Business Process as a Service

Model Based Business and IT Cloud Alignment as a Cloud Offering

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***Abstract*—Cloud computing proved to offer flexible IT solutions. Although large enterprises may benefit from this technology, SMEs are falling behind in cloud usage due to missing IT-competence and hence lose the ability to efficiently adapt their IT to their business needs. This paper introduces the project idea of the H2020 project CloudSocket, by elaborating the idea of Business Processes as a Service (BPaaS), where concept models and semantics are applied to align business processes with Cloud deployed workflows. Four architectural building blocks are proposed for (i) design, (ii) allocation, (iii) execution and (iv) evaluation are discussed before providing and outlook.**

Keywords—Business Process as a Service, Business Processes in the Cloud, Business and IT Alignment, Meta Modelling and Semantic

I. INTRODUCTION

Cloud Computing is undoubtable the current mega trend that has the potential to massively influence current use of IT, especially for business applications. Estimated improvements caused by efficient, flexible and networked IT resources range up to 30%[1]. Hence, cloud computing is a chance for start-ups and smart companies that enter this global IT marketplace and obviously a risk for those, who do not appropriately take advantage of cloud computing.

The three key players Amazon, Microsoft and Google established their mainstream cloud offerings, whereas IBM and Oracle are positioning with alternative cloud strategies. Although the mainstream offerings are well provided by the world-leading IT players, there is a plethora of niche players and market places [1].

Hence it seems that cloud is ready to invite enterprises into the radical improvement of IT power, but in reality only enterprises that have relevant know how in their IT-departments can enter the cloud, whereas enterprises without such IT expertise – typically SMEs or start-ups –face barriers.

The challenge of BPaaS is to address the so-called business and IT alignment, and hence bridge the gap between the business and IT domains. With respect to cloud offerings this means that the current application view needs a corresponding business process view.

Currently typical parameters for SaaS – which is regarded as the current and upcoming key cloud market - are of technical nature such as pricing models considering technical parameters, computing power, availability or network capacity. Business parameters such as legal aspects, business packages, process interoperability, or avoidance of vendor lock are used for distinction between different cloud market players. Business Domain specific parameters like customer relationship for SMEs in the health domain, or Web-appearance of an IT company are potential future options.

Hence we observe the need to abstract parameters from pure technical distinctions up to business and domain specific characteristics, in order to describe and distinguish cloud offerings.

In the following the approach of the EU project CloudSocket [2] is introduced.

II. BPAAS USE CASES

Primary targets of CloudSocket are SMEs, but the introduced principles of BPaaS are not limited. SMEs and Startups have been selected as user groups as they typically have a strong business focus and traditionally lack IT departments, hence likely face barriers in using the cloud.
These barriers come in the form of a gap between pragmatic, legally influenced and well-defined business processes and a gigantic cloud market with numerous offerings that rarely consider the business episodes of an entrepreneur but focus on technical details.

At this stage the term “business process” is introduced as a sequence of manual, semi-automatic and automatic actions with the aim to achieve an organizational goal.

Hence the business process aligns all tasks with the business goals, independent if they are performed by machines, humans or a group consisting of several machines and / or several humans. Actions are typically separated in time, role or place. There is a set of different application fields for business processes such as but not limited to quality management, risk management, re-engineering, continues improvement, documentation, training but also model driven architecture and requirement analysis.

The first set of application fields see the business process model as "Information Value Provider", hence graphical models are not seen as some necessary step to move on to concrete

software code, but are seen as an independent document that is needed for day to day work within the organization.

The second set of application fields is concerned with, the model driven architecture, software requirement analysis, configuration of software components or software design. In those application scenarios the business process model is seen as a "Specification and Requirement Collection", which is further detailed and transformed to either specify deployable workflows or executable software code.

Business and IT alignment in CloudSocket is concerned with both, on the one side to smartly transform and detail business processes to become deployable workflows and on the other side keep the information value aspect for the business users.

There are several business processes such as customer relations and advertising, administrative issues on registration, IT services as well as after sales support that are necessary for business success, but can only be insufficiently supported by the IT resources of Startups or SMEs.
Hence in the following a first analysis of potential use cases is provided that has been worked out with end users to demonstrate the potential use of cloud computing for business processes. A complete analysis of the use cases is available at [3].

A. Business Incubator Use Case

The Business Incubator form Baden Württemberg focuses on supporting the "Coaching and Finance" efforts of start-ups facilitating designing, analyzing and simulating individual business plans, and processes. These aspects also demand a high degree of adaptability of Cloud Services for Start-ups, e.g. Customer Relationship Management, Order Management, Human Resources Management.

1) Ecological Agriculture

A 28 year old, biologist, has an idea to take biological waste from a restaurant and stimulates a biological decomposition process. Usually such a process takes several years but the idea of the startup is to use worm to speed up this process.

Initial situation: The startup presented the ideas to the business incubators. After this the consultants have discussed with her about how to transform this business idea into a solid business model.

CloudSocket technology intervention: The startup may require a range of different customer relationship and worm production management solutions.

Potential BPaaS solution: Business processes are a common instrument to explain, how the 28 year old biologist prefers to perform the customer relationship and worm production management. Based on those requirements, a mapping to (a) already existing SaaS solutions that cover the whole business process, (b) a combination of different SaaS and / or local installed applications or (c) no Cloud support is recommended can be performed.

2) Green Energy

This startup is a small-scale virtual power plant which connects to a grid infrastructure with power generation from wind, photovoltaic, and biogas. The company serves its customers with environmentally friendly energy for household and provides smart home functions through its remote access capability for turning appliances on or off.

Initial situation: The company is intending to expand its services to include mobile energy sources for recharging electric cars and offer them for rental as range-extension for drivers e.g. for a long weekend trip. The startup contacted the business incubator constultants.

CloudSocket technology intervention: The startup may require a range of different solutions for customer relationship, partner management and internal management processes.

Potential BPaaS solution: Based on business process models it is possible to define the expansion strategy and the required IT (Cloud) support. Depending on those requirements the different alternatives of Cloud support can be worked out.

3) Business Incubator Observation

The observation in this Business Incubator Use Case is that "supportive" business processes can be applied across several startups. So BPaaS addressing e.g. Customer relationship can be offered to wide range of startups. "Management" or "Core" business processes are not so obvious in this first phase of user requirements. Whereas it is reasonable that management decisions in Startups and SMEs are typically not structured in business processes, it is assumed that some "Core" business processes may be identified that can be exchanged between Startups or SMEs.

B. Cluster Process Broker Use Case

The Business Process Broker use case identifies typical business episodes of potential SMEs in different application domains such as eHealth, Manufacturing, Photonics, Government, Security, e-Commerce, Retails, etc. but share a common set of business processes.

In this use case analysis the ICT / Robotics cluster of Tuscany selected ICT companies as potential candidates for early CloudSocket usage, hence two representative potential cases are introduced.

1) Internet Research and Procurement Process

An SME sells software and integrated appliances/electronic components that make devices "Internet ready" in a few seconds and employs 10 people.

Initial situation: The SME continuously verifies prices of the electronic and mechanic components in the market and buys only products that match specific requirements in terms of customer needs and pricing. Monitoring the prices and the quality is a costly activity, which requires an ongoing analysis and trade-off between quality and price.

CloudSocket technology intervention: The Company needs a solution that reduces the costs for procurement activities by improving the effectiveness of the procurement process. Generic self-management infrastructure or special designed research processes including crawler and result databases have the potential to run in the cloud and to raise the productivity of this SME.

Potential BPaaS solution: This is a representative sample where business processes can be used to optimize the business of an SME, by providing consulting via business processes. Internet Recherché can be realized in many different business processes, ranging from pure manual to full automatic, from structured to non- structured or from ad-hoc to regularly triggered processes. Different business processes require different cloud support, ranging from no support, to SaaS support till personalized configuration of workflows.

2) Kiosk Distribution Process

A company with 180 employees aimes at distributing newspapers and magazines to kiosk and, in general, points of sales in an Italian town. Every day, about 250 different Italian and foreign newspaper are delivered to 600 points of sales.

Initial situation: Current customers are small kiosks with very limited IT infrastructure. Often the order is realised via Facebook comments. In order to improve the maturity of the ordering and interaction process with those kiosks new but still leight-weighted Web-application will be provided.

CloudSocket technology intervention: A new order process can be handled in the cloud, without IT installation on both – the supplier and consumer – sides. The scaling of the application with the expected peeks in ordering at the end of the working day or triggered by a special event indicates the use of cloud solutions.

Potential BPaaS solution: The process of ordering can reflect a better understanding of the distribution process due to the transparent business process model and raise awareness on IT difficulties – e.g. peek handling – and hence improve the distribution process. Business processes can also be used for a collaborative improvement.

3) Cluster Process Broker Observation

The observation in the second use case is that most of the potential end users of the CloudSocket have the potential need of generic business processes that may be individualized while the business process maturity growth. Hence the flexible configuration of business processes, hiding the complexity of the cloud and providing easy to use solutions, is a promising market segment.

C. The SME End User Perspective

In addition to the two aforementioned use cases – that describe the targeted end users market – we describe the entry point of any interested user.

We propose three steps for a typical SME as an end user:

- Check Cloud Readiness,
- Transform Business Processes to be executable in the Cloud,
- Enter the marketplace to access BPaaS.

The project provides a checklist for SMEs and start-ups in order to check, if they are capable in entering the cloud with their business processes. This framework is available in form of a demo accessible at [4] and is described in [5].

Here the cloud readiness is defined as [5]:

Cloud readiness = Company Maturity + Process Maturity

Questionnaires are provided to assess both, the company maturity that drills further down to:

Company Maturity = Business Architecture Maturity + Information Architecture Maturity + Technology Architecture Maturity + Strategy Maturity.

Whereas Strategy Maturity is seen as:

Strategy Maturity = Cloud Strategy + Compliance Maturity + Governance Maturity.

Process Maturity is a decomposition of the above from organization level to processes, activities and tasks.

For more information on the different maturities and how they are assessed in individual questionnaires, please refer to the corresponding deliverable D2.2 [5].

The transformation of business processes to be executable in the Cloud is divided in two transformations, whereas the first transformation is a horizontal one that transforms from one business process to another one and the second transformation is a vertical on transforming from business process to workflows. Although both business processes are not executable, the latter one has clear anchor points, where cloud offerings can be added. Hence the horizontal transformation extracts those parts of the process where a cloud offering can actually be applied.

The next transformation is a vertical one that maps to an executable workflow in the cloud - this actually provides the cloud offerings and enables the execution in the cloud. This next step is performed by entering the market place and selecting the most appropriate workflow that runs in the cloud. This selection can be supported by smart mechanisms.

This initial entry point into the cloud for SMEs is supported with tools, which can be accessed at [6]. Readers are encouraged to visit those tools and provide feedback to enable a collaborative improvement in order to reduce the barriers for SMEs that have no cloud competence.

It is expected that in addition to the two aforementioned CloudSocket brokers new CloudSocket brokers may be interested, hence in the following section, the entry point for new CloudSocket brokers are provided.

D. The CloudSocket Broker Perspective

The CloudSocket is a market place, where BPaaS are offered in a similar way as SaaS are offered today. Hence, from a technical or economic point of view, it is a common market place that is well known in cloud computing. There are the same mechanisms for BPaaS – in form of “executable business process” – as there are for SaaS. The differences between a SaaS and BPaaS marketplaces are the selection criteria. A SaaS offering is typically selected based on technical properties, whereas the BPaaS has a two step selection, considering first the domain properties and second the technical properties. This means that for one business processes there may be many different workflow realizations, and for one workflow realization there may be many different cloud offerings.

For organizations aiming to become a CloudSocket broker we propose the following steps:

- Identify the potential market for BPaaS,
- Plan Business Processes, by using a business process management tool that attracts potential clients,
- Build Business Processes, by implementing and executable workflows for the first selection step and deployable bundles for the second selection step.
- Run Business Processes, by offering workflows on an operative cloud market place infrastructure.
- Check Business Processes, by abstracting cloud monitoring logs up to domain-specific business indicators.

These initial recommended phases for the supporting CloudSocket Brokers are initially supported with tools [7].

"Plan Business Processes" denotes the use of business process management tools to acquire, design, analyse and simulate and finally release domain-specific business processes. Here we understand business processes as a know-how platform of an organisation; hence those processes have the potential for domain-specific consultancy and improvement. Traditional business process management tools such as ADONIS® [8] are used.

"Build Business Processes" denotes that each of the aforementioned business processes are made executable by a set of deployable and executable workflows. We agreed to use the term workflow for processes that are orchestrated and executable on an IT platform to strengthen the difference to human orchestrated or executed business processes. Traditional workflow design tools like yourBPM [9] may be used.

"Run Business Process" indicates the provision and operation of processes as a service within a cloud market place that are executed and run across services offered in the cloud. Although this is technically the most challenging part, the focus of this paper and the focus of the introduced CloudSocket project is on the alignment, hence the mapping between domain specific business processes and cloud deployable and executable workflows.

"Checking Business Processes" indicates the abstraction, using conceptual models and semantic, to introduce a semantic meaning into the technical data and process logs from the execution environment in the cloud. The meta model platform ADOxx [10] will be used to develop conceptual and semantic models that can be analysed and mapped to business processes.

III. Related Work

Current marketplaces offer such processes in the cloud, but focus on the combination of applications. Hence in our point of view, these are not business processes but these are workflows.

A. BPaaS Layer

In order to distinguish the different terms, a Taxonomy Wiki is published at [11]. In the following only the relevant layers are highlighted.

Therefore we define the following four layers:

- Layer I - Business Processes: Domain specific business processes that describe the business activities of a worker, which are – in the way they are presented – not executable, neither by a workflow engine within or outside the cloud.
- Layer II - Workflows: Executable business processes are represented by workflows that orchestrate the interaction between software applications. It is expected that one layer I business process refers typically to many layer II workflows depending on the level of automation, the selected applications and failure/ recovery/ variant handling.
- Layer III - Cloud deployable Workflow Bundles: Workflows that are packaged for cloud deployment consisting of all relevant deployment configurations, so that it can be deployed on demand. It is expected that one layer II workflows refers typically to many layer II cloud bundles depending on different cloud providers, the selected SLAs and deployment management strategy and multi cloud deployment.
- Layer IV - Workflow that is in production: Workflows are offered in the marketplace similar to SaaS offerings, hence can be immediately started by the user. It is important that this workflow is not a concrete running instance, but a workflow that is offered.

  One layer III cloud bundle may be registered in one or several market places. Depending on the deployment strategy of layer III, either services are pre-deployed or are automatically deployed when the BPaaS is selected for operation.

  The flexibility of BPaaS is introduced from layer II downwards.

  The concrete handling of instances is a multi-cloud environment is a typical cloud challenge, which is not within the scope of this paper.

B. Alignment Technology

In order to align aforementioned four layers, each layer has to be described in appropriate form. Hence, there are two challenges to be met: First, to find appropriate representation format for each individual layer, second to find appropriate mechanisms to link the different layers.

A well-known approach in providing concepts and instruments for both is the use of conceptual modelling. Meta modelling [12] is introduced as a realization approach to develop domain-specific IT-supported concept modelling. Based on Strahringer [13], Karagiannis and Kühn [14] a layered approach for conceptual modelling is used.

Meta models can be specified with a meta modelling language that is derived from a meta meta model. In the following the most prominent meta meta models based on Kern [15] are mentioned: (a) Ecore from the Eclipse platform [16], (b) GOPRR from MetaEdit+ Platform [17] and (c) MS DSL Tools and MS Visio [18]. Additionally the following meta meta models are introduced: (d) MOF [19], which is realized on different UML Profile platforms (e) ADOxx based on the equally named platform ADOxx [20], (f) Obeo Designer on Eclipse [21] and (g) Generic Model Environment GME [22].

Conceptual models are commodity in expressing processes and can be defined by any of the aforementioned meta models. There is a plethora of different process notations such as but not limited to BPMN [23], IDEF [24], BPMS [25], [26], UML [27], BPAL[28] or CMMN [29] each preferable depending, on the aspects have to be described. In CloudSocket [30] the well-aware BPMN [23], CMMN [29] and DMN [31] formats have been selected to describe the domain specific business processes.

The Enterprise modelling frameworks from Zachmann [32] is used as the basic skeleton for business and IT alignment as it identifies not only the different layers from business down to IT but also different aspects from process to human worker.

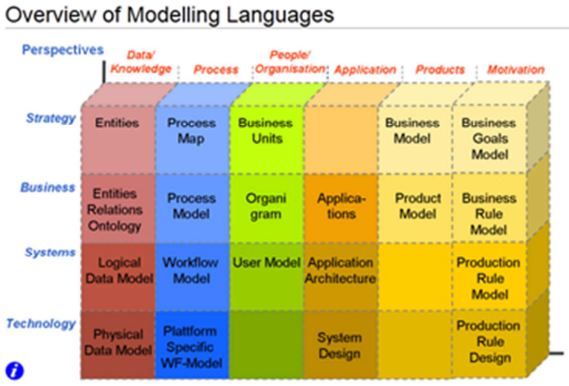

Figure 1 Modelling Languages for Business and IT

In the plugIT project the Business and IT alignment modelling language WIKI [33] has been developed based on extended aspects of the Zachmann framework in the form of data, knowledge, processes, people, organisation, application, products and motivation. Strategy, business, system and technology are the perspectives that span a matrix of modelling languages, each with a list of different modelling languages.

Other enterprise models like TOGAF [34] and Computer Integrated Manufacturing Open System Architecture [35] (CIMOSA) are mentioned for completeness reasons, although CloudSocket builds on Zachmann as classification framework.

Modelling for Cloud-based applications is a rather new research topic. Preliminary ideas are proposed in REMICS [36], as well in MODACloud [37] and Paasage [38].

BPMN is a semi-formal language, where formal semantics can be introduced via semantic lifting and operational semantics can be introduced via inheriting directed graph semantic. Furthermore the language is intuitive for a human user.

The executable part of BPMN is used to define the deployable and executable workflows; hence the same notation is used to define different aspects of a business process. ADOxx is used to develop this design tools in order to (a) realise a hybrid modelling tool that can model both aspects – the domain specific business process as well as the cloud specific technical workflow, (b) enable semantic lifting of business processes and workflows to enable smart business and IT alignment and finally (c) introduce an alternative way of modelling by introducing a text-based modelling tool like XText [39] but within a powerful meta model environment.

IV. Model Based Alignment

This section introduces how a model based approach can be used to align the different layers. In order to provide a brief overview, only the relevant model representation forms are mentioned, as well as the model weaving mechanisms that are necessary to link the different layers are introduced.

A. Meta Model Overview

The meta model overview is provided in FDMM form [40].

A meta-model is a tuple MM = <MT, <–, domain, range, card> where MT is the set of the defined model types, i.e. for i=1,…,m we have $MT=\{MT_1, MT_2, \dots, MT_m\}$.

The MT_i's (i=1,..,m) are themselves tuples $MT_i=\langle O_i^T, D_i^T, A_i\rangle$, where:

- O_i^T is the set of object types or classes,
- D_i^T is the set of data types, and
- A_i is the set of the attributes.

In CloudSocket we use the following model types:

- MT_1 Business Process Model Notation (BPMN),
- MT_2 Company Map,
- MT_3 Document Model
- MT_4 Working Environment Model
- MT_5 Decision Model Notation (DMN),
- MT_6 Business Process Described Services (BPDS),
- MT_7 Key Performance Indicators (Cockpit) and
- MT_8 Business Process Indicators (BPI)

Therefore MT={BPMN, Company Map, Document Model, Working Environment Model, DMN, BPDS, Cockpit, BPI}.≤ defines an ordering on O^T.

Let $o_1^t, o_2^t \in O^T$ we say o_1^t is subclass of o_2^t, if $o_1^t \leq o_2^t$

The domain is a function with domain: $A \rightarrow P(O^T)$

The range maps an attribute to the power set of all pairs of classes and model types, all data types, and all model types.

$$\text{range: } A \rightarrow P(\bigcup_j (O_j^T \times \{MT_j\}) \cup D^T \cup MT)$$

The card function

$$\text{card} : O^T \times A \rightarrow P(\mathbb{N}_0^+ \times (\mathbb{N}_0^+ \cup \{\infty\}))$$

For details on the modelling language, please refer to the CloudSocket development space on ADOxx.org [31].

1) Horizontal BPMN and DMN Weaving

Weaving is a modelling technique were different model types are connected. Additionally to the already defined MM of BPMN [23], we have to add some extensions of some Relations to the

$$\mathrm{MM}_{\mathrm{BP}_{\mathrm{spec}}} = \{\mathrm{MT}_{\mathrm{BP}_{\mathrm{spec}}}, \mathrm{O}^{\mathrm{T}}_{\mathrm{BP}_{\mathrm{spec}}}, \preccurlyeq, \mathrm{domain}, \mathrm{card}\},$$

$$\mathrm{O}^{\mathrm{T}}_{\mathrm{BP}} := \mathrm{O}^{\mathrm{T}}_{\mathrm{BP\_spec}}$$

$\mathrm{A}_{\mathrm{BP}} := \{\mathrm{A}_{\mathrm{BP}_{\mathrm{spec}}}$,
Referenced Decisions-from,
Referenced Decisions-to,
Referenced Service Description-from,
Referenced Service Description-to}

2) Vertical BPMN cloud-specific Enrichment

In order to support the vertical alignment between layer I – business processes – and layer II – workflows – the new model type called Business Process Described Services (BPDS) is introduce. This model type improves the communication between the business process designer and a workflow engineer. The Class 'Service Description' contains several attributes which should describe the business process services from the (a) technical, (b) domain, and (c) business point of view.

Those attributes are in text format to allow free formulation of requirements. The expectation is that the free text format can partly be transformed into a semi-formal representation after experience and user feedback.

The formal definition of this model type is as follows:

$$\mathrm{O}^{\mathrm{T}}_{\mathrm{BPDS}} = \{\text{Service Description}\}$$
$$\mathrm{D}^{\mathrm{T}}_{\mathrm{BPDS}} = \{\mathrm{String}\}$$

- $\mathrm{TechnicalAttrs} :=$ $\{\mathrm{Description}, \mathrm{Input}, \mathrm{Output}, \mathrm{Functional\ Details}\}$
- **DomainAttrs** $:=$ $\{\mathrm{Privacy}, \mathrm{Data\ Compliance}, \mathrm{Domain\ Country}, \mathrm{Domain\ Description}\}$, and
- **BusinessAttrs**$:=$ $\{\mathrm{Vendor\ Issues}, \mathrm{Payment}, \mathrm{Trust}, \mathrm{Securities}\}$

Then

$\mathrm{A}_{\mathrm{BPDS}} =$
$\{\mathrm{Name}, \mathrm{TechnicalAttrs}, \mathrm{DomainAttrs}, \mathrm{BusinessAttrs}\}$

Attribute attachments:

$\forall$ attr $\in \{\mathrm{A}_{\mathrm{BPDS}}\}$: domain(attr)= {Service Description},

$\forall$ attr $\in \{\mathrm{A}_{\mathrm{BPDS}}\}$: range(attr)= {String},

$\mathrm{card}(\text{Service Description}, \mathrm{Name}) = \langle 1,1 \rangle$

3) Vertical Layer I to Layer IV Alignment

Model assimilation is a technique where data sets are "assimilated" into conceptual models. Hence, data sets are semantically enriched and interpreted as attributes of models. The process of mapping attributes with semantically enriched data sets and copying the data value into the model is the process of assimilation of log data – coming from the cloud infrastructure – into business models.

In CloudSocket the assimilation is applied, when log data are mapped into business process models in order to graphically represent log data – in form of key performance indicators – in a domain specific business process. This assimilation technique enables the abstraction of technical cloud infrastructure logs up to business domain model.

This requires changes in the model type that is used to be assimilated. The relevant part is described as:

$$\mathrm{O}^{\mathrm{T}}_{\mathrm{BPI}} = \mathrm{O}^{\mathrm{T}}_{\mathrm{BP}}$$

$$D^{T}_{BPDS} = \left\{ \begin{matrix} D^{T}_{BP}, \mathrm{Enum}_{SLAtype}, \mathrm{Enum}_{DataLocation}, \mathrm{Enum}_{Storage}, \\ \mathrm{Enum}_{Capacity}, \mathrm{Enum}_{Legacy} \end{matrix} \right\}$$

- $\mathrm{Enum}_{\mathrm{SLAtype}} = \{\mathrm{gold}, \mathrm{silver}, \mathrm{bronze}\}$
- $\mathrm{Enum}_{\mathrm{DataLocation}} = \{\mathrm{Vienna}, \mathrm{Austria}, \mathrm{Europe}, \mathrm{USA}, \dots\}$
- $\mathrm{Enum}_{\mathrm{Storage}} = \{\text{storage x}, \text{ storage y}, \dots\}$
- $\mathrm{Enum}_{\mathrm{Capacity}} = \{\text{capacity x}, \text{capacity y}, \dots\}$
- $\mathrm{Enum}_{\mathrm{Legacy}} = \{\mathrm{Green}, \mathrm{Yellow}, \mathrm{Red}\}$

$$\mathrm{A}_{\mathrm{BPI}} = \{\mathrm{A}_{\mathrm{BP}}, \text{Capacity KPI}, \text{Storage KPI}, \text{Data Location KPI}, \text{Legacy KPI}, \text{SLA type KPI}\}$$

Attribute attachments:

$\mathrm{domain}(\text{Capacity KPI}) = \{\mathrm{Task}\}$,

$\mathrm{range}(\text{Capacity KPI}) = \{\mathrm{Enum}_{\mathrm{Capacity}}\}$,

$\mathrm{card}(\text{Capacity KPI}) = \langle 1,1 \rangle$

The attribute attachments for Legacy KPI, Storage KPI, Data Location, SLA type can be defined as the Capacity KPI.

Aforementioned results on model weaving, assimilation and service description extensions are described in more detail in the ADOxx.org development space [30]. The reader is encouraged to collaboratively use and improve this meta model.

B. Model Based Aproach in Business and IT Alignment

In order to apply aforementioned meta model, we refer to the well-established BPMS paradigm in business process management. This section introduces the five phases from the BPMS paradigm to transform from domain specific business processes to cloud executable workflows and provides how the aforementioned meta model will be used.

1) The Knowledge Externalization:

A business user and a Cloud solution provider represent the features of the cloud services in a way that is both adequate for humans to interact with and that allows for machine assistance for the identification of appropriate services

Models are a means for communication between people, in our case the users and providers of cloud services. Moreover, if models have a clear semantics and are represented in a formal

language, they provide the basis for, automated analysis, adaptation and evaluation.

We use and adapt standard modeling languages for enterprise architecture, OMG's BPMN for business processes, CMMN for non-structured processes (case management), BMM for business motivation, UML class diagrams for data models and UML component diagrams.

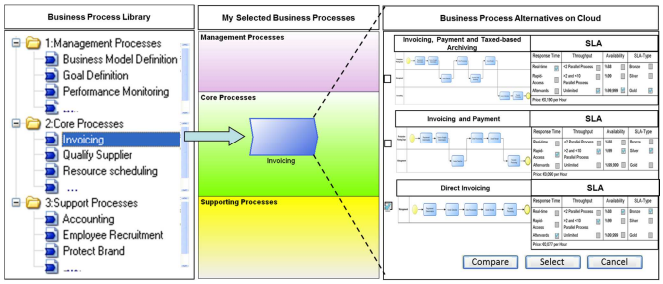

Figure 2 Business Process Libraries for Cloud Solutions

Figure 2 depicts a mockup of a potential BPaaS market place, where on the left side the user can select from the CloudSocket Broker business process library. The business user selects one process and can then select in two steps, first the realization workflow and second the technical properties.

Each BPaas bundel – reflecting the selected workflow and technical parameters – is listed with a certain price.

2) BPaaS-Design:

Smart Business-IT alignment maps the business process to cloud services which serve as building blocks to realize the business process as a service. Typically, several components cover the processes, but in some cases there might be a single service that maps the whole process.

In our scenario the user specifies the requested services by modeling three dimensions:

Business Episode: Each business process represents a concrete business episode that characterizes the tasks that have to be performed. It covers the whole spectrum from structured routine processes to dynamic case management. The description is mapped to the workflow.

Business Compliance: Legal issues such as dealing with personal data or country-specific aspects about data storage are considered in this dimension. In addition properties as confidentiality, privacy or integrity are also parameters such as accepted failure rate or cycle times. This dimension defines SLAs.

Quality/Costs: The usage of Cloud must be aligned with the strategy and the goals in the organization like cost savings or increased speed of innovation [31]. However, the "right" services with the "right" pricing model need to be found. This dimension considers the findings of Service monitoring.

The challenge is to map business language to technical solutions. This is comparable to buying a computer. In an online-shop the computers are described with technical details like processor type, frequency, and memory size. But how do the customers know which specification matches their requirements? Ideally, customers would specify what they need the computer for (e.g. gaming or managing their 50'000 photos); the system would then recommend the appropriate configuration. This is an analogy of what we aim for with Smart Business-IT in the Cloud Alignment.

Hence in the design phase the CloudSocket Broker has to model the business processes – layer I -, may be supported with the aforementioned extended Service Description Business Process model type, and create one or several executable workflows – layer II.

3) BPaaS Allocation:

Each workflow in the Cloud can be seen as a service. Hence, the approach of CloudSocket is to create workflows as deployable services. The BPaaS design phase already provides concept models for the creation of workflows as a service. Thus, the concept of the Livebase Cloudlet is used in this allocation phase as a starting point to act as a configuration file for the BPaaS deployment. This bundle file is based on the PaaSaage format but extended by late deployment parameters and the introduction of business process information – layer I – into those deployment files.

This enables not only the correct deployment of the workflow and / or the corresponding services, but enables the market place to use domain specific business process information for the market place.

Hence, workflows orchestrate different services, systems or components from market like docker [42], Cloudify [43] or one of the Amazon components [44], or "develop" a specific cloud application for the user in order to fulfill the functional and non-functional requirements of the workflow specification.

In addition to enhanced Cloudlet specifications, deployment rules to pro-actively react on findings of the Service management component are added.

4) BPaaS Execution:

Cloud orchestration by introducing a higher abstraction layer between Cloud services is introduced and deployed in the form of BPaaS. Knowledge-based execution is introduced by adding deployment rules in DMN format to allow adaptation of the workflow like (a) substituting SaaS components, (b) obtaining additional cloud resources, (c) exploiting different cloud resources-services (migration), (d) SaaS re-composition or data flow modification.

Based on the results of the SeaClouds project a messaging platform is provided in the Cloud to enable (i) synchronous operation of component elements, (ii) multiple data formats, (iii) context awareness applications, (iv) non-standard application interface protocols.

This message platform orchestrates different Cloud services and Cloud service components that are provided by third-party Cloud providers. The composition, integration of data and platform requirements are already defined in the aforementioned steps, so that knowledge-based execution is focusing on the orchestration and life-cycle management, the multi-clouds monitoring, assessment of end to end SLA fulfillment, as well as on alerting and / or triggering an adaptation of the deployment and on accounting and billing.

5) BPaaS Evaluation:

SME's and in particular startups have to be agile and react flexibly on changing market requirements and business development. This means that also the realization of their business processes is also subject to changes.

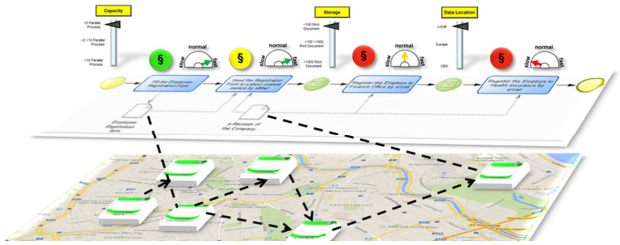

Figure 3 Sample of Conceptual Analytics of BPaaS

The last phase collects all information form the BPaaS deployment in a multi-cloud environment and abstracts it with conceptual analytics technology to the business level enabling all stakeholders - business client, BPaaS Broker, I/P/Saas and component provider - to collaboratively optimize their billing models.

Conceptual analytics is introduced as a combination of process mining and conceptual modeling with particular focus on graphical representation and so-called "assimilations" of process mining results.

The idea is to semantically lift process log data and integrate them into concept models like business processes and hence enable a graphical representation of the Monitoring results.

Figure 3 introduces a sample, where the used data storage locations are assimilated with a geographical map, so business client can easily follow where the data had been stored during the execution of the business process. Furthermore the business process on top is enriched with monitoring symbols, such as a green, yellow and red indication with respect to legal compliance, a tachometer indicating to what extent the SLA has been fulfilled or additional bars representing key performance indicators of the business process.

V. BPAAS REFERENCE ARCHITECTURE

CloudSocket comprises four phases, each phase supported by a corresponding building block in the architecture:

- the design environment to describe business processes, business requirements and workflows
- the allocation environment linking deployable workflows with concrete services,
- the execution environment that executes and monitors the workflow as well as
- the evaluation environment that lifts key performance indicators back to business level.

Figure 4 introduces the four major building blocks, whereas each of the four building blocks support one phase of the BPMS paradigm when applied for business process management in the cloud.

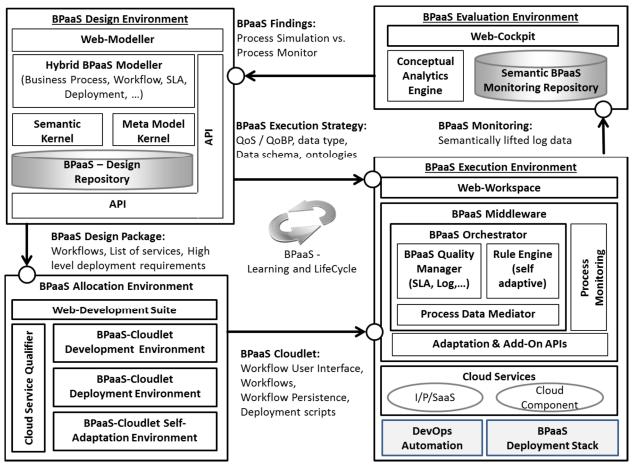

Figure 4 CloudSocket High Level Architecture

Based on the major building blocks – each supporting one phase of the BPMS methodology – the current status of the architecture is stated in the following paragraphs.

A. Design Environment

BPaaS Design Environment is based on the freely available meta modelling platform ADOxx [30].
Functional Capabilities are:

- Business Process Design including visualization, query, simulation, transformation of domain specific business processes in BPMN format,
- Executable Process Design including visualization, validation and transformation of executable workflows,
- Top Down KPI definitions for all layers such as Business Process, executable Workflow, Deployment and Operative process instance,
- Meta Data Composition to describe business processes and executable workflows, and
- Semantic Lifting of domain specific business processes and executable workflows.

Identified roles are:

- Business Process Designer, who has competence in domain specific business process modelling,
- Executable Process Designer, who has competence in technical scripting of executable workflows,
- Ontology Expert, who can maintain the ontology for semantic lifting, and
- CloudSocket Broker who represents the organization that offers the BPaaS marketplace.

B. Allocation Environment

BPaaS Allocation Environment receives an executable workflow and creates a deployable package.

Functional Capabilities are:

- Creation of SLA on service and on workflow level,
- Creation of deployable workflow package for target workflow engines and DevOps Automators and
- Creation of deployment rules for self-automation. It has to be pointed out that one executable workflow may have several bundles that consider different deployment options during this allocation.

Identified Roles are:

- Executable Process Designer, who has competence in technical scripting of executable workflows and
- Cloud Infrastructure Designer, who has competence on the targeted cloud infrastructure and the deployment mechanisms.

C. Execution Environment

The Execution Environment consists of all marketplace relevant components, as well as all orchestration and monitoring relevant components.

Functional Capabilities are:

- Marketplace providing executable workflows in form of SaaS,
- Deployment of predefined allocation packages,
- BPaaS / SaaS instance management,
- Multi Cloud deployment of BPaaS / SaaS,
- Technical monitoring,
- Balanced Loading for higher availability of process engines and
- Application of scalability and elasticity rules.

The identified roles are:

- Operator / Broker for the execution of the workflows and for hosting the market place,
- Cloud provider hosting the execution environment and
- Atomic service provider hosting the services that are used during the execution of the workflow.

D. Evaluation Environment

The Evaluation Environment abstracts concrete technical log data to semantically lifted business KPIs.

Functional capabilities are:

- Bottom Up mapping of process, service and monitoring logs with semantic descriptions,
- Aggregation and decomposition from technical logs to domain specific business KPIs,
- Conceptual Analytics engines that enables root cause analysis, drill down of business indicators and push of technical indicators,
- Presentation of a monitoring dashboard that enables a management overview of the business processes that run in the cloud.

Identified roles are:

- Business Goal Designer who is familiar with balanced scorecard-like approaches,
- Cloud Infrastructure Designer who has competence in technical rule management and can configure the technical monitoring as well as
- Cloud Socket Broker who runs the BPaaS in a multi-cloud environment and hence needs to check the profitability of the current deployment.

This section describes how the model-driven approach has been realized in the high level reference architecture. For more details on the architecture, please refer to [45].

VI. Outlook

This paper introduces the idea of BPaaS in the context of the H2020 project CloudSocket, which started 01.01.2015.

Hence this paper introduces the project idea of BPaaS and the use of a model-based approach to align domain specific business processes with cloud related executable workflows.

First findings in identifying business episodes and possible business process models are introduced and the current status of the architecture is briefly presented.

The project can provide the first set of business episodes, a first reference architecture and an environment to check the cloud readiness of an end users.

All prototypes are available either as open source, open use or as provided services. A roadmap for technology provider indicates how alternative tools can be provided for a CloudSocket broker.

Research on smart mapping between domain specific business processes and cloud based executable workflows are expected by the end of 2015.

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