation

 Enterprises

 Consumer

 Digitization (Data) & IoT (Machines)

Motivation
Motivation: Theses on the Digital Transformation

• **Thesis 1: Digital transformation is ubiquitous**
  – It goes over *pervasively* into our daily professional and private life.

• **Thesis 2: Digital transformation is unavoidable!**
  – Whatever can be digitalized will be digitalized in the long run.
  – Customers will demand for digitally enabled services and business.

• **Thesis 3: Digital transformation not only concerns Industry 4.0 (i.e. industrial production)**
  – For service providers, there exist similar potentials, e.g., if the (digital) services refer to *physical objects*.

• **Thesis 4: Digital transformation is interdisciplinary and requires domain knowledge!**

• **Thesis 5: Digital transformation is more than automation!**
  – Enterprises that only want to reduce media disruptions with their digitalization projects will miss the real digitalization opportunities.
Motivation: Theses on the Digital Transformation

• Thesis 6: Digital transformation often leads to new business models

• Thesis 7: Digital transformation leads to cyber-physical systems
  – Real-world objects continuously produce large amounts of data, notify the environment about their state, and communicate with each other.
  – As a result, cyber-physical systems are emerging whose interplay enables new (digital) services and business models.

• Thesis 8: Digital transformation drives mobile work, mobile work drives digital transformation

• Thesis 9: Digital transformation requires comprehensive process knowledge and support
  – Process knowledge is required in order to digitalize processes properly.
  – The digital processes need to be continuously aligned with the real-world ones. Otherwise, any process support will not be accepted by the users!
  – One should not solely focus on business processes, but consider any kind of structured actions!

• Thesis 10: Digital transformation requires elastic infrastructures
BPM as Enabler for Digital Transformation?
Scenario 1: Traditional Business Processes
Scenario 2: Healthcare Processes & Application Integration

Scenario 3: Mobile Processes – Here, There and Everywhere

The full potential of labor can be utilized only if there is mobility in labor.  
Paul Hoffman
Scenario 4: Smart Processes
Scenario 5: Large Collective Process Structures

Automotive Engineering

Scenario 6: Cyber-Physical Processes (Industry 4.0)
Scenario 7: Logistics & Human / Robot Integration
CHALLENGES AHEAD
Business Process Management (BPM) is a discipline involving any combination of modeling, engineering, automation, execution, control, measurement, and optimization of business processes, in support of enterprise goals, spanning IT systems, employees, customers and partners within and beyond the enterprise boundaries.
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Adopted from K. Swenson, BPM'14 Keynote
Industry has Understood ...
Industry has Understood ...

... but does not always provide mature BPM solutions reflecting the state of the art!
... whereas the BPM Community is at a rather early stage.
... whereas the BPM Community is at a rather early stage
How BPM research can foster Digital Transformation 
Process Automation with 
ADEPT / AristaFlow BPM Suite
**Enforcement:** Guardrails (on a road) prevent deviation, but also prevent anything not predicted.

**Guidance:** Guidelines (on a road) show people where to go, but do not prevent deviations if they are necessary.

ADEPT / AristaFlow – Enforcement vs. Guidance + Flexibility

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"It is not the strongest of the species that survives, not the most intelligent that survives. It is the one that is the most adaptable to change."

Charles Darwin
ADEPT / AristaFlow – Basic Features

- process modeling
- process execution
- process monitoring
- application invocation ("play")
- application integration ("plug")
- process instance changes

**Process Template**

**Process Instance**

**Office**

**SOAP web service**

**Application service**

**Repository**

**PAIS**
ADEPT / AristaFlow – Basic Features

- process modeling
- process execution
- process monitoring
- application invocation („play“)
- application integration („plug“)
- process instance changes
- process schema evolution

Process designer

Administrator

End user

PAIS

process schema evolution

template change change propagation

correctness
ADEPT / AristaFlow – Engineering the Framework

- **FR 1** process execution
- **FR 2** logging
- **FR 3** resource modeling
- **FR 4** worklist management
- **FR 5** process monitoring
- **FR 6** persistent storage
- **FR 7** application invocation („play“)
- **FR 8** process modeling
- **FR 9** process adaptation
- **FR 10** application integration („plug“)
- **FR 11** process management & versioning
- **FR 12** API & development framework

- **NR 1** scalability/performance
- **NR 2** robustness
- **NR 3** extensibility
- **NR 4** ease of use
- **NR 5** independence/modularity
- **NR 6** reuse/non-redundancy
- **NR 7** maintainability
- **NR 8** ability to evolve/flexibility

- DIN ISO 9126 (software quality, product quality)
ADEPT / AristaFlow – Industrial Transfer

Enhancing AristaFlow BPM Suite with Advanced Features

Business Process Compliance Modeling

Process model to be checked

Generated counterexample:
Execution path and corresponding process context violating the constraint
Enhancing AristaFlow BPM Suite with Advanced Features

Business Process Compliance Monitoring


Enhancing AristaFlow BPM Suite with Advanced Features
Integrating Temporal Constraints in the Process Lifecycle


Enhancing AristaFlow BPM Suite with Advanced Features
Integrating Temporal Constraints in the Process Lifecycle
Advanced Applications of the AristaFlow BPM Suite
Clinical Pathway Support

Advanced Applications of the AristaFlow BPM Suite
Process-driven Emergency Management for Water Infrastructures

Advanced Applications of the AristaFlow BPM Suite
IloT-Driven Processes for Handling Malfunctions and Breakdowns in Plants with Industrial Furnaces
Advanced Applications of the AristaFlow BPM Suite
Managing Freight Wagon / Car Management and Maintenance Processes
Advanced Applications of the AristaFlow BPM Suite
Enabling Track & Trace in Pharmaceutical Packaging

Uhlmann B1440 Blister Packaging Press Line

- **Input**: Tablets
- **Filling Station**
- **Touch-sensitive HMI**
- **Deflection Pulley**
- **Output**: Blisters
- **Input**: Aluminium/PVC/PC Foil
- **Forming Station**

**Output**: Blisters

**Box packing**

**Carton packing**
Advanced Applications of the AristaFlow BPM Suite
Enabling Track & Trace in Pharmaceutical Packaging

- Tablet Production
- Blister Packaging
- Final Packaging

- Working Instructions
- Electronic Form
- Electronic Form

- Production Machine
- Blister Packaging
- Final Packaging
Advanced Applications of the AristaFlow BPM Suite
Enabling Track & Trace in Pharmaceutical Packaging

- Order
  - Tablet Production
  - Blister Packaging
  - Final Packaging

- Format Change
  - Packaging
  - Completion
  - Cleaning

- Prepare Machine Station
  - Provide Packaging Material
  - Insert Folding Boxes
  - Run Test
  - Check Quality
  - Finish Preparation
## Advanced Applications of the AristaFlow BPM Suite
### Enabling Track & Trace in Pharmaceutical Packaging

<table>
<thead>
<tr>
<th>Format Change</th>
<th>Blister Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare machine station</td>
<td>Format Change</td>
</tr>
<tr>
<td>Provide packaging material</td>
<td>Packaging</td>
</tr>
<tr>
<td>Insert folding boxes</td>
<td>Completion</td>
</tr>
<tr>
<td>Check quality based on the SOP</td>
<td>Cleaning</td>
</tr>
<tr>
<td>SOP Quality Check</td>
<td></td>
</tr>
</tbody>
</table>

### Process Editor

- **Main Process**
  - Level 1
    - Format Change
    - Blister Packaging
    - Tablet Production & Packaging
  - Level 2
  - Level 3
  - Order data

### Control elements
- Working step
- Command label
- Machine attribute
- Machine sensor
- Signature

### Advanced Applications of the AristaFlow BPM Suite
- Enabling Track & Trace in Pharmaceutical Packaging

### Process Diagram

- Format Change
- Packaging
- Completion
- Cleaning
- Prepare Machine Station
- Provide Packaging Material
- Insert Folding Boxes
- Run Test
- Check Quality
- Finish Preparation

### Notes
- Electronic signature
Advanced Applications of the AristaFlow BPM Suite
Enabling Track & Trace in Pharmaceutical Packaging
Advanced Applications of the AristaFlow BPM Suite

Smart Process Guidance with AristaFlow BPM Suite
Advanced Applications of the AristaFlow BPM Suite
Smart Process Guidance with AristaFlow BPM Suite

Maintenance & Service Processes:

• Triggered through events, e.g., timer, errors or wear indicators
• Hundreds of tasks to be executed, e.g.
  – Cleaning
  – Replacing Spare Parts
  – Adjusting configuration settings
• For each task, a specific handbook and/or checklist exists
• High process variability due to varying assemblies of press lines
Advanced Applications of the AristaFlow BPM Suite
Smart Process Guidance with AristaFlow BPM Suite

- Error-prone
- Inefficient and time consumable
- Not available for everyone
- Complicated

Smart Process Guidance

- Digital process management and guidance with Augmented Reality

Target groups:
- Machine Operator
- Production Staff
- Maintenance Staff
- Service Technicians
- Quality Management
Advanced Applications of the AristaFlow BPM Suite
Smart Process Guidance with AristaFlow BPM Suite

- Interactive process execution on HoloLens
- Supports manual human tasks with augmented view
- Shows assets, task descriptions, SOP definitions

- Dynamic & interactive Process/SOP Modelling
- Machine and Point of Interest Setup
- Asset Management & Assignment
- User and Task Reporting

AristaFlow process engine with modular execution environment
Advanced Applications of the AristaFlow BPM Suite
Smart Process Guidance with AristaFlow BPM Suite: KALUNA Modeler

The image shows a screenshot of the KALUNA modeler software, which is used for creating process models. The screenshot includes a process template for Line Clearance, with various tasks and subtasks highlighted. The software interface allows for the creation of process models, linking assets, points of interest, organizational models, and activities to process models.

Process Model Management:
- Create process models (e.g., Line Clearance SOP)
- Link assets, points of interest, organizational models, and activities to process models
Advanced Applications of the AristaFlow BPM Suite

Smart Process Guidance with AristaFlow BPM Suite: KALUNA Modeler

Set Point Of Interests (POIs) on your machine for modelling processes

Management of holographic user management
- Define point of interests for machine
- Link process models to point of interest
Advanced Applications of the AristaFlow BPM Suite
Smart Process Guidance with AristaFlow BPM Suite: KALUNA AR Client

- Enriches the user’s view of the physical environment with virtual objects (e.g. checklists, videos).
- Process-oriented assistance supporting human tasks with an augmented view:
  - Digitalized Checklists
  - Task guidance
  - Displaying task-related assets (e.g. videos, SOPs)
  - Full traceability
Advanced Applications of the AristaFlow BPM Suite
Smart Process Guidance with AristaFlow BPM Suite: KALUNA AR Client
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Smart Process Guidance with AristaFlow BPM Suite: KALUNA AR Client
Advanced Applications of the AristaFlow BPM Suite
Smart Process Guidance with AristaFlow BPM Suite: KALUNA AR Client
Advanced Applications of the AristaFlow BPM Suite
Smart Process Guidance with AristaFlow BPM Suite: KALUNA Reports

Generate reports and evaluate results of your processes for:
- individual analysis and
- process optimization
Advanced Applications of the AristaFlow BPM Suite


Case Study

*Maintenance Processes of a Press Line*

Requirements & Challenges:

High process variability requires context-dependent process configurations!

Context is determined by both static factors (e.g., press line variant) and dynamic elements (e.g., machine status, sensor data).

Process guidance with AR needs to be context-driven!

*Variant 1*

*Variant 2*
Advanced Applications of the AristaFlow BPM Suite
Smart Process Guidance with AristaFlow BPM Suite: Runtime Process Adaptation

Case Study
Maintenance Process of a Press Line

Requirements & Challenges:
Robust and flexible execution of maintenance processes!

Enabling ad-hoc changes to handle exceptions and errors.

Pharmaceutical packaging requires full traceability of any process change to comply with Title 21 Code of Federal Regulations (CFR) Part 11

Advanced Applications of the AristaFlow BPM Suite

Smart Process Guidance with AristaFlow BPM Suite: Context Modeling, Assessment and Adaptation

Case Study

Maintenance Process of a Press Line

Requirements & Challenges:

Determine contextual situation (CS) from the current context model

Example of a CS: Occurrence of production error FormFoilEnd (e)

Relevant CS should be describable and assessable (b - e)

Requires sensor data integration

Core concept: Context-aware Process Injection ⇒ Injection specifications (f) control changes of running process instances (h) based on evaluated CS

Advanced Applications of the AristaFlow BPM Suite
Smart Process Guidance with AristaFlow BPM Suite: Interaction, Attention, Mapping

Interaction

- gestures
- gaze pointing (head movement)
- location movement

Feedback
- flashing lights
- siren
- haptic buttons
- visual elements
- sound
- speech
- vibrations on AR device

Pharma Packaging Machine

AR Device

Attention

- Task Fill Tablet Feeder with Sample Tablets
- Task Replace Forming Station Spare Parts
- Task Calibrate Forward Feeder
- Task Insert Missing Blister Container

Mapping

- Mapping physical objects (i.e., machine parts) to virtual counterparts from the context graph
- Enables AR device to present the additional digital information in an AR view or to automatically change configuration settings of a machine to fit the currently built-in format part
- Shall enable precise interactions and proper attention guidance
- Marker-based (e.g., QR code) vs. markerless object detection & tracking
The DBIS Factory
Exploring Processes
The DBIS Factory – Exploring Cyber-Physical Processes in the Lab
“We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run.”

AMARA’S LAW
Large Process Structures & Process Coordination
Large Process Structures & Process Coordination
The Current Situation in many Companies

Business Level
Model created by domain expert

IT Level
Model created by IT expert
Large Process Structures & Process Coordination
Challenge: Coordinate Execution of Multiple Interrelated Small Processes

Relational Process Structure

- Captures process types and their structural relations

Semantic Relationships

- Describes inherent patterns in the coordination of processes

The PHILharmonicFlows Approach
An Object-Centric Approach to BPM
The PHILharmonicFlows Approach
Object Lifecycle Process: Modeling

Vacation Request Form
(real-world business object)

[1] Künzle, Vera and Reichert, Manfred
PHILharmonicFlows: towards a framework for object-aware process management
Journal of Software Maintenance and Evolution: Research and Practice

Object-Aware Process Management
PhD thesis, University of Ulm.
The PHILharmonicFlows Approach
Object Lifecycle Process: Execution

The diagram illustrates the lifecycle of a vacation request. It starts with an initialized state, where the request is submitted with dates and other attributes. The request then goes to a decision pending state, where it can be approved or rejected. If approved, it moves to an approved state, and if rejected, it remains in the pending state. The lifecycle attributes include dates, approval status, and comments.
The PHILharmonicFlows Approach
Object Lifecycle Process: Execution
The PHILharmonicFlows Approach
Semantic Relationships


The PHILharmonicFlows Approach
Coordination Process
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<tr>
<th>ID</th>
<th>Status</th>
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<th>Date</th>
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<td>491891550757312524</td>
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</table>
Hybrid Process-Aware Information Systems
Human Robot Collaboration
The PHILharmonicFlows Approach

Are Scalable Object-Aware Processes Technically Feasible?
The PHILharmonicFlows Approach
Are Scalable Object-Aware Processes Technically Feasible?
Mobile Processes
# Mobile Processes

## Scenarios

### Approach 1

**Physical Process Fragmentation**

- Statically determined
- Mobile fragment

### Approach 2

**Logical Process Fragmentation**

- Migration: dynamically determined
- Mobile fragment

### Approach 3

**Single Mobile Task Handling**

- Migration: dynamically determined
- Mobile task

**Central process**: coordinating the fragments
Mobile Process Support for Therapeutic Interventions
Mobile Processes

Mobile Process Support for Therapeutic Interventions: Motivation
Mobile Processes

Mobile Process Support for Therapeutic Interventions: Homework Characteristics

Stretching
- 70% Stretch
- Hold for 25 sec.
- 3 times each side

Strengthening
- Extra aids
- 80% of HF\(_{\text{max}}\)
- 3 sets / 25 repet.

Stabilization
- Max. Stretch
- Hold for 25 sec.
- 1 time each side

Dependencies between exercises
Mobile Processes
Mobile Process Support for Therapeutic Interventions: Key Points

- Hierarchical Information Exchange
- Therapist-Patient-Researcher Relationship
- Expectations & Opportunities
- Integration of Smart Mobile Devices
- Use of internal and external Sensors
- New Concepts & Methods
Example: Follow-up Treatment after Cruciate Ligament Reconstruction
Mobile Processes

Mobile Process Support for Therapeutic Interventions: Common Homework Application Procedure

1. Homework adjustments only at personal meetings
2. Exchange of feedback only at personal meetings
3. Time-consuming feedback discussion & evaluation
4. Context of homework cannot be controlled by therapists
5. Homework outcome cannot be monitored by therapists
Meta Model
Model
Mobile Processes

Mobile Process Support for Therapeutic Interventions: Basic Approach

How to enable domain experts to flexibly create and remotely change homework?

How to assist domain experts during therapeutic homework configuration?
How to realize appropriate monitoring and feedback concepts for therapeutic homework?

Mobile Processes
Mobile Data Collection – The QuestionSys Framework

A Model-Driven Framework for Enabling Flexible and Robust Mobile Data Collection Applications
Mobile Processes
The QuestionSys Framework: Mobile Data Collection Instruments
Mobile Processes
The QuestionSys Framework: Mobile Data Collection Instruments

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Country</th>
<th>Logic</th>
<th>Releases</th>
<th>Instances</th>
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</thead>
<tbody>
<tr>
<td>Tinnitus Research</td>
<td>World-Wide</td>
<td>○</td>
<td>3</td>
<td>≥ 25,000</td>
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<td>Supporting Parents after Accidents of Children</td>
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<td>○</td>
<td>5</td>
<td>≥ 2,500</td>
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<td>Risk Factors during Pregnancy</td>
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<td>5</td>
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<td>Airline Catering</td>
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<td>Germany</td>
<td>●</td>
<td>2</td>
<td>≥ 200</td>
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Conclusions

- BPM needs good theories, methods, and technologies for contributing to the digital transformation!
- To create an impact in the digital era, a stronger focus on process automation (i.e. engineering and runtime) is needed!
- We need to rethink BPM applying it in a broader scope!
- Emerging technologies (e.g. RBA, Blockchain, Smart Devices) will open up opportunities to totally rethink processes
Conclusions

• Flexible BPM platforms deliver the ability to manage work while dynamically adapting processes according to a contextual awareness and understanding of content, data, business and events.

• This is the basis of intelligent automation, making BPM technologies the appropriate platform for digital transformation.

• But: True digital transformation requires more than just digitizing back end processes!
Find a truly original idea. It is the only way I will ever distinguish myself. It is the only way I will ever matter.