World Academy of Science, Engineering and Technology
International Journal of Industrial and Manufacturing Engineering
Vol:9, No:4, 2015

The Cost of Innovation in Software Development Projects

Mihai Liviu Despa

Open Science Index, Industrial and Manufacturing Engineering Vol:9, No:4, 2015 publications.waset.org/10001052/pdf

***Abstract*—**The paper tackles the topic of determining the cost of innovation in software development projects. Innovation can be achieved either in a planned or unplanned manner. The paper approaches the scenarios were innovation is planned for. As a starting point an innovative software development project is analyzed. The project is depicted step by step as it was implemented, from inception to delivery. Costs that are proprietary to innovation in software development are isolated based on the author's personal experience in managing the above mentioned project. Innovation costs components identified by the author are then validated using open discussions with software development professionals and projects managers on LinkedIn groups. In order to receive relevant feedback only groups that focus on software development and innovation management are targeted. Additional innovation cost components suggested by software development professionals and projects managers are also considered. Based on the identified cost components an indicator is built. The indicator is meant to formalize the process of determining the cost of innovation in a software development project. The indicator aggregates all the innovation cost components that are identified in the research process. The process of calculating each cost component is also described. Conclusions are formulated and new related research topics are submitted for debate.

***Keywords*—**Innovation cost, IT project management, software development.

I. Developing an Innovative Software Application

INNOVATION is regarded as an important driver for competitive advantage [1]. The current paper focusses on IT and particularly on software development innovation. The research efforts were focussed on the hypothesis where developing an innovative software application will involve all the costs generated by developing a classic software application to which innovation proprietary costs will be added. The goal of the research process was to provide a tool that facilitates proper estimation of innovation costs before the actual implementation of the project. The innovation cost plays a decisive role in whether developing an innovative software application is feasible or not [2]. In order to identify innovation proprietary costs an innovative software application was analysed. The project owner was UPC Romania, one of the largest cable, Internet and telephone service providers in Romania. The project was going to be implemented by the Graffity PR agency and was going to be aimed at highlighting UPC superior Internet speed and reliability. In order to avoid any confusions, naming conventions will be used. UPC will be referred to as *the project owner* and Graffiti PR will be referred to as *the provider*. The only requirements made by the project owner were that an innovative online solution should be implemented and the solution should emphasize the quality of its Internet services.

In order to identify an idea for a web application that will meet the project owner requirements, the provider organized a set of internal meetings. There were three separate meetings organised with the project team. First meeting was focused on identifying ways of proving to a large online audience that an Internet connection is fast and reliable. Results of the first meeting are presented in Table I.

TABLE I
Results of the Project's Team First Meeting

Hypothesis	Scenario
Web applications that require considerable bandwidth run properly only on fast and reliable Internet connections.	Built a web application that uses considerable bandwidth. Make sure users are aware that that application requires considerable bandwidth. Make sure application works flawless and users know the infrastructure is provided by the project owner.
Downloading large amount of date form the Internet requires a fast and reliable Internet connection.	Build a web application that allows users to download a large amount of data. Display public statistics on download speed for all users. Highlight the statistics for users that were accessing the application using the project owner's Internet connections.
Participating in an online event that requires live interactions can only be done with a reliable Internet source.	Build a web application that enables interaction and requires live actions from the users. Make sure that the application works flawless and users that have the provider's Internet service enjoy it.
Accommodating a large amount of traffic requires a hosting infrastructure that has access to fast and reliable Internet.	Build a web application that will attract a large number of users. Make sure that users know that the application is very popular and is hosted on the project owner's infrastructure. Make sure that application has no downtime and accommodates user traffic without any problem.

Hypotheses were validated with the project owner and a second meeting was setup. The second meeting focused on identifying types of applications that matched the hypothesis. The results of the second meeting are displayed in Table II.

For each of the application types that the provider identified as being suitable for the project's scope three similar applications were present as a reference to the project owner. Also the project owner was presented with a rough budget and time estimated for implementing each type of application. Feedback from the project owner is summarized in Table III.

Mihai Liviu Despa is with the Bucharest University of Economic Studies, Bucharest, Romania (phone: +40.722.381.138; e-mail: mihai.despa@gdm.ro).

Open Science Index, Industrial and Manufacturing Engineering Vol:9, No:4, 2015 publications.waset.org/10001052/pdf

TABLE II
RESULTS OF THE PROJECT'S TEAM SECOND MEETING

Hypothesis	Web application
Web applications that require considerable bandwidth run properly only on fast and reliable Internet connections.	- video streaming -VoIP video conferencing - file hosting services
Downloading large amount of date form the Internet requires a fast and reliable Internet connection.	- demo website that allows the download of very large test files
Participating in an online event that requires live interactions can only be done with a reliable Internet source.	- live chat - real-time game
Accommodating a large amount of traffic requires a hosting infrastructure that has access to fast and reliable Internet.	- website with popular content that will attract considerable traffic

TABLE III
PROJECT OWNER FEEDBACK ON PROPOSED APPLICATIONS

Web application	Feedback
video streaming	viable option but must find interesting content to stream; stream must be 24/7
VoIP video conferencing	already to many popular software solutions on the market
file hosting services	
demo website that allows the download of very large test files	lacks innovation; lack meaningful functionality
live chat	lacks innovation; hard to relate to reliable Internet services
real-time game	high developing costs; hard to relate to reliable Internet services
website with popular content that will attract considerable traffic	hard to relate to reliable Internet services

Based on the project owner's feedback it was decided that live video streaming application will be implemented. The streaming application will be hosted on the project's owner infrastructure. By being online non-stop it will demonstrate that the project owner's Internet services are reliable and by streaming live video content it will demonstrate that considerable bandwidth is available. In order to determine what type of content to stream the provider used two focus groups and determined that content related to nature would be the best choice. This led to the idea that a live stream from the Bucharest Zoo would be an innovative web solution that will appeal to a large audience. Complementary to the video stream other useful functionality will be implemented in order to promote the Bucharest Zoo. An interactive map of the Bucharest Zoo was going to be integrated in the web application. Also an online adoption centre would be implemented where users can virtually adopt an animal from the Bucharest Zoo and receive an honorific diploma. The concept was accepted by project owner and planning began for building an application that will stream live video with the animals from the Bucharest Zoo. The project was named Digital Zoo. The project profile was new for the provider so the first step was a thorough documentation on online live video streaming. After the research process enough info was collected so that a demo version of the project can be developed. The architecture of the demo version is presented in Fig. 1.

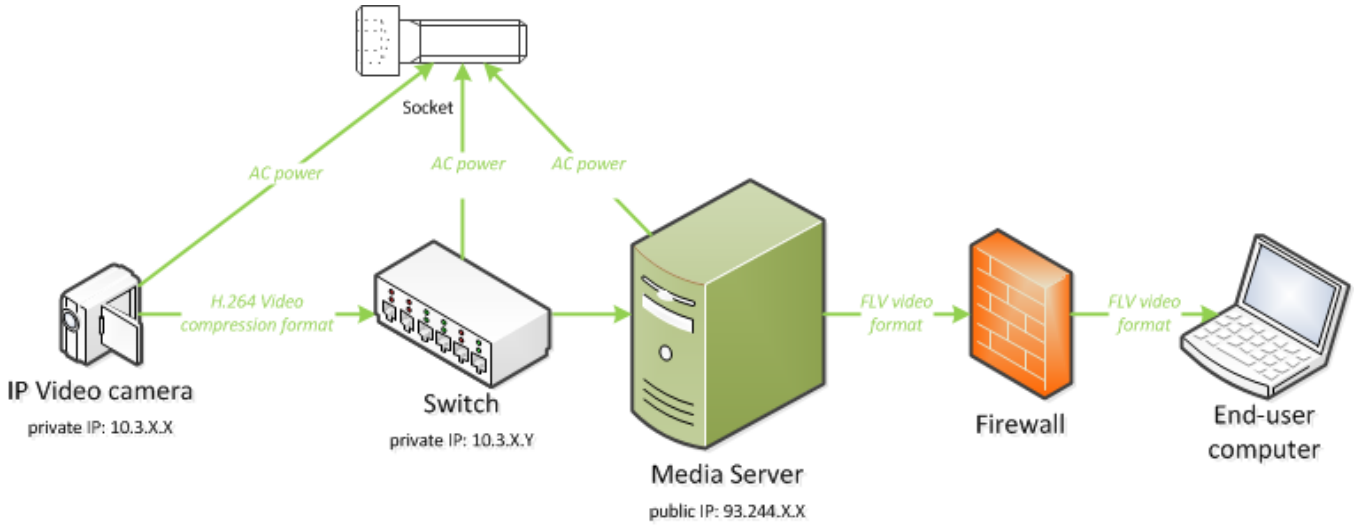


Fig. 1 Demo version architecture

The demo version was built on a LAMP stack with CentOS as the Linux distribution. IP camera would stream video in H.264 format to the media server through the switch. At server level video processing is performed using the FFmpeg solution. Processing involves converting the video stream into a format that is compatible with web players, adjusting video size, adjusting video frame rate, adjusting video bit rate and adjusting the video buffer size. FFmpeg was chosen as it is an open source solution and also because it was already successfully used in other high profile streaming projects and proved reliable. Most software components used in the demo version of the application were open source. Using open source usually provides the freedom to deploy and experiment without licensing restrictions and enables the development of innovative solutions [3]. After processing the video the server is able to deliver video streaming to end users in FLV format via the FlowPlayer web player. The plan was to use exactly the same architecture for the live application and scale it up in order to accommodate multiple IP cameras. Demo version was approved by the project owner and work started on building

the final version of the streaming application. After the first visit to the Bucharest Zoo it was immediately clear that architecture of the demo version should be changed. In the animal establishments there were no sockets so cameras could not be powered by conventional means. The media server was going to be in the project owner's data centre and not in the same place with the other equipment as was the case with the demo version. At the Bucharest Zoo there were frequent power outages. In order to cope with these problems a new architecture was designed for the live environment. The architecture used for the live environment is depicted in Fig. 2.

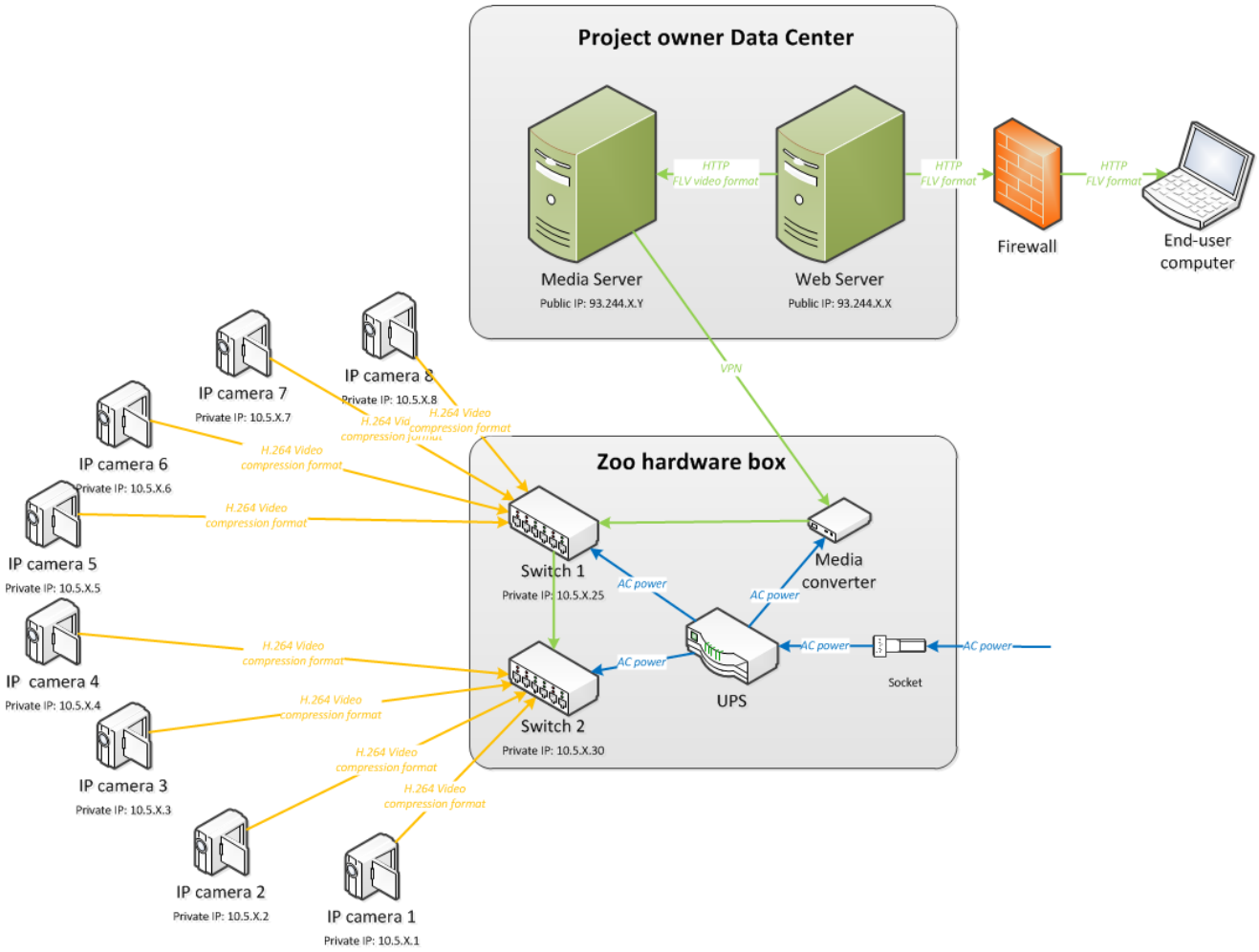


Fig. 2 Live system architecture

The live system would incorporate 8 cameras placed in the animal establishments. In order to power the video cameras POE, Power over Ethernet, technology was used. POE compatible cameras are powered over network cable. This scenario also required a type of switch that incorporates a POE module with at least 8 POE compatible ports. Blue arrows in Fig. 2 depict cables that carry AC power. Orange arrows are cables that transfer AC power and data. Green arrows are cables that transfer data. POE technology is only viable for distances up to 150 meters so the hardware box had to be setup in a position that will accommodate that distance for every camera. The only available option was to mount the hardware box outside of the main building. This meant that it was vulnerable to moisture and excessive heat. To tackle these problems a waterproof coating and two coolers were added. Also the system required two switches as no single switch could power over network cable all 8 cameras. In order to cope with the frequent power outages at the Bucharest Zoo a UPS was installed and all equipment was powered via the UPS. The video stream was sent to the project owner's data centre via optic fibber. In order to facilitate information flow over optic fibber a media converter was setup in the hardware box. Data transfer between project owner data centre and Zoo media box was secured by setting up a VPN. The software component of the system was hosted on two separate servers: a Web server and a Media server. The Web server hosted the database and the PHP code and HTML, CSS and JavaSript files required for the publicly accessible application. The Media server hosted the streaming component that includes FFmpeg, shell scripts, Squid proxy and CSF Firewall. The stream was rendered in the public application using FlowPlayer, a web player that accepted FLV format

Open Science Index, Industrial and Manufacturing Engineering Vol:9, No:4, 2015 publications.waset.org/10001052/pdf

streaming.

II. Innovation Cost Components

The system was implemented as planned and proved to be very successful. The web application won first place in the Entertainment and Culture category of the 2010 European Excellence Awards. It also won the Golden Award for Excellence in the Digital PR and Social Media category of the 2011 Romanian PR Awards Gala. Fig. 3 presents a screenshot of the actual application on the live environment.

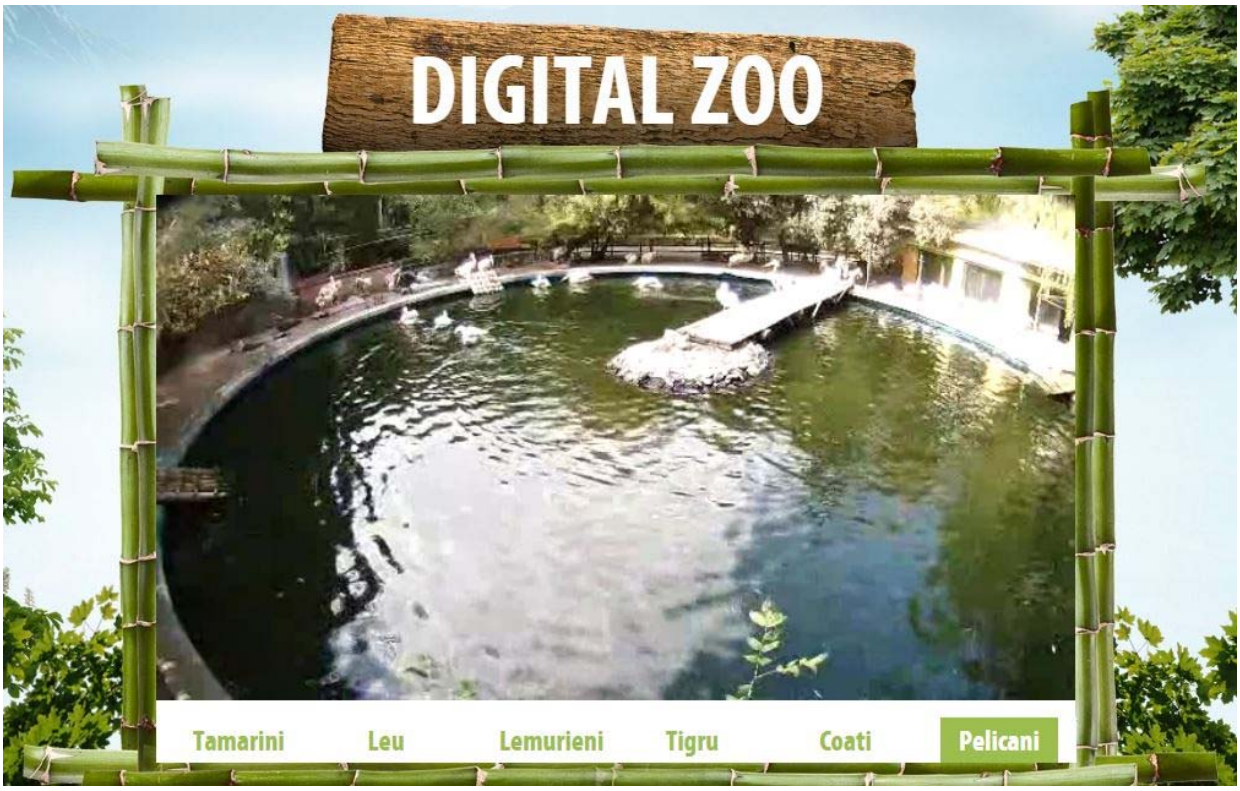


Fig. 3 Screenshot with the live application

TABLE IV
Innovation Costs in Digital Zoo Project

Cost component	Project activity
identifying the innovative idea	the project team dedicated time for meetings that were targeted at identifying an innovative idea; focus groups were used in order to get feedback and refine the initial concept
buying new technology	the team had to bring POE technology into the project to help compensate for the lack of AC power in the animal establishment
learning the new technology	the team had to invest additional time into learning how to configure and operate the hardware equipment; video processing via FFmpeg also required substantial learning time
building a prototype	considerable resources were invested into building a prototype that acted as a proof of concept
higher than usual unexpected costs	as the project profile was new there were substantial costs that were not anticipated in the planning stage; every IT project has unexpected costs but innovative IT projects have higher than usual unexpected costs; the UPS, waterproof coting, coolers were all unexpected costs.

By analysing the flow of the Digital Zoo project and by breaking down costs a series of elements, that were proprietary to the project's owner request for innovation, stood out. In the case of the Digital Zoo project innovation came with additional costs. The statement is also supported by the fact that the provider worked with the project owner on previous software development projects and could thus effectively benchmark cost components for the Digital Zoo project with cost components of previous projects. Table IV highlights innovation specific cost components as identified in the Digital Zoo project.

According to Table IV when planning to implement an innovative IT project, a project manager should budget for identifying or documenting the innovative idea, buying new technology, learning the new technology, building a prototype and higher than usual unexpected costs.

In order to identify additional cost components of innovation in IT projects debates were started on LinkedIn project management and software development groups. Debates were initiated on 19 LinkedIn groups starting the discussion with the following introduction:

I'm trying to determine what the cost of innovation is in a software development project. So far I've identified the following elements that generate cost:

- identifying / coming up with the innovative idea (research, focus groups, surveys)

Open Science Index, Industrial and Manufacturing Engineering Vol:9, No:4, 2015 publications.waset.org/10001052/pdf

Open Science Index, Industrial and Manufacturing Engineering Vol:9, No:4, 2015 publications.waset.org/10001052/pdf

- acquiring new technology (your innovative software could be built on top of a new technology)

- learning the new technology (training yourself and your team)

- building a prototype

Can you think of other elements that contribute to the cost of innovation?

Based on the information collected from the LinkedIn discussions additional innovation cost components were identified:

- the cost generated by protection of intellectual property rights like obtaining patents for the innovative software that has been developed;
- the costs generated by additional testing required when developing a software product that has a high degree of novelty;
- the cost of mitigating additional risk associate with innovation.

Debates on LinkedIn evolved towards the fact that the human factor is the fundamental driver for innovation [4] so it also has the highest share in innovation costs. Google figured this out early on and setup the Google Founders' Award. Launched in 2004, it rewards outstanding entrepreneurial achievement within the company, can amount to millions of dollars. Approximately two dozen recipients of the first award shared around $12 million worth of stock [5].

III. Innovation Cost Indicator

In order to properly identify and quantify innovation costs the Specific Cost of Innovation, SCI indicator is proposed. SCI indicator is built using the cost components identified by analysing the Digital Zoo project and by including cost components identified in LinkedIn debates. Not all the identified cost components were included in the SCI indicator. The cost components that were not included and reasons for not including them are presented in Table V.

TABLE V
Cost Components not Included in the SCI Indicator

Cost component	Project activity
cost of mitigating additional risk associate with innovation	Risk mitigation should be performed throughout the entire project. SCI indicator is dedicated to the planning stage so including a risk component would not be entirely relevant.
the costs generated by additional testing required when developing a software product that has a high degree of novelty	The amount of testing required for an application depends on a large array of factors but mostly it depends on the software development methodology and on the application's characteristics. Innovation usually plays a small part in the amount of testing required.
higher than usual unexpected costs	Unexpected costs are closely related to mitigating risks.

SCI is defined by the following relation:

$$SCI = Cii + Ctn + Citn + Ccp + Cpdt \quad (1)$$

where: Cii – cost generated by identifying the innovative idea; variable that is expressed in EUR; Ctn – cost generated by acquiring new technology; variable that is expressed in EUR; Citn – cost generated by learning new technology; variable that is expressed in EUR; Ccp – cost generated by building a prototype; variable that is expressed in EUR; Cpdt – cost generated by protection of intellectual property rights; variable that is expressed in EUR;

Cost of identifying innovative ideas derives from the need to invest resources in the formalization of a concept, the development of a theory or to formulate a principle that will act as the corner stone for the application that is going to be implemented. The cost of identifying an innovative idea is determined by using the following indicator:

$$Cii = \sum_{i=1}^{n} Cm_i \cdot No_i + Cc \quad (2)$$

where: n – number of project team members involved in the identification of innovative ideas; Cm_i – the cost generated by the *i* team member; variable that is expressed in EUR/hour; No_i – number of hours allocated by the *i* team member; variable that is expressed in hours; Cc – research costs derived from the process of identification of innovative ideas; cost generated by market research, surveys, questionnaires, online accounts to similar or complementary web applications; variable that is expressed in EUR;

Cost of acquiring new technology is generated by the need to integrate external components into the software application, components that generate added value. Such components are hardware equipment, access to specific databases, interaction with various online services through APIs and integration of monitoring and alerting services. Technologies or new software tools, which generate additional costs, are also used in the development of the application. Such components are usually represented by IDE tools. The cost of acquiring new technology is determined by using the following indicator:

$$Ctn = \sum_{j}^{m} Ct_j \quad (3)$$

where: m – number of new acquired technologies; Ct_j - cost generated by acquiring the *j* technology; variable that is expressed in EUR;

Cost of learning new technologies is represented by the effort invested in documenting the new technologies that are either going to be integrated into innovative application or that are going to be used to develop it. The cost of learning new technologies is determined by using the following indicator:

$$Citn = \sum_{k}^{m} Cm_k \cdot No_k \quad (4)$$

where: n – number of project team members involved in learning new technologies; Cm_k – cost generated by the *k* project team member; variable that is expressed in EUR/hour; No_k – number of hours allocated by the *k* project team

member; variable that is expressed in hours;

Cost of building a prototype is generated by the need to test and validate the innovative idea concept before actually investing in it. Validation of the idea is needed in order to reduce the inherent risk of every innovative initiative and also to facilitate raising additional funding. Developing innovative software often involves building several prototypes and selecting for implementation the one that meets the projects owner's requirements and the end-user's needs. The cost of building a prototype is determined by using the following indicator:

$$Ctp = \sum_{l}^{v} Cp_l \quad (5)$$

where: v – number of prototypes that were built; Cp_l - the cost of building the *l* prototype.

Cost of protecting intellectual property rights is driven by the need to obtain documents attesting to the software's application originality and of the ownership rights. The cost of protecting intellectual property rights is determined by using the following indicator:

$$\text{Cpdt} = Tcj + Tic + Cdoc \quad (6)$$

where: Tcj – consulting and legal proceedings fees; variable that is expressed in EUR; Tic – taxes paid to institutions; variable that is expressed in EUR; Cdoc – costs generated by writing documentation; variable that is expressed in EUR;

In Romania software applications are registered at the Romanian Copywriter Office, ORDA. No patent is granted for software applications. The name and logo of a software application can be registered at the State Office for Inventions and Trademarks, OSIM. Consulting and legal proceedings cost about 1,300 EUR. Taxes paid to ORDA and OSIM are about 100 EUR. The cost of writing the documentation is determined by the number of hours allocated by each team member to this particular activity and the cost per hour generated by each team member. ORDA documentation requires a description of the application's modules, functionality, technologies, safety standards and levels of access. Registering the software application to ORDA will also require building a demo version.

It is not mandatory that an innovative software development project include all the cost categories of the SCI indicator. For example the Digital Zoo project did not have costs related to protecting intellectual property rights.

IV. Conclusion

Properly identifying innovation specific costs is a prerequisite for successfully integrating innovation into an IT system. Developing an innovative software application involves specific costs that stand out from costs that are usually encountered in regular software development projects. Identifying these costs accurately at the beginning of the project is important because it allows the project manager to properly budget the innovation factor. As proposed in the current paper innovation specific costs are generated by: identifying the innovative idea, acquiring new technology, learning the newly acquired technology, building a prototype and securing intellectual property rights. Based on the identified costs the SCI indicator is defined. The SCI indicator aggregates all the costs related to innovation in a software development project. The SCI indicator is subject to further refinement by adding other relevant cost components or by improving the methodology for estimating current cost components. By identifying a set of costs that are specific to innovation in software development projects the research hypothesis has been validated. As a future research topic one might tackle the subject of return on innovation as a counterpart for the cost of innovation.

Acknowledgment

This paper was co-financed from the European Social Fund, through the Sectorial Operational Programme Human Resources Development 2007-2013, project number POSDRU/159/1.5/S/138907 "Excellence in scientific interdisciplinary research, doctoral and postdoctoral, in the economic, social and medical fields -EXCELIS", coordinator The Bucharest University of Economic Studies.

References

[1] K. H. Tsai, "The impact of technological capability on firm performance in Taiwan's electronics industry," The Journal of High Technology Management Research, Vol. 15, No. 2, pp. 183-195, 2004, DOI: 10.1016/j.hitech.2004.03.002.

[2] G. Xingguo, S. Xiaozhong; Z. Weiwei, "Dynamic Evaluation Based on Timing Sequence Multi-Index for Technological Innovation Cost," Proceedings of the International Conference on Management and Service Science, MASS 2010, 24-26 Aug. 2010, Wuhan, China, Publisher: IEEE, doi: 10.1109/ICMSS.2010.5576182, pp.1-4.

[3] J. P. Allen, "Open Source Deployment at the City and County of San Francisco: From Cost Reduction to Rapid Innovation," Proceedings of the 43rd Hawaii International Conference on System Sciences, HICSS, 5-8 Jan. 2010, Honolulu, USA, Publisher: IEEE, 2010, doi: 10.1109/HICSS.2010.295, pp. 1-10.

[4] Cornell University, INSEAD, WIPO, "The Global Innovation Index 2014: The Human Factor In innovation," second printing. Fontainebleau, Ithaca, and Geneva, 2014, http://www.wipo.int/edocs/pubdocs/en/economics/gii/gii_2014.pdf.

[5] A. Savoia, P. Copeland, "Entrepreneurial Innovation at Google," IEEE Computer, vol. 44, no. 4, pp. 56-61, 2011, ISSN 0018-9162, doi: 10.1109/MC.2011.62.

Open Science Index, Industrial and Manufacturing Engineering Vol:9, No:4, 2015 publications.waset.org/10001052/pdf