

Dynamic Model of the Java Ecosystem Hype Cycle

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Abstract—It is proposed an approach to design a Hype Cycle for the Java ecosystem. A set of essential structural elements of the Java ecosystem is proposed. Simulation modeling of ecosystem development was carried out based on a model constructed using Control Theory. The oscillatory nature of the Hype Cycle has been established and substantiated. By means of the MATLAB package, simulation modeling of the development of the Java Ecosystem was carried out.

Keywords— Java ecosystem, open source, hype cycle, control theory, transfer function

I. INTRODUCTION

The hype cycle (HC) is an approach to graphically representing the state and forecast of the development of high-tech innovations, developed by the American information technology research company Gartner in 1995 [1]. One of the goals of developing the HC was to provide investors with an effective tool that allows them to determine the effective point in time for investment based on an analysis of the maturity of a technological innovation. Information about the HC of various innovations is updated annually. At the same time, the system of innovations that form the graphic content of the HC includes only those that represent a truly new technological approach to solving problems that are promising for production, science and society. For example, in 2022, twenty-five breakthrough technologies are combined into the following three groups:

Group 1 - immersive technologies that implement virtual ecosystems of life - digital people, metaverse, Web3 and other technologies;

Group 2 - technologies for the transition from automation to fully automatic systems using artificial intelligence - AI technologies, ML code generation, NLP natural language processing and other technologies;

Group 3 - innovations optimizing development technologies - cloud data ecosystems, software development platforms, open source software generation support platforms and other innovations.

The main distinctive features of the HC in relation to other approaches to describing the state and prospects for the development of innovations are, firstly, a systematic view of the development of innovations, when various technological innovations are considered together on a single time scale; and secondly, clear principles for graphically displaying the maturity state of each technology. Figure 1 shows the canonical view of the HC, which contains the following five stages of development of innovative technology:

1. Technological trigger - technological discovery, development of a corresponding innovative product and its public demonstration. At this stage, innovation is characterized by increased consumer interest in it and their high expectations.

2. The peak of inflated expectations, as a rule, provoked by aggressive advertising, not only in the production and consumer chain, but also in the scientific aspect.
3. Fading interest in an innovation that does not live up to the predicted characteristics of its operational functionality.
4. Renovation of a technological discovery and a corresponding innovative product with clearly stated characteristics and confirmed in current operation.
5. Production maturity of the product.

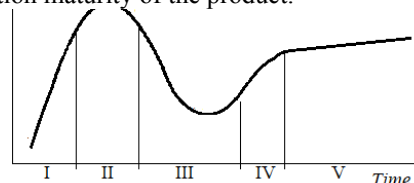


Fig. 1. The canonical view of the hype cycle

Gartner's selection of disruptive technologies is based on the assumption that they are expected to achieve a sustainable production cycle within two to ten years. This approach allows investors to determine the entry point into an innovative project and its prospects.

There are few works on the mathematical description of the dynamics of the hype cycle. They use the following approaches: the apparatus of logistic functions (for example, [2]), the stochastic approach to the social bubble hypothesis (Social Bubble Hypothesis [3]) [4], an approach similar to the formalized description of transitions between quantum levels [5]. However, exact solutions to the function describing the development of innovation along the hype cycle curve have not yet been obtained. Even the order of the model has not been established. It can be considered that the hype cycle curve remains poorly formalized [6, 7].

Thus, the goal of this work is to develop an approach to describing a mathematical model of a system of innovative technologies of the hype cycle using the example of the Java ecosystem using the apparatus of transfer functions of the theory of automatic control.

II. SYSTEM ANALYSIS OF THE JAVA ECOSYSTEM HYPE CYCLE

A systematic view of the development of innovative technologies requires taking into account the mutual influence of all technologies in the hype cycle among themselves and with the external environment of the technology system. This approach allows us to formulate the problem of searching for a mathematical model of the hype cycle as a problem of describing the development of an ecosystem. Moreover, each innovation is a multicomponent system in which the elements are in conditions of mutual innovative development. To describe the interaction of elements, it is necessary to establish a component of the

ecosystem, which is common to both innovation in the hype cycle and its external environment. Let us choose the object-oriented programming language (PL) Java as such a component. The choice of Java is due to the fact that it is one of the most popular languages. Therefore, we can assume that it is both a structural component of innovations of the third group (from the above-mentioned groups of innovations in 2022) of the technologies of the hype cycle, and a component that forms the interaction of the technology system with the external environment of innovative development.

Figure 2 shows the dynamics of the popularity of the main programming languages [8]. Limiting the pool of the most popular languages are Ruby and JavaScript, which appeared simultaneously with Java in 1995, as did PHP. In six years, the Java language took a leading position in the programming language market and held it for ten years, being in the second stage of the hype cycle. However, by 2008, Java began to shift along the curve of the hype cycle towards the border of the third stage - interest in the language began to fade, partly due to rare releases. Subsequently, the frequency of Java releases became comparable to the frequency of Go and Rust releases, but this became possible only when the vendor changed in 2010, when Oracle took over the platform. Oracle increased the frequency of Java releases in 2018, providing an opportunity to advance the entire Java ecosystem.

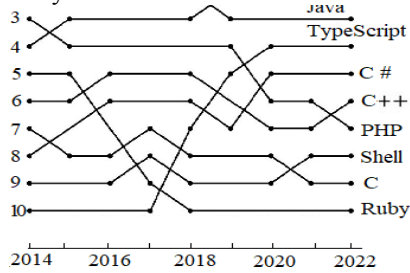


Fig. 2. The popularity of programming languages on GitHub [8]

Figure 3 shows the number of companies in the UK using open source software in their products as of 2021.

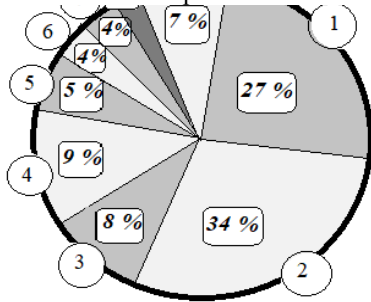


Fig. 3. Contribution of open source software (OSS) to the revenue generation of UK companies in 2021 [9]:

- Group 1 (27% of companies) – do not receive income from using OSS;
- Group 2 (34% of companies) – do not determine the OSS contribution;
- Group 3 – receive 100% of the company's income from using OSS;
- Group 4 – 60 ÷ 100% of income comes from the use of OSS;
- Group 5 – 40 ÷ 60% of income comes from the use of OSS;
- Group 6 – 20 ÷ 40% of income comes from the use of OSS;
- Group 7 – 10 ÷ 20% of income comes from the use of OSS;
- Group 8 – 5 ÷ 10% of income comes from the use of OSS;
- Group 9 – less than 5% of income was obtained using OSS

It is shown in [9] that the largest number of companies using open source software (OSS) are among those with the highest and lowest levels of annual net profit. This is because the former are interested in innovative development with access to a broad base of creative software innovation, which may have contributed to the market entry of AdoptOpenJDK in 2021. The least profitable companies use OSS due to its commercial attractiveness. The forecast of sustainable activity in the open source development segment contributed to Microsoft's acquisition of the GitHub web service in 2018. This can also be seen as a manifestation of the Java function in the connections of the hype cycle technology ecosystem with the external environment.

The robust development of the Java ecosystem is also due to the fact that companies such as Amazon, Google, Netflix, Pinterest, Spotify, Square and Zoom use Java in their extensive code bases. This language served as the basis for programs such as Hadoop and Kafka. The presence of a large-scale data infrastructure based on the Java ecosystem guarantees the damping effects of the external environment on it.

III. GRAPHICAL MODEL OF THE JAVA HYPE CYCLE

As a result of the above analysis, it was established that contributing to the Java ecosystem, its periodic updates and extensions are necessary elements of the life support of the Java ecosystem and perform a resource function in relation to it. Thus, the time of the start of a new release of any component of the ecosystem is the time of launching a new wave of contributing, aimed at eliminating obvious discrepancies with the regular expectations of contributors. This can be associated with an innovative impulse of short duration but high power, launching both the process of proactive user contributions and corporate contributions of third-party vendors directly to the Java ecosystem, as well as software development processes for the effective use of the current version. At the same time, the main shortcomings of the new version are eliminated in a short time. This can be interpreted as a rapid change in the quality of a new release, which corresponds to the transition of the Java technology ecosystem to a new level of optimality. And finally, over time, non-critical or non-obvious shortcomings of the new release are eliminated, i.e. it is smoothly brought to the level of quality that can be provided in a given language ecosystem. Subsequently, in connection with the development of related technologies of the hype cycle, a crisis of confidence in the effectiveness of the language ecosystem occurs, which causes a new cycle of its improvement. During this cycle, one can expect a significantly smaller correction in the contributing mode, since over time and with an increase in the frequency of releases, the ecosystem asymptotically approaches the optimal state.

Figure 4 shows a qualitative curve of the hype cycle of the Java ecosystem, taking into account the analysis of the stages of its development. The difference between the proposed curve and the canonical form of the hype cycle (see Fig. 1) is that the curve has a clearly defined oscillatory nature. In addition, the proposed hype cycle curve lacks an asymptotically constant hype characteristic. This is fundamental, since the limit of innovative development must be determined by the limit of development of all components of the Java ecosystem. However, as has been established, among others, the structural component of the ecosystem is

the community of developers and user-contributors, which makes the process of stabilizing the hype unlikely.

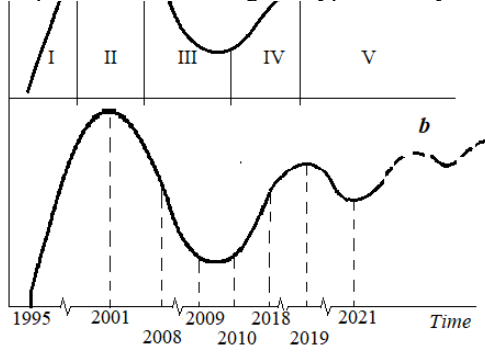


Fig. 4. The canonical hype cycle (a) compared to the Java ecosystem hype cycle (b). Characteristic points: 2001 – Java came to first place among popular programming languages; 2008 – the beginning of the stage of disappointment in Java associated with rare releases; 2009 – 2010 – the least demand for Java; 2010 – transfer of Java assets to Oracle Corporation; 2018 – the frequency of Java releases becomes comparable to other leading languages; 2019 – the beginning of licensing support for the Java ecosystem; 2021 – AdoptOpenJDK entering the market

The proposed hype cycle allows us to consider the development of the Java ecosystem in terms of Control Theory, as an oscillatory system, and to use the apparatus of transfer functions to synthesize a mathematical model [11].

IV. SYNTHESIS OF A DYNAMIC MODEL OF THE JAVA ECOSYSTEM HYPE CYCLE

To synthesize the Java ecosystem model, we use the general principles of synthesis of dynamic systems adopted in control theory. Namely, we will decompose the Java ecosystem into its main structural elements, establish relationships within the ecosystem, and determine the types of external influences. Then, from general considerations, we obtain analytical dynamic characteristics of the structural elements and the entire Java ecosystem. We will carry out simulation modeling in order to establish the parameters of analytical characteristics. We will choose transfer functions as analytical dynamic characteristics.

So, let's assume that the Java ecosystem is linear and is represented by three groups of elements typical for an ecosystem: a set of developing technologies, a community of users and a set of values (production, financial, social, etc.). Let's simplify the task and highlight the following main structural elements in the ecosystem.

1. Element “Java Language” – we will assume that this is a linear element of the ecosystem, which can be described by an inertial first order element of a block diagram, taking into account discrete releases that take the demand for the language to a new level. Such an element of a block diagram is characterized by a time constant T_1 and a gain k_1 . Both of these parameters form the “acceleration curve” of the dynamic characteristic, which can be associated with how quickly developers will demand (in what quality and to what extent) language innovations.

2. Element “JDK” – with a similar interpretation and the same dynamic characteristics: time constant T_2 and gain k_2 .

3. Element “Releases” of PL and JDK is an integrating element of a block diagram, which is launched as a result of

the integration of PR processes, analysis of the viability of so named “polygon” languages (Scala and Kotlin) and changing user preferences formed by new technological tasks. This structural element is characterized by the transmission coefficient k_R , which characterizes the degree of product update, and the time constant T_R , which characterizes the period of relevance of the release.

4. Element “Projects” that extend the functionality of Java (Hibernate, Spring, etc.) and constantly support developers in the Java ecosystem. We will consider this component a proportional element of a structural diagram with gain k_4 .

5. The element “Users-contributors” can be represented by a non-ideal differentiating element of a structural diagram with a decreasing dynamic characteristic - maximum at the beginning of a new release. The dynamic properties of this element, accurate to the gain factor k_5 , are determined by: T_{51} – time constant, depending on the frequency of releases and T_{52} – time constant, characterizing the period of the maximum number of PR. The model of the “Contributing Users” element is adequate for $T_{51} > T_{52}$.

6. The element “Developers” as a whole can be formalized as a first-order inertial element of a block diagram, with a transfer coefficient k_6 , characterizing the satisfaction of initial expectations from the release, and a time constant T_6 , characterizing the period of adaptation of developers to the innovations of the Java ecosystem.

7. Element “Value System” can be formalized as a regulatory element of the type of proportional-integral-derivative regulator. At the same time, the regulator settings can be set in such a way that will lead to a reduction in the excitement and to the migration of some users, as, for example, in 2019. Then this element is modeled by an integro-differentiating element of a structural diagram. In general, the tuning parameters are: a gain factor depending on qualifications, as well as two time constants, one of which characterizes the time to achieve the predicted level of user satisfaction, and the other relates the rate of decline in user interest in the ecosystem with innovation in it.

As an external influence in the model, it is necessary to consider the influence of the entire set of technologies of the HC, in our case, the third group of technologies of 2022, indicated in the Introduction. The state of the model represents the observed hype cycle of the Java ecosystem. Figure 5 shows a block diagram of the Java ecosystem. The transient process at the model output is shown in Fig. 6 and is interpreted by us as an observed hype cycle.

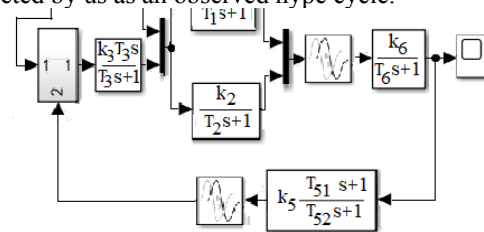


Fig. 5. The Block diagram of the Java ecosystem hype cycle model

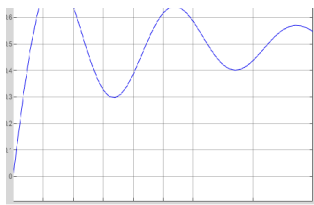


Fig. 6. MATLAB simulation experiment. Transient response of the model – response to a step impact

Figures 6-8 shows the results of simulation modeling in MATLAB of the observed hype cycle under various types of external disturbances. In all cases, curves were obtained demonstrating the oscillatory nature of the dynamic process. In the first case, in Fig. 6, a step signal associated with a sharp change in the state of the external environment of the Java ecosystem was considered as an external influence. This may be the case when an innovation enters the technology market, no matter whether it competes with Java for resources, or, conversely, requires the support of the Java ecosystem for its successful implementation. Figure 7 shows the transition process in the model with a proportional increase in the resource in the system. This impact can be attributed to the increase in the number of users resulting from the creation of innovative products to support the Java ecosystem. Figure 8 shows the hype cycle curve under the condition of the combined action of the two previous factors.

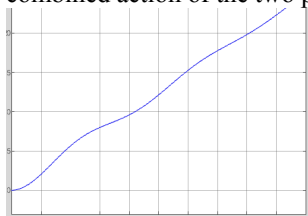


Fig. 7. MATLAB simulation experiment. Model response to the proportional influence of the external environment

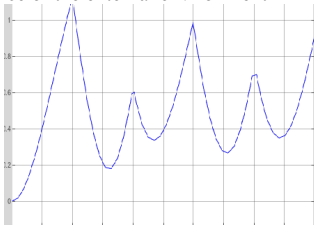


Fig. 8. MATLAB simulation experiment. Model response to the combined influence of proportional and step signals

The model hype cycle curve differs from the simulated data. The main reasons for this are the following. Firstly, significant assumptions were made when constructing the model, namely its linearity, composition and dynamic

characteristics of its structural elements. Secondly, the dynamic characteristics presented in Fig. 6-8 reflect the discrepancy between the parameters of structural links and real values; however, searching for parameters of transfer functions that satisfy the real indicators of structural elements of the Java ecosystem is a complex task that is not within the scope of this study. And, finally, the complexity of the influences of the external environment is not limited to the set of input influences of the model, which is described above, since at this stage of the study, maximum simplifications have been made in relation to the input signals. But, in any case, the data obtained indicate the oscillatory nature of the hype cycle with an increasing envelope.

CONCLUSION

The paper proposes an approach to building a hype cycle for the Java ecosystem. Based on a systemic analysis of the state of the study area, a set of essential structural elements of the ecosystem is proposed. Simulation modeling of ecosystem development was carried out based on a model constructed using control theory. The oscillatory nature of the hype cycle has been established.

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