Linking social media, intelligent agents and expert systems for formulating open innovation strategies for software development

ADENIYI ADETOLA a, SHULIANG LI a,b, ALISON RIEPLE a and TRINO-MANUEL NIGUEZ a

a Westminster Business School, University of Westminster, 35 Marylebone Rd, London, UK
b School of Economics & Management, Southwest Jiaotong University, Sichuan, China
adeniyi.adetola@my.westminster.ac.uk; S.Li05@westminster.ac.uk; a.rieple@westminster.ac.uk; t.m.niguez@westminster.ac.uk

Abstract: Open innovation for software development is a challenging task in the digital age. In this paper, a new framework for linking social media, intelligent agents and expert systems to support the formulation of open innovation strategies for software development is proposed and presented, on the basis of a literature review.

Key-words: open Innovation; innovation for software development; social media; intelligent agent; software agent; expert system

1. Introduction
Previous research [7, 8, 12, 17, 19, 49] has presented various aspects of open innovation content, context, practices and how companies might benefit from the new innovation model. In this study, we discuss the use of social media and intelligent agents for supporting open innovation for software development innovation process, and proposed an intelligent-agents-based framework to help managers of software products in deploying strategies for open innovation practices. The complexity of collaborations with outside parties such as firms, suppliers and consumers via social media for co-creation efforts require support of innovative decision-making systems. More importantly, the fast pace and radical changes in the software sector require new models for describing how firms can profit from their software innovation efforts [38].

Open Innovation (OI) has attracted attention in the innovation management since Chesbrough[9] pioneering article. Most companies that buy-in to open innovation still lack knowledge on how to do it and when to do it, hence the need for an integrated framework [19]. OI has come a long way since 2003, with social media and crowd sourcing being thrown into the mix. What is lacking is a new decision making tool which can identify the decisions to be made, while structuring the strategies in an easy to implement order, as well as highlighting pertinent factors so that managers can quickly and competently navigate through lesser known areas of OI practices [19]. With several models for OI practices almost isolated, we believe that it is ultimately how companies plan, and utilize them within their innovation process that will determine the greater benefits, hence the necessity for this study.

The paper is organised as follows. The next section presents background of related work on open innovation and practices, social media, software development ecosystem and decision-making models, techniques and methods. Section 3 describes the proposed intelligent-agent-based framework for developing an integrated open innovation strategy for software product development innovation process. The final section concludes the paper and gives future direction.

2. Open Innovation, practices and models
In this paper, we use Chesbrough et. al[8, p.1]) definition OI as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation, respectively”. In traditional innovation process also referred to as “closed model” [29], companies generate their own innovation ideas, develop, build, market, distribute, service, finance, and support them on their
There are two parts to open innovation: “inbound open innovation” is internal use of external knowledge, while “outbound open innovation” is external exploitation of internal knowledge. The following are some factors that companies can look into when considering OI practices: cost of open innovation, shorter time to market, more sales, lower cost, innovativeness, number of innovations, financial benefit, non-financial benefit, product qualities, and the degree to which product meet specific customer needs. Open innovation’s context is affected by several internal and external characteristics. According to Huizingh, the characteristics are demographics and strategies: demographics characteristics such as number of employees, sales, profits, age, location, market share, and ownership type; while strategy characteristics include strategic orientation, organizational culture, aspect or goals of the innovation strategy, incumbents versus new entrants.

Researchers have published various models to help practitioners and academics understand open innovation content, context, stages, and characteristics: Gassmann and Enkel describe the distinction between inbound, outbound and coupled activities; Van de Vrande et al distinguish between various open innovation activities or indicators and classify open innovation in two parts: exploitation (venturing, outward IP licensing and employee involvement) and exploration (customer involvement, external networking, external participation, outsourcing R&D and inward Intellectual property (IP) licensing); Fetterhoff and Voelkel further describe the stages in open innovation; Wallin and von Krogh discuss managing knowledge integration, governance issues such as selection, evaluation of contributions, ownership of intellectual property, division of profit and losses, group decision-making and conflict management. Lee et al provide an intermediate network model for dealing with open innovation intermediaries; Building absorptive capacity; West and Gallagher propose four strategies for motivating outsiders; Dahlander and Gann (2010) model helps to understand the process of capturing value from innovation. According to Chesbrough, companies should look into sharing IP through joint venture, licensing agreement and other arrangements.

Open innovation practice has come a long way since 2003, to include new models such as social media, crowdsourcing (customer-led innovation) and several platform innovations such as the mobile app stores. Social media is a by-product of internet-based applications (e.g. Facebook, Twitter, YouTube, Blog, virtual social world) that build on the technological foundations of Web 2.0. The literature has highlighted the role of social media and networks for engaging consumers / customers in activities that result in new product ideas, evaluation and commercialisation. Customer can share initiatives on company’s products, promotions, environmental and social commitment, and other aspects. Social media is still at embryonic stage, this means companies do not yet fully understand it or how to effectively take advantage of it for improving product innovation process. Among the few notable social media models include: the typology of customer co-creation in innovation process; the impact of social media on co-creation was discussed by Piller et al.; idea screening and evaluation; the five axioms for using social media and creative consumers in international marketing strategy; SLATE, an Enterprise 2.0 model for working with social media tools; ten pieces of advice for companies deciding to use social media; and seven functional blocks of social media.

Looking at various models as well as future perspective of open innovation, Huizingh suggest that the missing part from the open innovation literature is “an integrated framework that helps managers to decide when and how to deploy which open innovation practices. In what stage of the innovation process is collaboration most effective? With which parties to collaborate, and how to find and select them? What is the best way to capture value in collaborative networks, especially when formal protection methods are less feasible e.g. with service innovations or small firms”.

2.1 Software ecosystem and innovation process

Software products are very unique compared to most other physical products, especially when considering
the amount of efforts, resources, and cost of development and maintenance for continuous improvement, as well as intellectual property matters [33]. The process of developing software has a defined structure, a typical software development process has the following stages: (i) requirement analysis, (ii) design / specification, (iii) software architecture, (iv) implementation / coding, (v) documentation, (vi) training and maintenance [18]. This development process is highly influenced by the ideas and directions from the consumer for which the product is being developed. For any company to be competitive in this age, it must innovate its development process [46]. The innovation process cut across most industries in the same way. Innovation is described as the development and implementation of new ideas or activity that result in new processes, products or systems [2]. The innovation process can be described in three main stages as Fuzzy Front End (FFE), Product development and commercialization [1]. The FFE refers to the activities prior to product development such as idea generation, screening and selection through market requirements, technology choices etc. [31].

2.2 From open source practice to open innovation

The closest software sector has gotten to open innovation is open source development. Open source is often confused with open innovation. Chesbrough et al. [8] argue that where open innovation and open source begin to part ways when you bring in the idea of business model as well as sharing of risks and rewards, since open source is not a profit driven model for innovation. An interesting development is how open source and proprietary software philosophy can be supported and benefit from open innovation practices [36].

Open source allow users and developers the right to contribute, use, modify and redistribute a software source code [33]. In proprietary software development, source code is solely developed by a technology firm and is not released to the public. Open source requires long-term development and investments for maintenance [33], which is why it is hardly sustainable if managed by a firm whose underlying business model is providing profit-oriented services. A recent example is that of EllisLab, a software company that manages the popular open source PHP framework, now seeking new owner for the project [14]. Unlike open source, OI promises a greater return on firm’s innovation process [9].

2.3 Effective decision-making in software development innovation process

Every project is unique in software development, and several uncertainties exist in the development and innovation process that requires intelligent and appropriate decisions being made. Integration of strategy, process, measurement of performance and effectiveness, and continuous improvements are among the greatest challenges in product development management in recent years [2].

There are two main types of decision making in software development: managerial decisions and technical decisions. According to Boehm [5] managerial decisions are related to software development economics e.g. resource allocation. Technical decisions are related to the internal and external properties of the product e.g. architectural design, test selection and component selection [39]. Traditionally, decision-making is a rational process in which sequential steps are clearly defined and followed in order to make optimal decisions based on weighing options or alternative solutions [13]. A well-known decision theory is called Descriptive Decision Making (DDM), which places emphasis on “how real people think and behave” [3]. The principle of Descriptive Decision Making (DDM) summarised in Drury et al. [13] are that: Uncertainty affects decision maker; Information is not collected rationally; Behaviour are adapted; Complexity of problem and / or internal conflict affect decision making; and contextual differences affect decision making. This kind of decision-making is also described as Rational Decision Making (RDM), and is based on well-structured settings and options for deciding between alternatives [22]. In real life decision-making situation, multiple options must be generated and compared on a set of evaluative criteria [13].
2.4 Existing relevant intelligent systems and techniques for effective decision-making

Over the years, there have been various artificial intelligence methods and techniques used for supporting decision-making. Decision Support System (DSS), Analytic Hierarchy Process (AHP), Fuzzy AHP, Delphi, Expert systems are common techniques. Decision Support System (DSS) and Group DSS support decision-making by utilizing data and models to solve unstructured problems [23].

These techniques have been applied in past studies, for example, in support of marketing strategy and planning [24, 26, 27, 28, 32], strategic portfolio management decision-making system [35], product evaluation model for assessing commercialisation opportunities using Delphi method and fuzzy AHP approach [10]. The AHP method’s ability to structure complex, multi-person, multi-attribute, and multi-period problem hierarchically is one of its main strength [10]. A technique often used in concept generation and evaluation based on factors and criteria is called Multiple Criteria Decision Making [1]. A step-by-step framework and procedure for solving multi-criteria problems was proposed by Cohon[11], the steps include: Identification; Quantification of relevant objectives; Definition of decision variables and constraints; Data collection; Generation and valuation of alternative; and Implementation of selected alternative.

Recent studies [26, 52, 55] have shown several approaches of how intelligent agents are utilized in decision-making circumstances. Intelligent agent is defined as “the articulation of human decision-making behavior in the form of a computer program” [41, p.1]. Agent can be used to handle information retrieving, filtering, synthesizing within a system [40]. Amongst the characteristics of agents that make them useful as support system are social ability, autonomy, pro-activity, flexibility for integrate systems [40, 55].

3. The intelligent-agents-based framework for supporting an integrated open innovation practices for software development

In the literature review, we have identified various open innovation practices and models, as well as described how various intelligent techniques and methods have been applied in different situations to address non-structured and semi-structured decision-making. The open innovation models are integrated in our proposed conceptual framework, for helping software companies in making appropriate strategic decision under uncertainty considering external and internal factors and characteristics. It consists of modules that are subsystems, processing information through special functions and interplaying between intelligent agents, expert systems and AHP components. The purpose of creating an intelligent-agents-enabled framework for an integrated open innovation practices for software development are to:

- Help identify which practices should be deployed in a given context (firm-level and consumer-level), and which decisions are to be made, in what order and structure?
- Recommend effective collaboration at each stage of the innovation process (Fuzzy front end, product development and commercialisation).
- Suggest which parties to collaborate with, when how and with whom.
- Capturing value in collaboration networks including social media

Fig. 1 on the shows our conceptual framework for achieving the objectives set above.

Intelligent agent can be employed to assist data exchange and communication among the models, AHP component and expert system. The following steps are initially defined based on the key steps of product innovation process and consideration from synthesizing relevant literatures [1, 10, 12, 15, 16, 19, 26, 29, 43, 49, 56, 57].

3.1 Step 1: Initialisation and filtering of context and factors

Initialisation agents can be created to retrieve user inputs for firm environmental factors and characteristics, followed by filtering and preparation for open innovation model agents. The user will clarify fundamental product innovation issues that can be solved or improved by third parties (firm-level and
consumer-level). This will also involve initial evaluation of key demographic and strategic factors identified in Huizingh [19] and initial version of the hierarchy model processed via the AHP pair-wise comparison of criteria to determine the relative importance [10, 26].

3.2 Step 2: Strategic evaluation and modeling
At this step, various open innovation practice models are decomposed into layers of individual processing for each stage of the innovation process i.e. fuzzy front-end (idea generation, screen and selection), product development (prototyping and concept development and testing) and commercialisation (paths to getting the product to the target market). This needs to be aligned with business strategy (Papadopoulus et al., 2013). This stage is reliant on the stored expert opinions of experienced managers, intermediaries and thought leaders built around the Expert System (ES). These operational knowledge may be used for evaluation results and final selection processed by implementing ES inference engine to generate best possible paths and alternatives to follow and in what order [35] deploying the open innovation strategy. Not all models will apply for every given context, depending on the stage of innovation, for example social media models may be more appropriate where the third party needs is concerning consumer creative ability. Another example is that of intermediate network, which may not apply to all firms, depending on the demographic elements and strength and knowledge of the firm’s human capital.

3.3 Formulation of advice and recommended strategies
The key element of this process is to be able to make a coherent presentation of workable expert knowledge and strategic approach generated within the system for deploying and profiting from open innovation for software innovation process. This is achieved through a custom explanation mechanism within the ES, a harmonious processing combining a knowledge base and database of fact and additional functions. Output is presented to the user (manager) using a responsive and asynchronous graphical user interface.

Fig.1. A decision-making framework for open innovation for software development

4. Conclusions and future research
In this article, we have introduced a conceptual framework for integrating open innovation practices in software development innovation process with the aid of intelligent systems and techniques. Our conceptual framework combines the advantages of different open innovation practice models to provide the structure that will help in evaluating the effectiveness of open innovation activities for software development innovation process. The literature provides necessity for this study. Based on the framework proposed in this study, we recommend that it should be empirically tested among software / technology companies. At the time of this report, the authors have sent out an online questionnaire survey to the managers and CEO of software products in the UK to establish more facts and needs for such a framework. This will be followed by associated software system development and case studies of specific software companies to test overall model.

Acknowledgments
The research work reported in this paper is financially supported by the Westminster Business School University Of Westminster PhD scholarship (studentship) awarded to the first named author, AdeniyiAdetola. The publication of this paper is funded...
by Sichuan 100-Talent Scheme research grant (Grant holder: Shuliang Li) that is hosted by Southwest Jiaotong University, China.

References
[14] EllisLab, EllisLab Seeking New Owner for CodeIgniter,(2013) [Online], Available at: [http://ellislab.com/blog/entry/ellislab-seeking-new-owner-for-codeigniter], Last visited: [09/10/2013].


[56] F. Piller, C. Ihl, A. Vossen, A typology of customer co-creation in the innovation process. *Available at SSRN 1732127*,(2010).

