Open Source Software Development: A Systems Dynamics Model

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Abstract

Evidence suggests that only a small percentage of open source development (OSSD) projects are active, have significant participation, or have delivered operational software. We develop a system dynamics based simulation model to analyze the dynamics of open source project participation process and software development process. We show that the complex interaction between participation and development processes affects crucially success or failure.

1. Introduction

Despite the recent incredible growth of open source as a social movement, development approach and business strategy, evidence suggests that only a small percentage of open source development (OSSD) projects are active, have significant participation, or have delivered operational software[1, 2]. Why is that so?

How the success of a project is sensitive to initial participation, initial code-base, or timing of project relative to other projects? How does the evolution of community developer participation affect the development process and project success?

We develop a *system dynamics* model that attempts to answer these questions. We focus on the process of joining and exiting OSSD projects when there are many projects “competing” for their development attention. We provide insights into the co-development and co-evolution of OSSD community participation, and software development [1].

While there is a large empirical literature on OSSD projects in the form of detailed case studies, modeling and simulation of the OSSD process is needed [1] because of the its inherent complexity and large heterogeneity when it comes to motives of participants, size of participation, methods of coordination, quality of output etc.

A primary objective of this research is to develop a systems dynamics framework [3] for open source development. System dynamics is well suited to analyzing process dynamics as a result of feedback loops. The fundamental premise of modeling is that the structure of feedback loops of a system determines the dynamic behavior of the system through time [3].

Because this paper is a simulation it is complementary with other simulation research modeling open source development most notably [4-6].

In what follows, we provide an overview of systems dynamics approach, describe the model, discuss some intuition and conclude.

2. Systems dynamics approach

System Dynamic’s basic tenet is that the structure of feedback loop relations in a system gives rise to its dynamics. Pioneered by MIT’s Forrester, SD calls for formal simulation modeling that provides a rigorous understanding of system behavior. Two major types of diagrams are used to formalize system structure: causal loop diagrams and stock and flow diagrams. Causal loop diagrams depict the positive or reinforcing and negative or balancing feedback loops characterizing the system under study. Stock and flow diagrams (figure 1) depict how flow variables accumulate into stock variables, providing useful features such as memory and inertia. A major insight of SD simulation modeling has been that, at the right level of abstraction, SD researchers encounter similar causal processes that underlie *seemingly* highly diverse phenomena

One challenge of SD research is justifying the validity of the model. In our study, the structural and behavioral validity of the model has been ensured through an iterative process as described by [7] and the mainstream systems dynamics research literature.

An initial model was developed based on an extensive review of the empirical OSSD literature [1] and most importantly detailed case studies such as [8-12].

Structure validation involves experts providing feedback on model structure. OSSD project participants were asked to provide feedback. The model was tested in reproducing observed behavior using data from Sourceforge projects. This iterative process leads to the final version of the model.

3. Overview of model

We will now describe some main features of the model and some intuition.

A number P of open source projects are "competing" for attention by a population of potential OSS developers. The projects differ in attractiveness, reputation, stage of development, initial code-base etc. The potential developers are heterogeneous: a percent of them is motivated by delayed career rewards (extrinsic motivation) [13] and a percent of them is intrinsically motivated developers [14]. All developers are volunteers and they choose how long they want to participate in a project and how much to contribute based on their motivation.

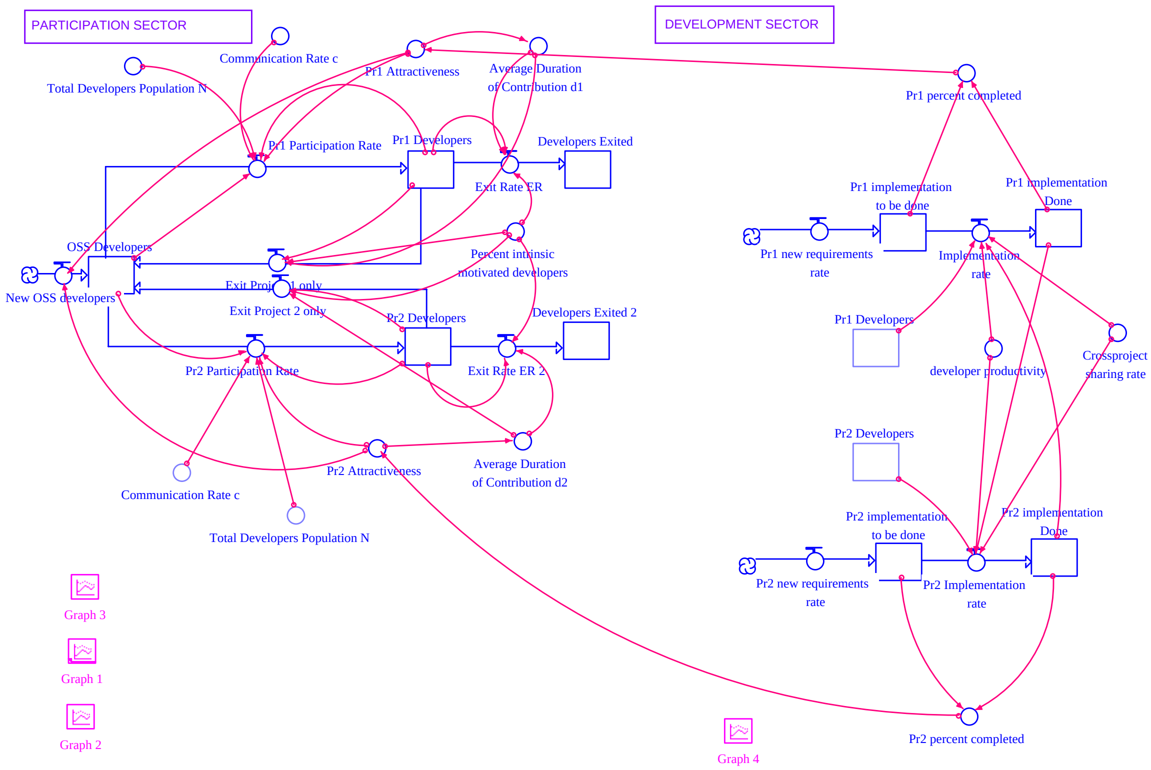

Figure 1. System dynamics model and feedback loops (version 1)

Within projects, developers self-select tasks [12], coordinate and develop code which may be shared with other projects to some extent (cross project network externality). The larger the number of developers in a project improves peer-review and feedback, improving the quality of the output (within project network externality).

4. Discussion

Simulation and analysis of the dynamics of this ecosystem of project shows that most of the projects are *inherently unstable*, confirming empirical evidence. Projects compete for developers (and user attention) which are finite. There is limited commitment to a specific project, excluding only the most successful ones, and because of the volunteer participation it appears difficult to enforce commitment. Developers may switch from project to project, or once the most interesting work is done there are few people working on the "not-enjoyable" tasks, so participation & results (completed/successful projects) may fluctuate widely. Intrinsically motivated developers are likely to switch from project to project based on what attracts their interest (having fun from development). Extrinsically motivated developers are likely to exit open source development completely, once they gain enough reputation etc.

Does this affect the stability of the community in the long-term? Possibly yes, if there are not many projects succeeding, then the community, e.g. the pool of developers from which projects attract participants may shrink affecting all projects. On the other hand, success (the small percentage of projects) leads extrinsically motivated developers out of the community, which again affects negatively the long-term stability of the community.

However, critical development levers, such as code modularity, fast feedback, and sharing of code across projects lead in complex ways to self-reinforcing feedback processes that affect positively the participation. It is this interaction of development process and participation process that leads to success or failure.

5. Concluding remarks

Our current research focuses on the process of participation in OSSD communities and projects and the interaction of this process with the development process and the output of the project.

In future research we plan to expand our system dynamics modeling to capture detailed aspects of the development coordination and performance of different coordination mechanisms. We plan also to model the interaction between commercial firms sponsoring open source development and the community. In complementary work, we have modeled the strategic competitive effect of open source software in the market and its disruptive potential [15] [16].

Besides developing academic theories our models could be used by practitioners to understand how changes in various factors related with the development process may affect process performance and dynamics. For example, leaders of open source communities can gain insight into better community leadership, and firms that sponsor open source projects can learn what policies benefit the project the most.

6. References

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