

# Workflow Management Systems – an analysis of current open source products

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**Abstract:** Business process management and IT supported processes are an actual topic. The procedure of finding a business process system that implements your processes the best way is not easy and takes a lot of time. In this article you will find a recommendation for an open source system. Four selected open source workflow management systems are tested and analyzed. Mean criteria for the evaluation are listed in a criteria catalogue and rated by experts by their importance. Finally, the systems are evaluated by the criteria and the best evaluated system can be recommended.

**Keywords:** Workflow Management Systems, Business Process Management Systems, analysis according to criteria catalogue

## 1 Introduction

In order to increase operational excellence enterprises permanently search for appropriate measures. In recent decades, process-orientation has been recognized as an important impact factor on operational excellence. Processes are defined, documented, analyzed, optimized and also automated [Mü06]. Business Process Management is not understood as a single project but as a long-term organizational framework for continuous enterprise process improvement [De00]. This results in shorter lead time, improved information and transparency, reduced complexity, as well as an increased efficiency and cost effectiveness [Mü06]. Business Process Management Systems (BPMS) are used to model processes and to support the realization of processes, as well as the administration and analysis of the operations [Mü06].

There is a variety of BPMS available, both, open source as well as proprietary systems with different support levels and functionality [De15]. The selection of the right BPMS depends on enterprise-specific requirements and often it is necessary to adapt the software to the enterprise-specific needs – often at high cost. BPMS is subject to continuous adaptation on both sides, the enterprise processes as well as the software itself. Open source software, in fact, can often be downloaded for free and provide the advantage of adaptation through the IT department of the enterprise.

However, the selection of an adequate open source BPMS is difficult and should follow a standardized approach. The software does not only vary in functionality but also in the terms used for the functionality. Consequently, we raise the question of how to assess and

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select open source BPM software. In order to answer this question it is necessary to define criteria for comparing the software systems.

In our work, we propose general criteria for evaluating open source BPMS. In order to apply these criteria for analyzing available open source BPMS, we presented the criteria list to experts in the field and asked for validation and assessment. This empirical analysis was used to assign weights for each of the criteria.

Our work is structured as follows: in the next paragraph we present related work. In section 3 we describe our approach for the analysis which is conducted in section 4. Section 5 summarizes the results, and we provide an outlook on future work.

## 2 Related Work

Workflow Management Systems (WfMS) gained interest in enterprises starting in the 1990th when personal computing found its way into business [JBS99], [VV04]. In order to derive criteria for the assessment of the BPMS we consider the work of the Workflow Management Coalition, especially the WfMC reference model [Wf95].

In his work, Müller [Mü06] summarizes developments in the field and also analyzes WfMS and presents a catalog of criteria. Allweyer [Al14a] also mentions open source solutions and describes current developments of WfMS. Nowadays, *Business Process Management System* is a term that obviously supersedes *WfMS* [Al14a]. According to Chang, J. F. [Ch06], BPMS is a further development of WfMS, that supports additionally *process design*, *process analysis* and *process development*.

A market analysis on WfMS has been conducted by the Fraunhofer Institute [Ad14]. They especially analyze proprietary systems. In contrast, a framework for the analysis of open source BPMS is proposed by Delgado, et al. [De15]. The authors propose a methodology to evaluate BPMS while considering the specific needs of an organisation. In our approach we want to provide a framework which is independent from enterprise-specific requirements.

## 3 Approach

In order to analyze four comparative BPMS they must all comply with some basic requirements: the systems are named WfMS, BPMS or refer in any way to the WfMC reference model. The systems should be available in German or English language and have an open source license. Ultimately, they should conform to the BPMN 2.0, which provides standardized symbols for a uniform process model [BMW09]. Modern open source BPMS can be found in respective literature such as of tar Hofstede [Ad10], Allweyer [Al14a] and in research papers (e.g.[As14], [ALS15]).

In addition, the official host page of numerous open source solutions <http://www.sourceforge.net> can be used to find respective BPMS.

As a result, we find that the four systems, Bonita BPM, ProcessMaker, Camunda BPM and jBPM, match our fundamental selection criteria. Additionally, these systems are frequently cited in current literature, stand out by notable clients or they are ranked best on SourceForge by download numbers.

### 3.1 Description of the analysis

Our analysis follows three steps: examination, test and evaluation. As a first step, general information given by the providers are summarized and examined.

In the second step, we install the system and test it by the proposed sample process of the provider. The sample process is always a simple Human Workflow in which an employee of a test organization requests an approval. During the process implementation we analyze the system built-up and the required steps to implement the process. We assess the ease of use regarding the process implementation and application by end users.

Finally, the system will be evaluated by a catalogue of criteria in order to compare it later to the other systems.

### 3.2 Evaluation criteria

The criteria catalogue for the systems' evaluation consists of 11 main criteria and 24 sub criteria.

The criteria are derived from an intensive literature and internet research and are listed in Table 1. Sources for the research comprise works of Jablonski, B. [JBS99], Müller [Mü06], studies by Fraunhofer Institute [Ad14] and BPMO&O [ALS15], such as two websites ([Si15], [So15]).

Main criteria	Sub criteria
1 Initiation and operation	1.1 Effort of initiation 1.2 Support
2 Modelling	2.1 Model options 2.2 Process visualization 2.3 Document management 2.4 Version control
3 Reporting	3.1 Report generation 3.2 Report content 3.3 Report configuration
4 User concept	4.1 User friendliness 4.2 Interaction

5	Process Portal	5.1	Portal set-up
		5.2	Design/Layout
6	Process Governance	6.1	Assignment and administration of rights
		6.2	Control of rights
7	Interfaces	7.1	Data interfaces
		7.2	Software interfaces
		7.3	Programming interfaces
8	Technical conditions	8.1	Technical architecture
		8.2	Access options to the software
		8.3	Deployment model
		8.4	Security of processes and data
9	Performance	-	
10	Data protection and information security	-	
11	General aspects about system	11.1	Provider information (e.g. clients, image)
		11.2	Costs

Tab. 1: Criteria catalogue

After the system tests we evaluated the sub criteria. In order to derive the system's score for each criterion we apply a questionnaire implementing a Likert scale. Each question can be answered by *right* (1pt), *partially right* (0,5pt) and *wrong* (0pt). The criteria score is calculated as average from the answers. When a question can only be replied by *right* in the commercial version of the system, it gets 0,5 points.

We normalize the score to the interval [0,100]. Sub criteria are weighted in order to identify the score of the main criteria as described in the next chapter.

### 3.3 Survey for criteria relevance

Since the various criteria  $c_i$  may differ concerning their importance for software users the criteria scores  $i_s$  are weighted by weighting factors  $w_i$  for the final evaluation score. In order to identify  $w_i$  we started a survey among 20 BPM experts. The respondents were asked to rate the different sub criteria  $c_{ij}$  and main criteria  $c_i$  in comparison to the other criteria by scores of importance  $s_i$  and  $s_{ij}$ .

We calculate the weighting factors for the sub criteria ( $w_{ij}$ ) of one main criterion and the weighting factors for the main criteria ( $w_i$ ) using the same principle: a resulting score  $s_{ij}$  resp.  $s_i$  at the rate to the sum of all scores  $s_{ij}$  resp.  $s_i$  builds the respective weighting factor. The following formulas show the calculation by the example of  $c_1$ :

$$w_{1j} = s_{1j} / \sum s_{1j} \quad \text{and} \quad w_1 = s_1 / \sum s_i$$

The final scores of the WfMS can then be calculated by a linear multivariate analysis as follows ( $c$  = evaluation points of criteria):



$$\text{Final score} = \sum(w_i * c_i) = w_1 * \sum(w_{1j} * c_{1j}) + w_2 * \sum(w_{2j} * c_{2j}) + \dots + w_{1j} * \sum(w_{11j} * c_{11j})$$

By means of a grades table containing all possible scores and the respective grades from 1 (best) to 6 (worst), the systems got a final vote. By the vote the four systems can then finally be compared to each other.

The results of the survey, so the given points of importance  $s_i$  for the respective main criteria and the resulting weighting factors  $w_i$ , can be seen in the following chart (tab. 2).

Criteria	Mean value $s_i$ (on a scale from 0 to 5)	Weighting factor $w_i$
1 Initiation and operation	3,55	9,18%
2 Modelling	3,45	8,92%
3 Reporting	3,2	8,27%
4 User concept	3,8	9,83%
5 Process portal	3,05	7,89%
6 Process governance	3,45	8,93%
7 Interfaces	3,65	9,44%
8 Technical conditions	3,25	8,41%
9 Performance	4,1	10,61%
10 Data protection and information security	4,2	10,87%
11 General aspects about system	2,95	7,63%

Tab. 2: Evaluation of the main criteria

## 4 Analysis

In this chapter we analyze each systems and compare all four systems at the end. For testing the systems a Medion Akoya E6234 with Intel® Pentium® CPU 2020M @ 2.40 GHz and installed memory of 4,00 GB with Windows 10 Home, such as a ASUS F550 with Intel® Core™ i5-3230M CPU @ 2.60 GHz and installed memory of 8,00 GB with Windows 10 Home will be used.

### 4.1 Bonita BPM

The following information, if not indicated otherwise, can be found on the official website of BonitaSoft [Bo16a].

Bonita BPM is the Software of the company BonitaSoft, Inc., presented in New York, San Francisco, Paris and Grenoble with more that 1000 customers in over 75 countries. There are two versions of the product: the open source *Community Edition* and the commercial *Subscription Edition* with additional features. We'll have a look on the first version since only this one is licensed open source. The BPMS can be downloaded from the official

homepage [Bo16a]. In order to test the software the newest version of the system (7.1.4) is downloaded and installed. The following information are based on own observations.

Before downloading the software you need to register in the *Customer Portal* where you find lots of introduction materials and a discussion forum. The download of Bonita BPM is a quick process and also the installation can be conducted in a few steps on your own.

The system follows primarily the reference model of the WfMC: it's based on a process engine with API and interfaces to proposed tools of the WfMC which are partly already integrated. Bonita provides for example the *Bonita BPM studio* as a process definition tool and the *UI Web Designer* in order to create forms. As workflow enactment service the *Bonita BPM Portal* is provided, where end-users can login and run processes. The programming language is *Groovey*, an extension of JAVA [Al14a].

After the successful installation, the software is tested by implanting the proposed sample process *Travel request process*. The process contains primarily two steps [Bo16b]: an employee starts the process filling out a travel request form and his or her manager receives the form approving or refusing the request. For implementing this process the following eight steps have to be executed [Bo16b]:

1. Define the data model
2. Model the process diagram
3. Define business variables
4. Define rules
5. Adjust business object
6. Assign roles/actors
7. Create process forms with UI-Designer
8. Build the application

The sample process shows how simple a process can be implemented following the documentation of BonitaSoft. So the criterion *effort of initiation* is valued very positively. Since no server has to be installed the system is very suited to beginners of the topic who want to learn and experiment with a BPMS [Al14]. The process modeling tool and the UI Designer for creating forms are easy to understand and intuitively to use by their drag-and-drop functions. So the user-friendliness gets a very positive evaluation. If there are problems, you can always discuss and find discussions in the forum. Unfortunately, there is no technical support using the Community Edition. But subscribing to the commercial version you can use it. It's also possible to attend (online) trainings that are also not for free. An advantage for German speaking users is the fact that the whole software can also be downloaded in German.

A big disadvantage is the fact that there is no report option. You also have to subscribe to the commercial version to profit from this function. Nevertheless, information scientists are able to integrate this function among an API interface.

Because of the simple operability creating process models and forms with offered tools, developers have to pass on development flexibility. So Bonita BPM is recommended overall to users with little programming skills who want to implement simple processes with little effort and for whom a community forum is enough as support.

## 4.2 ProcessMaker

The following information, if not indicated otherwise, can be found on the official website of ProcessMaker [Pr16].

The Software ProcessMaker is the product of the company ProcessMaker, Inc. located in numerous seats in north and south America, such as in Europe (France and England). The company has more than 1000 customers like Sony, KPMG or Toyota and over 35 business partners on five continents. There are three versions of the product: The *Cloud Edition*, *On-Premise Enterprise Edition* and the for our analysis relevant *open source Edition*. The first two versions are commercial and provide additional features. The free open source solution is based on the essential functions, but can be extended, in conformity with the WfMS reference model, among interfaces by REST API. External systems such as ERP, Business Intelligence, CRM and document management systems can be adapted easily. Special about the system is the fact that it's completely web-based and available from the common web browsers.

The following information are based on own observations.

The newest version of ProcessMaker (3.0.1.7) can be downloaded from its official host page SourceForge [So16a]. The download and installation are simple and do not need much time. Apache, MySQL und PHP are automatically installed and directly after, you can login in a web browser window as administrator.

From this page you have access to four areas: *Home* to administrate your own user page, *Design* to create the process models and forms, *Dashboard* to report processes and finally the *Admin* area to administrate the portal, users and their permissions.

In the so called *ProcessMaker University* of the official website you find lots of documentations and tutorial videos. With the help of one video we'll implement the proposed sample process *Travel Expense Report*. The process follows basically three steps: an employee starts the process and requests the recompense of travel expenses filling out a form and submitting the vouchers. After, his or her supervisor decides about the approval and transmits the approved request to the finance department that finalizes the process. If the supervisor refuses the request the form will be transmitted back to the requester. In order to implement the process you need to follow these 8 steps:

1. Create the process model
2. Define variables
3. Create forms
4. Define in and output documents
5. Create custom trigger
6. Integrate forms into the process
7. Integrate rule for the decision gateway
8. Assign roles to the activities

After implementing these steps every employee of the integrated organization is able to start and run the process from the web page. At the end of every activity you automatically see to who the request is forwarded.

The implementation is very easy and the fact that every step can be centrally followed on one portal reduces the complexity of the activities. So while you use three surfaces with Bonita BPM you can do everything on one side with ProcessMaker. The web page is also structured very good and enables an intuitive use. The process model and forms are created quickly by drag-and-drop functions and there is not much need of explanation.

Unfortunately, you are also limited by the given modeling tools and you have to pass to some modeling shapes you find at Bonita. An advantage is the report function in the *Dashboard* area. There you get an overview of running and finalized processes. However, reports are not really configurable.

All in all, the portal is very modern and clearly arranged. It's easy to use for process designers and end-users from everywhere in the organization since it is completely web-based. In order to guaranty the data security of customers, since the system is web-based, ProcessMaker provides firewall and anti-virus protection, such as SSL coding.

### 4.3 Camunda BPM

The following information, if not indicated otherwise, can be found on the official website of Camunda [Ca16a].

Camunda BPM is the result of the German start-up Camunda founded in 2008. The company is seated in Berlin and San Francisco with lots of named German customers like Deutsche Bahn, 1&1 and Zalando. Camunda BPM is also available in two versions: as commercial *Enterprise* and as for us relevant free *Community Edition*. Both editions are based on an open source license, so the process engine, but all additional features of the Enterprise Edition are not.

The core of the software is the *Model Execution Engine* with REST API or Java API interfaces, so it also conforms to the WfMC Reference Model. It's not linked to a certain server or database. So servers such as Apache Tomcat, Jobs, Wildfly, IBM WebSphere, etc. can be used [Ca16b]. In contrast to the other systems, Camunda supports not just

BPMN 2.0, but also CMMN<sup>3</sup> and DMN<sup>4</sup>. Additionally the system can be used in a cluster, it is scalable and supports a multi-client capability.

The software can be downloaded on the website <https://www.camunda.org> where to also find a lot of supporting materials. The following information are based on own observations.

In order to run the software you have to comply with some prerequisites. You need a JAVA JDK 1.6+ version, installed Apache Maven or Eclipse with Maven already integrated and the use of a modern web browser like Firefox, Chrome or Explorer 9+ [Ca16b]. After installing the missing programs you can download and install the Camunda BPM Platform and the Camunda Desktop Modeler.

After starting the program a web browser, command line and a JAVA window open. From the web page you can access three areas: *Camunda Task list* to implement human workflows, *Cockpit* to monitor processes and the *Admin* area to administrate users.

The installation needs much more effort than the installation of the first two systems. Fortunately, Camunda provides a lot of material where prerequisites are listed and the installation steps are described [Ca16b]. Registering at the *network* area you can find numerous tutorial videos that may help you starting and running the system.

As sample process to test the software, Camunda proposes the *loan approval* process [Ca16b]. The process is similar to the one of Bonita: an employee requests the approval of a credit starting the process and a manager receives the form and decides about the approval finishing the process. Four extensive steps are necessary to implement this workflow:

1. Create a Maven project in Eclipse
2. Create the process model
3. Integrate the process into Camunda Tasklist and adjust it
4. Create forms

As we see, the necessary steps are a few but they need much more effort to be implemented. Since you have to work with eclipse and insert program codes it's hardly impossible to implement own processes without programming skills. Over all, if you got an error message you need advice of an expert and the discussion forum does not help a lot. Because of this, Camunda BPM is over all recommended to developers and information scientists or managers who are supported by IT experts. Despite the technical focus the user-friendliness of the modeling tool and the portal is very high. They are easy and intuitive to use and have a modern and clearly structured design.

In contrast to the modeling tool for process models you don't have a tool for creating forms, but it's realizable by HTML scripts. At this point, user-friendliness gets a limit. But

<sup>3</sup> Case Management Model and Notation: Notation for unstructured activities [Ca16a]

<sup>4</sup> Decision Model and Notation: Notation for Business Rules [Ca16a]

at the same time you are completely flexible as a developer: you can create every process model and form by using own scripts.

Positive are also the numerous functions in the admin and cockpit area. Over all in the last one you have a good reporting and monitoring function. If you want to have more functions and use an extensive support you should think about an upgrade to the enterprise edition: there you got for example a life-time monitoring of running processes, the possibility to measure KPIs and see bottlenecks in so called *Heatmaps*. Camunda describes every feature in detail so you can decide reasonably if the upgrade is worth it.

All in all, Camunda provides a great all-in-one solution with lots of features. It is user and developer friendly and makes a professional and high-quality impression. Also recessions of customers are really positive and convincing. Of course, you should not forget, that the system needs IT expertise or support. If you do not have it or just want to implement an easy process as fast as possible, the first two systems are more suited.

#### 4.4 jBPM

jBPM is the result of a project of software developers of the Red Hat company [Jb16b]. Red Hat calls itself *Open Community*, that is specialized on flexible developer oriented products and that promotes the exchange amongst IT experts [Re16]. While the software is for free, you have to pay for a membership in order to have a support by Red Hat specialists and access to the community [Re16]. In the literature jBPM is potently mentioned and named as market leader [Ad10]. The following information can be found on the official website of jBPM [Jb16b].

The core of jBPM is a process engine with lots of features like an Eclipse and web-based modeling tool, a report function and Integra table functions by JPA/JTA. The system is Java based and the engine communicates by Java API, CDI, REST or JMS API [Jb16a]. An integration with Spring, Seam and OSGI is possible. Also this system follows the WfMS reference model The following information are based on own observations.

The newest version (jBPM 6.3.0) can be downloaded from the host side of SourceForge [So16b]. In order to run the system you need an installed Java JDK version (1.6+) and Apache Ant (1.7+). In addition, you need to add system variables with the paths to both programs on your computer. How this works is not described by jBPM documentations, only how the installation of jBPM works.

The installation process takes a lot of time and in our case, needs some tries until the installation of jBPM with jBPM Tools, Eclipse, Drools and the Wildfly Server works. For the installation it's already recommended to have good IT knowledge.

After starting the system Eclipse and a web page window open. Since jBPM does not provide a tutorial with a sample process for starters, but only documentations to show the different functions of jBPM, we will use the process of Camunda BPM. For the

implementation we will use the provided tools of the jBPM Platform, the *KIE Workbench*. Alternatively you could also use Eclipse to create forms and process models. The following five steps are necessary to implement the loan approval process:

1. Create a new project
2. Model the process
3. Define process variables and instances
4. Create forms
5. Release the process

At first side, the system seems modern and from the *KIE Workbench* you can centrally access to a lot of functions. Unfortunately, the implementation of the process needs relatively much time. On the web page you see numerous registers and windows that open for example for modeling a process and forms and you can't adjust them. The drag-and-drop functions work only delayed and the user-friendliness is not given like at the other systems. The fact that there are no introducing materials for *beginners*, makes it difficult to understand how the workbench is built up in general.

Nevertheless, jBPM provides a lot of features like the report function supplying already diagrams to running and finished processes in the dashboard area. This is very positive for business analysts. So the report function is in comparison to the other ones the broadest one and you do not even need an update. Instead of using the modeling tools you can also write and insert your own scripts, so you are very flexible implementing own processes. This is very recommended since the tools show certain weaknesses.

Because of the effort for the installation, the recommended use of own scripts and missing user-friendliness, this system is overall suited to IT experts and developers. The fact that documentations inform more about technical details underlines this assumption. However, the system provides all necessary functions and over all a great dashboard. For developers, it may be a good solution.

#### 4.5 Comparison of the systems

In order to compare the systems directly with each other they have been valued by the criteria. In the following chart (Tab. 2) you see the resulting scores for the main criteria after weighting the scored sub criteria.

Main criteria	Bonita BPM	ProcessMaker	Camunda BPM	jBPM
1. Initiation and operation	79,94	79,94	75,29	56,69
2. Modelling	67,99	74,76	74,74	71,99
3. Reporting	42,65	52,10	63,13	91,39
4. User concept	86,39	85,20	95,07	80,27
5. Process portal	45,09	53,63	90,26	68,27
6. Process governance	100,00	100,00	100,00	100,00
7. Interfaces	85,83	90,51	88,23	95,20

8. Technical conditions	84,79	94,27	84,90	81,04
9. Performance	75,00	75,00	100,00	50,00
10. Data protection and information security	100,00	100,00	91,67	100,00
11. General aspects about system	93,24	92,35	86,47	78,82

Tab. 2: Scores in the main criteria

After using the weighting factors for the main criteria and building the sum, the systems get the following end scores and respective votes:

WfMS	Scores	Vote
Bonita BPM	79,09	2,0
ProcessMaker	82,21	1,8
Camunda BPM	86,85	1,6
jBPM	79,40	2,0

Tab. 3: End evaluation of the WfMS

As we see, Camunda BPM got the best evaluation by the used criteria catalogue and can be recommended as BPMS.

## 5 Conclusion

Camunda BPM got in every criterion a relative positive evaluation and finally the best vote (1,6). Since it provides the best solution with a mixture of developer and user focus it can be recommended to BPMS users.

Nevertheless, since every company is different and may prioritize and evaluate criteria in another way, you should always use and fill out your own criteria catalogue to find the system that satisfies your individual needs the best way. So the recommendation is not an absolute one and partially subjective. Since customer needs and also technologic opportunities are changing it's interesting to see if Camunda BPM follows also future trends.

Allweyer says that during trends like big data and internet of things, the systems should be able to process masses of data and be more intelligent and flexible in order to control processes in life-time [A114b]. Additionally, there are trends like *Adaptive Case Management (ACM)*, which enables the realization of dynamic and complex processes, and *Social BPM* for information intensive and structured processes with more participants at the same time [A114b].

The fact that Camunda BPM already supports ACM and promotes its great performance implementing data intensive processes supports the decision for Camunda BPM.



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