Atom Inspired Model for Open Source Software Engineering: Seeking Bridge between Academia and Industry

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Abstract

Nature inspired engineering is state of the art paradigm, which exploits principles of natural systems to design man-made systems. The Open Source Software Engineering (OSSE) is a growing field that offers challenges and potentials. This paper proposes a model for OSSE that maps some features of atomic model to software engineering process. The model seeks bridge between academia and industry for sustainable growth of the open source. Pakistan stands among the countries that are striving for both, industry-academia bridge and open source. Therefore, this model should be suitable for Pakistan and similar cases.

1. Introduction

Natural systems are the best-created systems [1][2]. It is state of the art practice that natural science laboratories explore principles of natural systems, and scientists and engineers in various disciplines follow these principles to design man-made systems. The classical examples of this domain are; design of aircraft on birds' flight mechanisms, and use of steel columns in building pillars like vascular bundles (pipe like tissues) in tree stems. The recent examples of natural inspiration include the fields of Artificial Immune Systems (AIS) [3][4] and Immuno-tronics [5], the engineering systems inspired from natural immune system [1].

Atom is a thoroughly studied natural entity [2]. Bohr's atomic model describes the basic atomic principles. For the sake of simplicity and relevance, this paper will not go into details of atomic structure and processes. The scope of the paper is to follow simple atomic principles for proposing a relatively distinct model named Atom Inspired Model for Software Engineering (AIMSE). It would exhibit some features of the atomic model.

The proposed case study for the AIMSE aims to mobilize open source community in Pakistan; academia, research and development (R&D), and industry. The academic proposals and projects are the main focus of the model. The need for bridging multi-disciplinary and multi-tier open source community is being realized since the birth of field. However, the concept of AIMSE portrays the issue in different perspective.

The paper is organized as follows; section 2 describes the motivational factors of the topic. The source of natural inspiration, atomic model, is expressed in section 3. Description of AIMSE is given in section 4. Section 5 contains a proposal to apply the model to Pakistan's case, and section 6 concludes the essay.

2. Motivation

Seeking analogy from nature – the scientific community believes that natural processes and resulting products are the best created. Therefore, modern science is exploring and following natural principles to optimize the design of manmade processes and products. Depending upon the technical understanding and esthetics of designer, natural principles can be applied to any field including software engineering [1-4].

Triple helix model – this model denotes the university-industry-government. In developing country, universities increasingly need the ability to transfer existing knowledge to lower levels on the technology scale within their societies and also to provide inputs into the development of high-level technologies through training process complemented by consulting, incubation and transfer capabilities [6].

Bridging open source community – for a healthy open source community, it is evident to bridge multi-disciplinary and multi-tier intellectuals. The intellectuals from different fields and ranks should interact frequently to build and strengthen the bridge. Thanks to ICT (information and communication technologies), the bridging is viable through virtual project teams and technical focus groups.

Exploiting potentials of academic projects – academic projects should not die, after fulfillment of their academic purposes (degree etc.). The academic proposals and projects need careful management to contribute for sustainable growth of the open source [8][9].

Standardizing the process of academic projects – academia needs to follow standards to conduct the processes of academic projects. It will help students to

learn quality practices. The quality oriented intellectuals, processes and products will be valuable assets of open source community.

Web repositories for open source projects – some active web repositories [8][9] are contributing a lot towards the community. To his convenience, a person can find opportunity to participate in variety of projects/proposals at various process stages. The web repositories are allowing liberal but directional contributions resulting successful open source products like "apache" and "mozela".

University Cradle Investment Program Malaysia – Malaysia is among the rapidly progressing countries and setting examples for developing countries like Pakistan. Malaysia is making serious efforts to bridge multi-disciplinary intellectuals in academia, research and development, and industry. The University Cradle Investment Program (U-CIP) is one of the most vibrant programs in this domain [10].

3. Inspiration from nature

Natural systems are the best-designed systems to follow for engineering man-made systems. This section gives an overview of the natural inspiration of the proposed software engineering (SE) model.

The SE model presented in this paper is inspired from atomic model [2]. In an atom, electrons revolve around the nucleus in different energy orbits (please see figure 1). The orbit closest to nucleus is at the lowest energy level and the farthest one is at highest energy level. An electron releases energy (photon) when falls from high energy orbit to a low energy orbit (see a de-excited atom in right part of the figure). On gaining energy (photon), the electron of a low energy orbit jumps to an equivalent high-energy orbit (see an excited atom in left part of the figure). For example, if an electron in "transmitter" jumps from 3rd orbit to 1st, the released photon will make an electron in "receiver" to jump from 1st orbit to 3rd. It shows that de-excitation of electron(s) in an atom may excite electron(s) of an interacting atom to same level. It means, energy gain level of receiving atom is equivalent to energy contribution level of transmitting atom. This natural atomic principle can be exploited to propose a software engineering model, described in the following section.

4. Atom inspired model for software engineering (AIMSE)

The process (activities) and products of proposed model gain energy from the contributors to improve their states. The model operates on "project proposal" in four process phases; preparation, evaluation, realization, and validation (please see figure 2). The respective four deliverables are; standard proposal, feasible proposal, standard prototype, and valid prototype. Following section 4.1 describes the core phases of the process.

4.1. Core phases of software engineering process

Preparation - A process starts with proposal preparation phase. The main objective of the phase is to

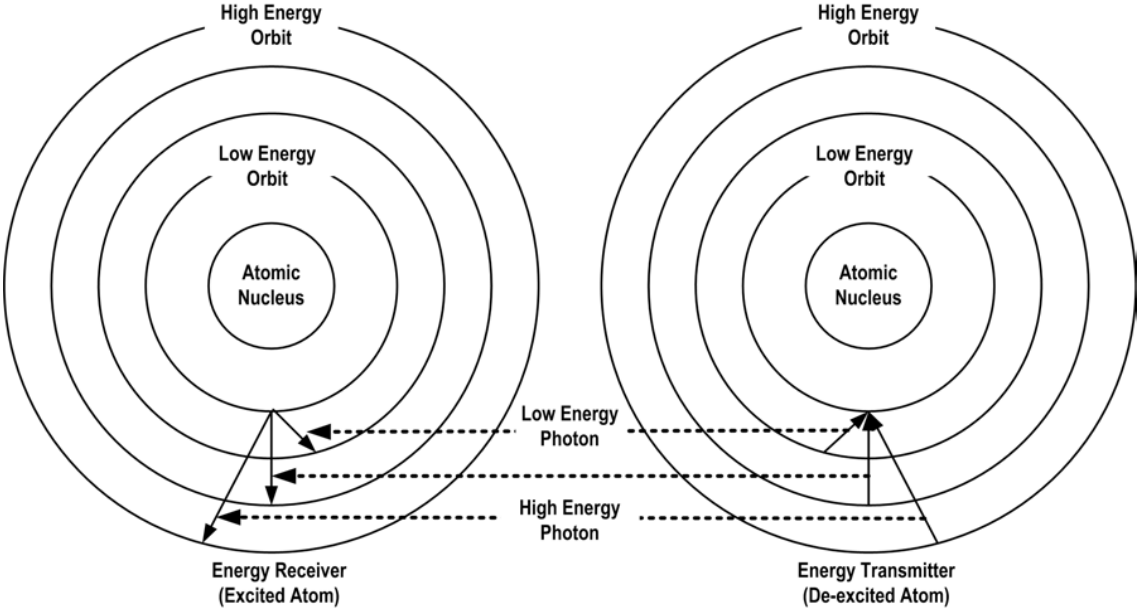

Figure 1. Interaction of two atoms for energy (photon) emission and reception

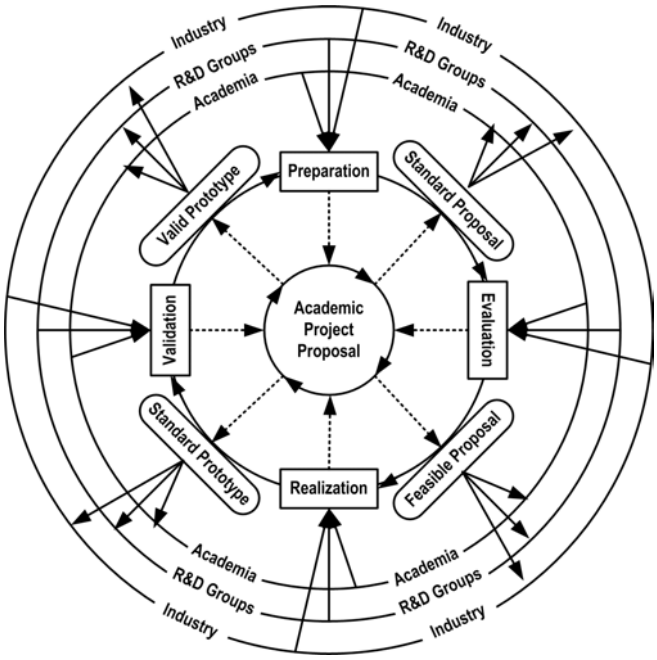

Figure 2. The atom inspired model of software engineering (AIMSE)

prepare a project proposal in standard format, which may contain;

- Introduction to project
- Motivation
- Objectives
- Related work
- Current status of the field
- Problem background
- Problem statement
- Project scope
- Methodology to solve the problem
- Required resources
- Expected contributions
- Expected deliverables
- Tentative schedule
- Budget estimate
- Expected beneficiaries
- Expected constraint, and
- References

An adequate proposal may save significant time in subsequent phases.

Evaluation - This phase is to conduct peer-reviews of the proposal, and get accord about the feasibility. Peers in academia, research and development, and industry should conduct the review. The authenticity and quality of evaluation can be determined by level and number of reviews. A reviewer may award some points to tell feasibility level of the proposal. The proposals with high feasibility points should enter the next phase of project realization.

Realization - Actual design and development of the project would be carried out in this phase. This phase stands upon the strength of preceding phases, preparation and evaluation. Realization phase should involve; application domain experts, software engineers, programmers, and testers. This phase may result an academic prototype or industrial product, depending upon the level of participation and number of evolutions. There may also be some other valuable deliverables like; technical reports, research papers, trained manpower, new infrastructures, and viable proposals.

Validation - The validation phase is to assess maturity level of product (prototype) and respective process. Stakeholders would carry out the validation. The key features (structure, function, and performance) of software engineering process and resulting product are considered to establish validation level. Similar to evaluation phase, points would be awarded to convey the maturity level. The deliverables of this phase include; valid prototype or product, test results within the specified requirements of the project, comparative study with related processes and products or previous versions of the same process and product, recommendations for improvement, etc. This phase may initiate next cycle to evolve the process and product.

4.2. Mapping to atomic model

The fitness of nature inspired engineering models depends upon the level of abstraction and mapping of

respective components. This section attempts to map features of atomic model to software engineering model, please refer figures 1 and 2, and table 1.

The components of proposed SE model (process phases and respective outcomes) are conceptualized as electrons in an orbit. The orbit in this case is complete process track (a circular track of process phases; preparation → evaluation → realization → validation, as shown in figure 2). The intellectual participation and application level (academia, research and development, and industry) determines the energy level of the orbit. For example, if process is applied to academia and receiving participation from academia only, it would be at low energy. The case would be vice versa for industrial level participation. It is like interaction of two atoms (please refer figure 1), where electron of one atom emits energy photon (transit from high energy orbit to lower one) and electron of other atom use the same energy photon to have equivalent rise in orbit. That is to say, a software engineering process receiving participation (energy) from academia, research and development, or industry is likely to attain respective level, incorporating relevant features in process activities and deliverables. The atomic interactions are like intellectual collaborations.

Table 1. Mapping atomic model to software engineering

Atomic Model	Software Engineering Model
Electrons	Components of model (objectives, process activities and deliverables)
Electron transition	Change in the status of model components (given above)
Energy orbits	Process tracks composed of various process phases (preparation, evaluation, realization, and validation)
Energy levels	Intellectual levels (academia, research and development, industry)
Energy emission	Contribution of knowledge and resources
Energy absorption	Utilization of knowledge and resources
Interactions	Collaborations

5. Proposal to apply the model for Pakistan

Pakistani academia is not behind the world in creative and innovative activities. They raise hundreds of valuable proposals and develop prototypes to fulfill academic requirements. Many of these projects can be evolved as valuable industrial products, but remain unattended and die after fulfilling their academic requirements. The only deliverable kept in libraries are project reports, which are not sufficient to properly reuse and evolve the projects by open-source community. Thanks to the government and agencies sponsoring scientific growth in Pakistan, the number and quality of academic projects is increasing appreciably with the increase of quality institutions, faculties, and indigenous research and development activities [11]. Here we seek focus of the Open Source Community in Pakistan (OSCP) to save and exploit the national wealth of academic projects. The proposed AIMSE model can be applied to evolve academic projects to industrial products through active participation of all stakeholders. Having inspired from sourceforge [8], freshmeat [9], and U-CIP [10] we propose a National Portal for Open Source Projects (NPOSP) as a viable mean of applying AIMSE model. The NPOSP would facilitate the successful completion of all phases of the model through participation of the community. It would also help fulfilling the following long term objectives;

- Keeping repository of reusable and evolvable proposals and projects
- Initiating positive competition among project teams
- Avoiding redundancy of efforts and contributions
- Establishing E-Teams and Focus Groups, having common interests
- Improving academia-industry collaborations and entrepreneurships
- Developing habits of standard practices
- Improving abilities for team work
- Appreciating efforts of the contributors

In our opinion, Higher Education Commission (HEC) Pakistan [11] and Open Source Resource Center [12] may jointly step forward to materialize the proposal.

6. Conclusion

Natural inspiration has been useful in engineering man-made systems. The proposed software engineering model, named Atom Inspired Model for Software Engineering (AIMSE), establishes some analogy of natural atomic features with the software engineering process. Although, need for bridging multi-disciplinary and multi-tier open source community (academia, research and development, industry) is being realized since the birth of field; however, the idea of AIMSE presents a new perspective. The potentials of academic proposals and projects have been the major focus for model application. The National Portal for Open Source Projects (NPOSP) would be a viable mean of applying AIMSE model and mobilizing Open Source Community in Pakistan.

7. References

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