Business Process as a Service – Status and Architecture

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Abstract: A Cloud Service is usually classified as Infrastructure as a Service, Platform as a Service or Software as a Service. This classification ist not sufficient, when Business Processes are considered. Therefore, Business Process as a Service (BPaaS) as next level of abstraction is in discussion. BPaaS is already an important topic for analysts and cloud providers. In the scientific community a discussion about BPaaS has been started. This contribution presents a literature analysis of the current state-of-the-art in BPaaS. In order to investigate how a Business Process can be built on top of a cloud service, a prototpye of an external application is presented, which is built on top of a cloud service using a RESTful API. For the realization of BPaaS existing architectures for cloud computing are discussed. A proposal for an advanced Architecture for Business Process as a Service is presented. Based on these findings, a brief outlook on future research questions concerning Business Process as a Service is derived.

1 Business Process as a Service

A common classification of cloud services has been developed by the National Institute of Standards and Technology (NIST), which assigns cloud services to three layers [LTMBMBL11]

- Infrastructure as a Service (IaaS),
- Platform as a Service (PaaS) and
- Software as a Service (SaaS).

This classification starts with IaaS, which refers to basic services e.g. for storage and reaches up to SaaS, where applications are provided as a service. In this classification each level abstracts from the functionality of the level below. The next level of abstraction above SaaS is Business Process as a Service (BPaaS) [SPBB12]. BPaaS means not only that software is provided to the user as a service. BPaaS means as well to

deliver the logic and control flow of the business process the user wants to execute as a service. As a result, a classification of services is obtained as shown in Figure 1.

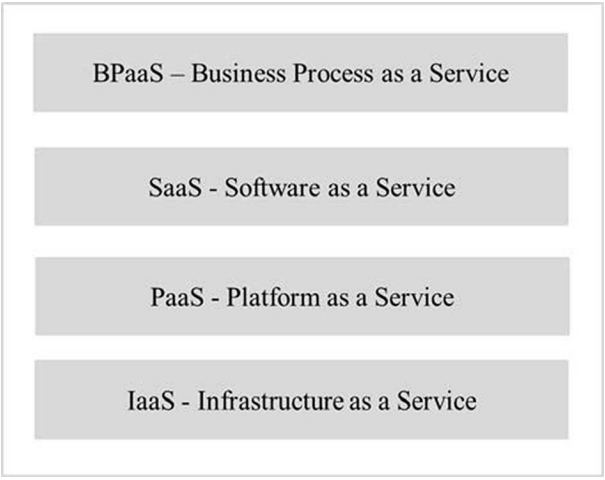

Figure 1: Classification of Cloud Services

Despite of the fact that consulting and software companies as well as market analysts are using the term BPaaS frequently, neither the exact meaning nor a concrete architecture of a BPaaS system are clearly defined in the scientific literature. Therefore this paper presents a state-of-the-art analysis of BPaaS, which starts with a literature analysis. As Business Processes as a Service have to be set up on existing cloud services, a protoype of an app is presented, that runs on top of a cloud service. Based on that analysis and the discussion of different architectures for cloud computing, an extension of current architectures is presented.

2 BPaaS in Literature

The state-of-the-art analysis of BPaaS starts with a review of the scientific literature on that topic.

2.1 Methodology

The lack of rigour of scientific literature analysis in the information systems discipline is often criticized. This criticism is especially related to the missing documentation and traceability of the analysis. Based on that analysis a procedure model for a literature analysis was proposed that consists of five steps [vBSNRPC09]: Step 1 to 3 addresses the preparation and literature selection and step 4 and 5 the analysis and classification of the results. In order to achieve traceability the literature analysis is based on that approach. The first step is the definition of the research questions for the literature analysis. This paper's research questions are:

- Question 1: How common is BPaaS in the scientific literature?
- Question 2: What are the research perspectives on BPaaS?

Step 2 is the conceptualization of the literature search process. Therefore search terms and context has to be defined [Co88]. For this analysis "Business Process as a Service" and "BPaaS" are defined as search terms. The context in which the search takes place is the international scientific literature in the field of information systems. Step 3 is the selection of the literature base in which the analysis should be done. This decision is directly related to the context defined in the step before. For this analysis these well-known two portals and two journals are chosen: SpringerLink, EBSCO, Business & Information Systems Engineering (BISE), MIS Quarterly (MISQ). Publications in English and German language have been considered in the search. Step 4 and 5 of the analysis are the literature search itself and the analysis of the publications found. The results of these steps are presented in the next section.

2.1 Results

The literature search, step 4, reveals that the keywords "Business Process as a Service" and "BPaaS" match with 40 publications in SpringerLink and with 59 in the EBSCOHost. Figure 2 shows the matches by keyword and portal or journal:

Searched in	"Business Process as a Service"	"BPaaS"
SpringerLink	40	24
EBSCO	59	36
BISE	0	0
MISQ	0	0

Figure 2: Literature overview

For step 5 the search results have been refined by an analysis of the title and the abstract of each publication that was found. During this process all publications that don't have a strict relation to BPaaS and all publications that were found in non-scientific media have been eliminated. Especially on EBSCOHost many publications from analysts or newspapers have been found. The result of this process is 16 BPaaS publications. In order to answer the first research question all publications have been displayed in a chart that shows the number of publications per year on BPaaS (Figure 3). The chart illustrates that only two relevant publications have been published before 2011. The largest number of publications is found in 2013. These numbers indicate that BPaaS is an actual topic in nowadays and starts to get in the focus of scientific research at the moment.

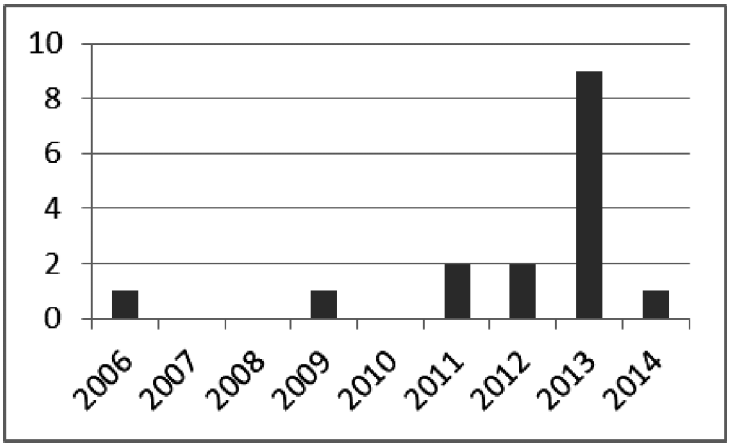

Figure 3: Publication on BPaaS per year

The second research question is about the perspective on BPaaS that the analyzed publications take. All found publications have been classified into four perspectives that are shown in Figure 4:

Publication	Classification
[YW13]	Business Perspective
[AR12]	Business perspective
[HHLM13]	Business perspective
[LM06]	Business perspective
[Be14]	Business perspective
[ME13]	Business perspective
[Fe 13]	Business perspective
[GWvLJ13]	Development
[HSGMB09]	Development
[WITZYHL12]	Development
[OOM13]	Development
[Ra13])	Development
[MH11]	EA in the Cloud
[Ma11]	EA in the Cloud
[MA13]	Security
[Pe13]	Security

Figure 4: Classification of selected BPaaS publications

The following paragraphs describe the specific classifications in more detail:

Business Perspective

The seven publications that regard BPaaS form a business perspective focus on economic aspects of the business software. The major topic is outsourcing of business processes into the cloud or special business tools that are provided in the cloud. All these publications have in common that they stress the impact of BPaaS or its measurement and not the architecture or implementation of BPaaS.

Development

The five publications that have been classified in the development perspective focus just the opposite of the business perspective publications. Their focus is on the architecture, implementation or on technology stacks that could be used to implement cloud services and BPaaS. The work presented in these papers is often based on standards like BPEL or RESTful services.

EA in the Cloud

The two publications that are classified in the enterprise architecture perspective regards how cloud services can be integrated in the software architecture of a company. The found publications in that category describe fundamentals and basic principles on the topic. In relation to the publications form the business and the development perspective these papers are in-between these two categories. They are less technical than the development publications but are more focused on the realization und integration of BPaaS in a company than the business perspective publications.

Security

The last category is security. The two publications in that category describe security lags of processes in the cloud and privacy and security concerns. They analysis what security problem occur by outsourcing business processes into the cloud. But a final solution to this problem is still an unsolved research question.

The literature analysis reveals that BPaaS has gained importance in the scientific literature in 2013. Despite of the increasing impact most publications neither define the term BPaaS nor do they propose how to build BPaaS applications. The development of BPaaS applications requires to develop applications on top of cloud services. Therefore, the following sections start with the presentation of an application, which was built on top of a cloud service. Finally, the architecture of BPaaS applications is considered, where a proposal for an advanced Architecture for Business Process as a Service is presented.

3 Building Applications on top of Cloud Services

This chapter follows the question how to build an applications on top of a cloud service. In order to show how an external application can be built, an application is presented, which has been developed on top of the popular OpenStack software using so called RESTful APIs.

3.1 RESTful APIs

APIs are used to connect different applications. And, new applications are developed by integrating existing applications with each other. Such a new application is called mashup. A lot of APIs, which are used in order to develop mashups, rely on an architectureal style, which is called REST (REpresentational State Transfer). The main principles of RESTful Services are as follows [Fi00, Ti11, Ba14]:

- RESTful Services are based on resources, which are identified by URIs. In general, any source of information, which serves a special purpose, describes a resource. The weather forecast of a city or the descriptions of a product are examples of a resource. A collection of resources e.g. all products of a specific product group is also a resource.
- RESTful Services have a uniform interface. In case, data have to be retrieved (read only) within an order-management application, there is only one single method, which has to be carried out. As an example, both order and product data are retrieved with the same method.
- For every Resource, data should be available in different data formats. As an example, a consumer should be able to request information for a product in an XML or JSON format.
- The communication within a RESTful Service is stateless. A change of state may be recorded by a provider by means of a changed resource. On the other hand, it may be the task of a consumer to handle the state of an application.
- A RESTful Service uses Hypermedia to carry out follow-up processes. In case, a consumer has carried out an order, the Service reply should contain hyperlinks which allow e.g. to check or cancel this order.

In case of internet applications HTTP is commonly used as protocol. As a consequence, the uniform interface is formed by the well-known HTTP methods GET, POST, PUT and DELETE.

3.2 The OpenStack project

There are a lot of projects, which offer RESTful APIs. In the area of Infrastructure as a Service, OpenStack is a very popular example. OpenStack is an open source solution for a standard cloud computing infrastructure for both public and private clouds [OS].

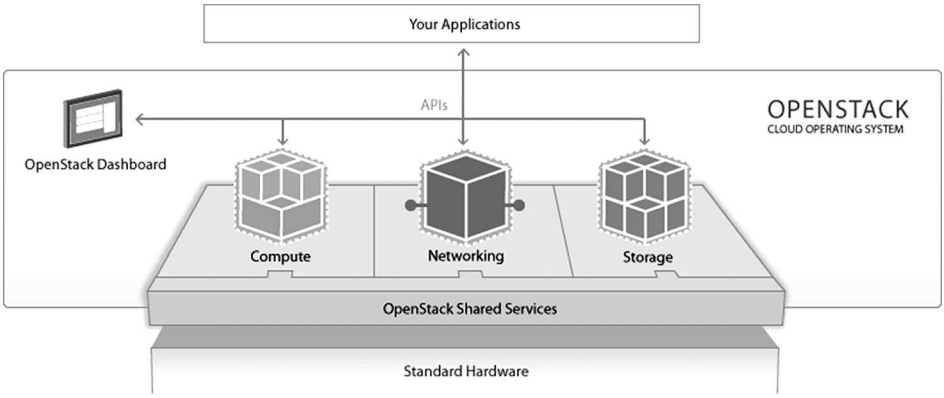

Figure 5: Overview of the OpenStack Software [OS]

The OpenStack software, as shown in Figure 5, is organised around three major concepts: compute, networking and storage. Additionally, there are shared services like e.g. identity management. The OpenStack dashboard is the graphical interface for administrators and users. Different OpenStack components are integrated with each other by means of RESTful APIs. For this purpose every OpenStack project offers a RESTful API [OSAPIs]. Therefore, it is on one hand easy to continuously enhance the functionality of OpenStack by means of further projects. On the other hand, building applications on top of cloud services is simplified, when RESTful APIs are available.

3.3 Building an app on top of OpenStack

OpenStack contains „Shared Services“, which offer several functions for all components via RESTful services. In case of functions for authentification and user administration the Identify API is responsible to answer internal and external requests. The main resources for a user administration and there relation to the unifrom interface, which consists of four methods, are represented in Figure 6. The resources are as follows: The accumulative resource „/v2.0/users“ stands for all users. The resource „/v2.0/users/{userId}“ identifies a single user with identification numberer {userId}. All operations, which are carried out for a single user, like e.g the change of the password, occur at resource „/v2.0/users/{userId}“. Method GET serves for requesting information for a resource. GET is used with the accumulative resource to list up all users and to receive the details of a single user, when it is applied to the resource, which identifies a single user. By means of method PUT a single resource is updated, it is not used in relation to a accumulative resource. The creation of a new user is carried out, when applying method POST on the accumulative resource „/v2.0/users“. POST is not used in relation to a single resource. DELTE serves to delelte single users. The deletion of all users via the accumulative resource is not implemented in the Identify API.

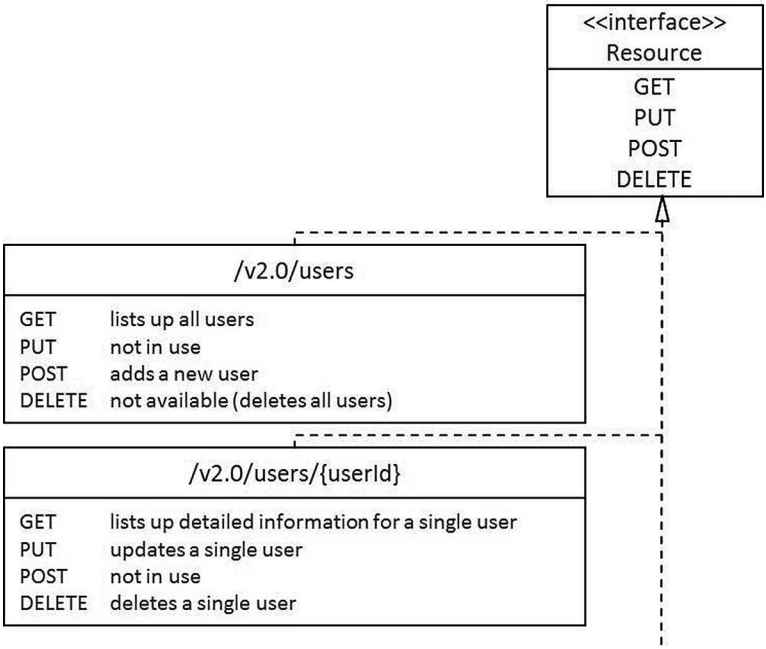

Figure 6: Main resources for user administration

The Identity API is used to build an external application on top of OpenStack. This application runs on a Android smartphone. It has been developed in Java using Eclipse as an integrated devevlopment enviroment. In order to develop this application the Identify API is applied to the resources, which are shown in in Figure 6. The application contains four functions, which are shown in a screen shot (Figure 7).

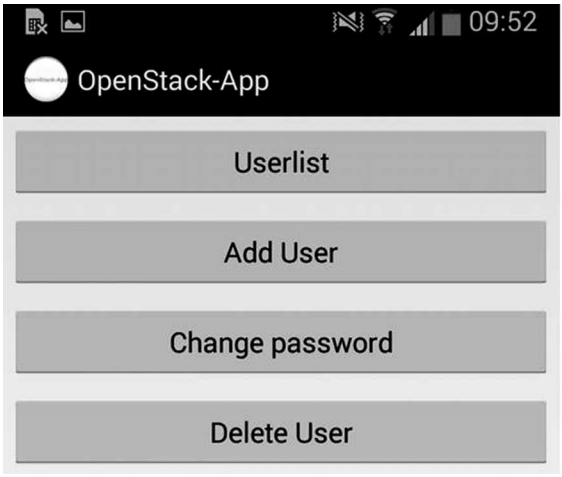

Figure 7: App for user administration (overview)

The application allows to list up all users, to add a single user, to change the password of an existing user and to delete a single user. The application interacts as an external application with a Identify service in OpenStack by means of a RESTful API.

4 BPaaS Architectures

This chapter contains the closing part of the state-of-the-art analysis. It examines the architecture for cloud computing in order to realize BPaaS.

4.1 Cloud Computing Reference Architecture

The US National Institute of Standards and Technology (NIST) define a Cloud Computing Reference Architecture. The main actors are Cloud Consumer and Cloud Provider. A Cloud Consumer is an individual or organization that acquires and uses cloud products and services. A Cloud Provider is a person, an organization or an entity responsible for making a service available to a Cloud Consumer [LTMBMBL11]. Within this work a scenario is considered, where only the main actors Cloud Consumer and Cloud Provider are involved. Other actors are not considered here.

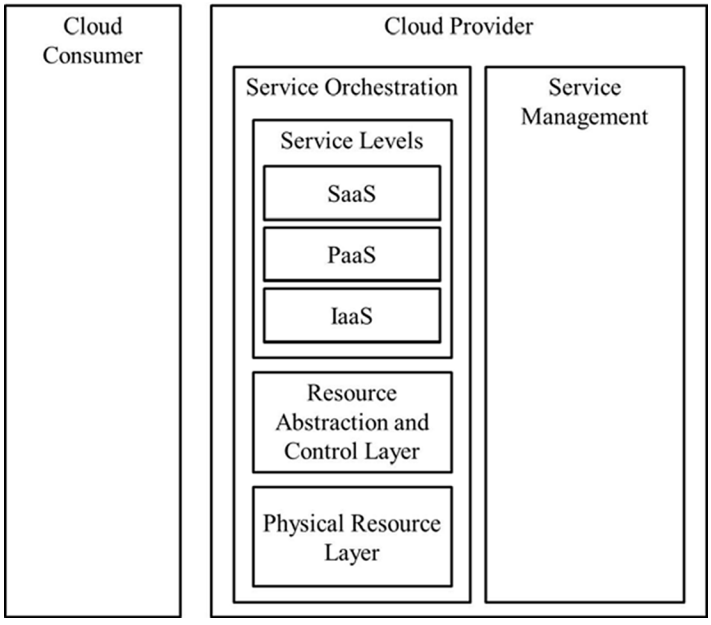

Figure 8: Representation of the NIST cloud computing reference architecture (only two actors and two activities are shown)

Figure 8 shows an overview of the NIST cloud computing reference architecture with the following restrictions: Only Cloud Consumer and Cloud Provider are considered as actors. In addition only two activities are shown: Service Orchestration and Service

Management. Service Orchestration refers to the arrangement, coordination and management of cloud infrastructure to provide different cloud services in order to meet IT and business requirements. The service layers within a Cloud Provider define the interfaces for Cloud Consumers to access cloud services. The resource abstraction and control layer contains system components to provide and manage access to physical computing resources. The physical resource layer includes all computing resources. Service Management implies all the service-related functions that are necessary for the management and operations of services for Cloud Consumers [LTMBMBL11]. Within it's Cloud Computing Reference Architecture IBM has defined an own reference architecture for cloud computing. In addition to the existing three Service Models IaaS, PaaS and SaaS, IBM defines a fourth Service Model named Business Process as a Service (BPaaS) [SPBB12].

4.2 BPaaS Architecture and RESTful Services

In order to set up an architecture diagram for Business Process as a Service the cloud computing reference architecture, as suggested by NIST and as shown in Figure 8, is taken as a starting point. To consider BPaaS, another layer has to be introduced. In contrast to IBM's cloud computing reference architecture BPaaS should not extend the already existing layer for the Service Levels, which belong to the Cloud Provider, because a layer for Business Process as a Service cannot be strictly allocated to either a Cloud Provider or a Cloud Consumer or any other actor.

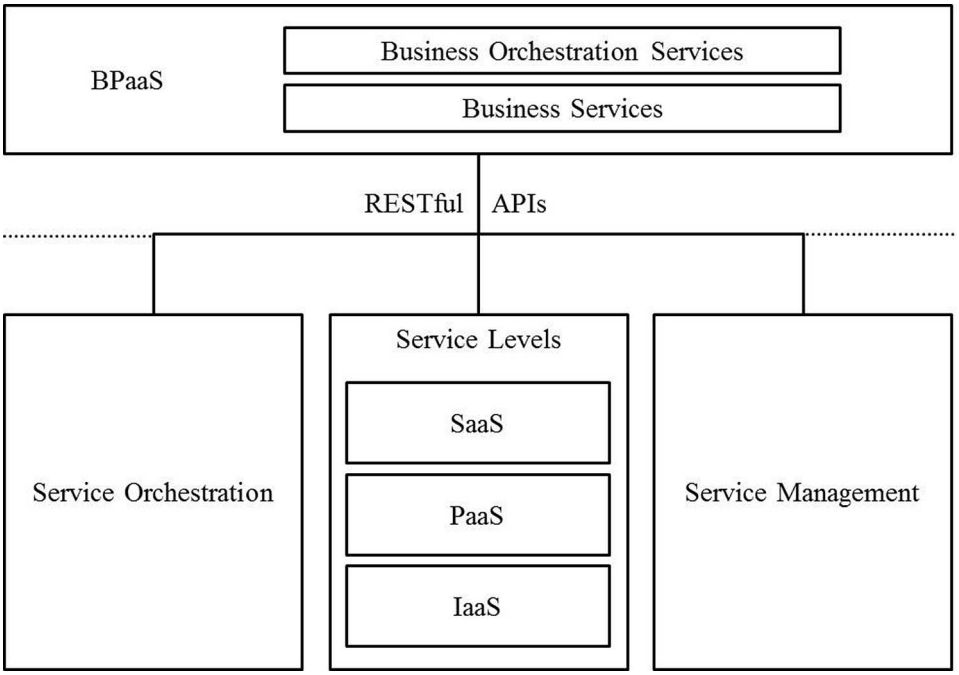

Figure 9: Architecture for Business Process as a Service

There has to be always the choice for an enterprise to determine where a layer for Business Process as a Service should be located. Certainly, a lot of CIOs would not agree to delegate Business Processes to any actor outside their companies. Therefore, a layer for BPaaS should extend already existing layers without any assignment to an actor. As a consequence Cloud Consumer and Cloud Provider cannot be included in an architecture diagram for BPaaS. Business Process as a Service requires functions to set up Business Services and to orchestrate Business Services within on demand applications. As a sufficient standardization RESTful APIs shall be available in order to connect to different applications and projects. RESTful Services could serve as enabler to connect software components with each other (Figure 9).Furthermore the BPaaS layer on top of the three standard NIST layers can be used to integrate different software business models. In order to integrate different software business models in order execute one Business Process the following scenario is considered (Figure 10). It shows one on-demand application in the area of Customer Relationship Management (CRM) and one on-premise application for Enterprise Resource Planning (ERP). The BPaaS layer on top of the SaaS layer can be used to integrate these different application business models. This can be realized by an orchestration service on the BPaaS layer. And, the BPaaS layer can either be controlled by the cloud provider or by the cloud Customer or in a hybrid way, where the control is distributed between these two parties.

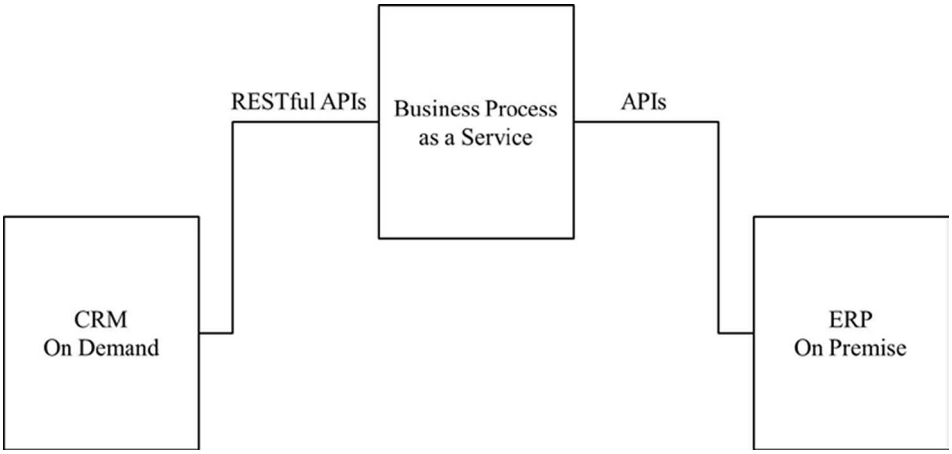

Figure 10: BPaaS scenario for an on-demand and an on-premise application

5 Summary and Outlook

The literature analysis in chapter 2 reveals that the number of papers on BPaaS has increased during the last two years, which indicates that BPaaS has been put on the research agenda.

By means of an app for OpenStack, as shown in chapter 3, a proof of concept has been presented, that an external application can be built on top of a cloud service, where

REST APIs are used as interfaces to connect the external application with a cloud service.

IBM's Cloud Computing Reference Architecture has been analyzed. As a result, an additional BPaaS layer on top of the Cloud Computing Reference Architecture, as suggested by NIST, has been included, which is not necessarily under control of the cloud provider. RESTful APIs shall be used to connect services on a BPaaS layer with cloud services on IaaS, BPaaS or SaaS layers. The new BPaaS layer may be used to integrate the two different software business models, on demand and on premise.

Despite of the research presented in the reviewed paper and the architecture discussion presented here, there are further open requirements, which should be subjects of future research:

- First of all, a consistent description on Business Process as a Service with clear definition of the term has to be formulated.
- Secondly, a concept for distributed REST based modeling and design of Business Processes has to be developed.
- At third, it has to be clarified, how the orchestration of such a Business Process that is located into a BPaaS layer on top of the SaaS layer is carried out. Furthermore the prototypic implementation of such a Business Process as a Service system has to be considered.

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