

# Intelligent Simulation Models based on Business Rules Approach in Banking Sector (WIP)

**Roman R. Veynberg**  
Plekhanov Russian University  
of Economics, 117997,  
Russia, Moscow  
[veynberg@gmail.com](mailto:veynberg@gmail.com)

**Aleksandra Varfolomeeva**  
Plekhanov Russian University  
of Economics  
Russia, Moscow  
[aovarfolomeeva@gmail.com](mailto:aovarfolomeeva@gmail.com)

**Kseniya Grigoryeva**  
Plekhanov Russian University  
of Economics, 117997,  
Russia, Moscow  
[kseniya\\_mail93@mail.ru](mailto:kseniya_mail93@mail.ru)

## ABSTRACT

In this paper, we discuss business rules management systems (BRMS) and their use in bank scoring models. Business rules are considered as an effective tool in determination of trustworthiness and solvency of borrowers, taking into account their socio-demographic and personal characteristics. This article will be informative for scientists in applied IT field, finance, banking, as well as for practicing risk managers and insurers.

## Author Keywords

BRMS; Business rules; scoring; global rule flow; embedded rule flow; credits; bank client, intelligent system.

## ACM Classification Keywords

I.6.1 SIMULATION AND MODELING (e.g. Model Development).

## 1. INTRODUCTION

Popularity of lending facility is growing every day. Market is regularly appended with new products: credits for individuals (consumer, education, automobile credits, mortgage and credit cards), for small businesses, affiliate programs, and consists of great number of conditions/rules and ideas under each category. Startup of modern mass lending facility, which is rather quick and convenient for clients, is accompanied by a certain number of challenges, one of which is credit risk management problem, definition of assurance factor of borrowers, quick processing of credit applications and every day operational decisions, concerning credits.

The crisis in the banking sector has shown how quickly market conditions can change and, therefore, banks have to adjust their business policies, processes of lending facility, rules of decision-making concerning credits. For banks, this problem becomes relevant, and they start to reconsider their strategies in the field of information technologies and systems, to look for new approaches for quick response to external and internal changes. The use of business rule

approach will allow increasing transparency of decision-making logic, reducing labor intensity and changes cost.

## 2. LITERATURE REVIEW

From the late '80s, special attention was paid to the efficiency of business processes and development of data structure. In the early nineties, the failure of this approach became apparent. Describing the processes and data, researchers found out that there was another different field of knowledge, which was rather critical for understanding nature of the organizations - their business rules. Designed for business structure support, control and influence on the businesses behavior, business rules appear due to restrictions imposed on business.

Ron Ross [6,7], Barbara von Halle [1], then James Taylor [5], Tony Morgan [5] and other authors [2,3], popularized this approach. There were attempts to describe, collect, categorize business rules. They determined that this approach should include such parameters as terms, facts and conditions. There was the emphasis on the rules in business terms.

Nowadays, the notion of business rules is widely used; there are special groups of organizations, such as Business Rules Group (BRG) [6], Object Management Group (OMG) [7], which develop different standards for business rules. However, there is no single standard format for business rules, but there has been developed a number of related standards, such as: Semantics of Business Vocabulary [12] and Business Rules (SBVR) [12], Production Rule Representation (PDR) [6,7] etc.

However, the study of business rules, focused on the subject field, has been worked out rather scarcely in modern literature; especially it concerns banking sector, where business security, anonymity and privacy have high priority and unprecedented security level. In this article authors have attempted to use the model of business rules as part of scoring analysis of borrowers in order to determine their trustworthiness and solvency.

Existing scoring systems (such as Credit Scoring Solution, EGAR Application Scoring, dm-Score, Deductor, KXEN, Forecsys Scoring Pilot etc.) are hard to change within

already set up business process, meaning not enough flexibility for credit banking world with its rapid fluctuations and data sets change [1].

### 3. STATIC BUSINESS RULES

Static business rules can be formally expressed using atomic formulas, boolean connectives, first order quantifiers, alethic modalities  $\Box$  and  $\Diamond$ , and deontic modalities  $O$ ,  $F$  and  $P$ . Below is a standard definition of a formula of a full first order language with alethic and deontic modalities [4]:

$$\begin{aligned} \phi ::= & P^n(t_1, \dots, t_n) \mid t_1 = t_2 \mid \neg\phi \mid \phi \wedge \phi \mid \phi \vee \phi \mid \phi \rightarrow \phi \mid \\ & \exists x\phi \mid \forall x\phi \mid \Box\phi \mid \Diamond\phi \mid O\phi \mid P\phi \mid F\phi \end{aligned} \quad (1)$$

where  $P^n$  is an  $n$ -ary predicate symbol and  $t_1, \dots, t_n$  are terms (variables or constants),  $\neg$ ,  $\wedge$ ,  $\vee$ , and  $\rightarrow$  are classical boolean connectives (not, and, or, implies),  $\exists$  and  $\forall$  are existential and universal quantifiers. This part of the definition corresponds to full first order logic.  $\Box$  (referred to as necessity, or box modality) and  $\Diamond$  (referred to as a possibility, or diamond modality) are called alethic modalities. Intuitively,  $\Box\phi$  means that  $\phi$  is true in all states and  $\Diamond\phi$  means that  $\phi$  is true in at least one state.  $\Diamond\phi$  is definable as  $\neg\Box\neg\phi$ . Deontic modalities include  $O$  (it is obligatory that),  $P$  (it is permitted that) and  $F$  (it is forbidden that).  $P\phi$  is definable as  $\neg F\phi$  and  $F\phi$  is definable as  $O\neg\phi$ .

In addition to the ordinary existential quantifiers  $\exists x$ , we also adopt counting quantifiers  $\exists^n$ ,  $\exists^{0\dots n}(n \geq 1)$ ,  $\exists^{n..}$ , and  $\exists^{n\dots m}(n \geq 1, m \geq 2)$  which mean “there are exactly  $n$ ”, “there are at most  $n$ ”, “there are at least  $n$ ” and “there are at least  $n$  and at most  $m$ ” respectively. These counting quantifiers can be defined in terms of the standard quantifiers in a standard way.

To avoid the paradoxes of standard deontic logic (SDL) and use the same semantics as for the static alethic rules, we propose to define deontic modalities using alethic ones and a sentential constant  $V$  for ‘undesirable state-of affairs’. Intuitively,  $O\phi$  will be interpreted as saying that all states of the knowledge base satisfying  $\neg\phi$  are ‘forbidden’, or satisfy  $V$ :

$$\begin{aligned} O\phi &=_{def} \Box(\neg\phi \rightarrow V) \\ F\phi &=_{def} O\neg\phi = \Box(\phi \rightarrow V) \\ P\phi &=_{def} \neg F\phi = \Diamond(\phi \wedge \neg V) \end{aligned} \quad (2)$$

### 4. METHODOLOGY OF BUSINESS RULES APPROACH

Use of automated decisions based on business rules (business rules management systems - BRMS) will allow banks to make their operations and decisions more transparent in logic terms, to respond to changes in the external and internal environment more dynamically, to reduce time for applications approval for commercial

lending facility, will also allow managing scorecards more mobile, etc.

In order to respond quickly to any changes, increasing of flexibility and transparency of decision-making logic, the use of business rules technology can become rather effective.

Examples of banking organizations, which have turned their attention to BRMS of different manufacturers, are:

1. Bank of America (USA), Deutsche Bank (Germany), Bank One (USA), Natixis Financement (France), Barclays Bank (England) – Ilog JRules;
2. Bank (England), The Royal Bank of Scotland (Scotland) – Corticon BRMS;
3. Sony Bank (Japan) – FICO;
4. Volkswagen Bank (Germany), KfW (Germany) – Visual Rules.

It proves that use of BRMS in solving operational banking issues can solve problems mentioned above due to the automation of the repetitive operational decisions in the sphere, which is optimized for business logic management and perspectives of the use of business rules technology in order to provide necessary system flexibility and quick response to changing environmental conditions. Business process of lending facility consists of great number of operational decisions and business rules. The degree of this process automation influences the efficiency of the entire credit organization work, speed and service quality for client's requests, as well as quality of credit decisions made. Therefore, one of the key objectives is fast processing of credit applications and decision-making, concerning credit disbursement, but at the same time, it is necessary to evaluate credit worthiness, solvency, credit risks on applications etc.

Assessment of potential borrowers can include data verification of the borrower, scoring assessment and evaluation of the borrower's financial position [8]. One of the popular methods of risk assessment concerning credit applications, related to the borrowers and their credit applications, used in scorecards process, which rules are set of answers and questions to potential borrower (about age, education, income, property, etc.). Credit score is one of the stages of data assessment of the borrower. The integrated assessment of these parameters, as well as analysis of credit status are carried out by banks, based on the developed trustworthiness assessment system of their clients.

Bank representatives in assessing the trustworthiness of an individual compare, how the requested credit amount corresponds to the personal income of the borrower, as well as they carry out the overall assessment of the financial position of the borrower [9]. The process of decision-making concerning the credit application can allow the

interference of credit inspector or it can be completely automated. The main objective of the activities of the lending facility department of individuals is to perform such functions as: accepting the applications for the lending facility, applicant assessment, determination of the parameters of the credit extension, considering the issue concerning the credit extension, preparing credit documents and monitoring execution of borrower's obligations of interest payment and principal payments. These functions can be automated partially using business rules technology.

Due to the analysis of business rules basic sources, there have been specified the following rules of lending facility processes and activities of the bank credit department, which are described in Table 1.

Formalized rule	Source, type
<b>IF</b> borrower.credithist = true <b>THEN</b> set status = «reject», set description = «reason: borrower has unpaid credit»	Static, credit policy
<b>IF</b> borrower.gender_id = 1 <b>AND</b> borrower.age <18 <b>THEN</b> set status = «reject», set description = «reason: age < 18» <b>IF</b> borrower. gender_id = 1 <b>AND</b> borrower.age >60 <b>THEN</b> set status = «reject», description = «reason: age > 60»	Static, credit policy
<b>IF</b> borrower.expir > 12 <b>THEN</b> set status = «reject», set description = «reason: experience < 1 year»	Static, credit policy
<b>IF</b> (20100 < borrower. income < 26000) <b>THEN</b> inc_score = 56	Static, scoring
<b>IF</b> total_score > 621 <b>THEN</b> set status = «approve», set description = «risk - min» <b>IF</b> 480 < total_score < 620 <b>THEN</b> set status = «person - processing», set description = «risk - normal» <b>IF</b> total_score < 480 <b>THEN</b> set status = «reject», set description = «risk - high»	Static, policy advice
<b>IF</b> Application.cred_id = 1 <b>AND</b> Application.curr = «rub» <b>AND</b> (3 < Application.time < 12) <b>THEN</b> set interest = 17.1	Static, interest policy
<b>IF</b> Application.cred_id = 1 <b>AND</b> Application.curr = «dol» <b>AND</b> Application. sum*27.9 > Lim <b>THEN</b> set decision = «get involved the second guarantor» <b>IF</b> Application.cred_id = 1 <b>AND</b> Application.curr = «dol» <b>AND</b> Application. sum *27.9 < Lim <b>THEN</b> set «give the full amount of the credit»	Static, regulation of lending facility

**Table 1.** Rules of the lending facility processes and activities of the bank credit department

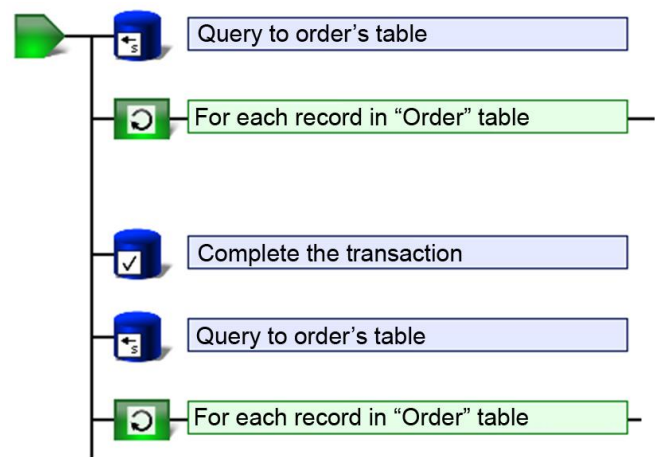
Due to the analysis of bank instructions concerning the lending facility of the borrowers, there have been developed

several dozens of rules, mentioned above, although in real system, we can speak about several thousand [10]. Further stage of the business rules concept implementation requires entering of developed rules into selected system, i.e. creation of a business rules model.

## 5. MODELING OF BUSINESS RULES

### 5.1. Graphical representation of business rules

Business rules have been implemented in the environment of Visual Rules Modeler™ [12]. The main flows of rules describing decision-making logic are the following trees and tables of decisions, shown in figure 1, presented as a part of the global flow of rules. The flow of the rules is presented in the context of the work of database and according to the described stages of the credit application review and decision-making concerning the credit disbursement.

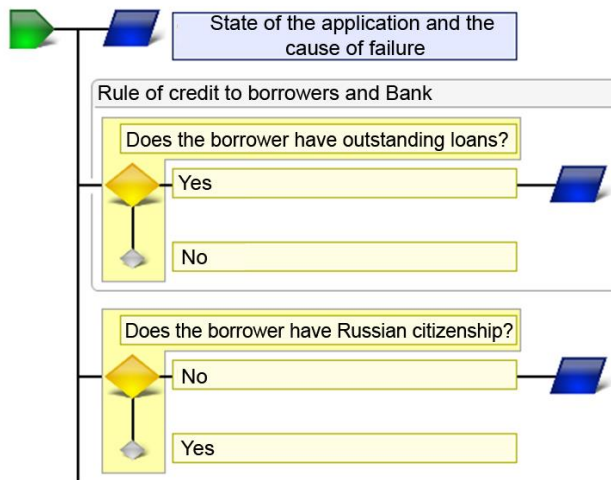


**Figure 1.** Main (global) rule flow.

It shows the whole set of business rules like a tree, as well as the rules interaction with the database during the credit application processing and the decision-making concerning the credit disbursement. Let us consider the work of rules in details.

According to scenario, the first step is to check the borrower according to the general requirements. On this stage, there are the following checks, which are shown in figure 2 as a flow of rules “General requirements for the borrower”.

The objective of this step is to implement the first level of assessment within the overall process of analysis and automation of business decisions. If the set of rules is performed, then the processing continues. During the first stage, there is the analysis of the borrower's data according to the stop factors, for example, such as the excess of the age range, the absence of permanent registration or the presence of the credit debt. As according to the flow of rules, it leads to an automatic refusal to accept application for processing and explanation of the reasons for refusal. The results of the application are saved in database.



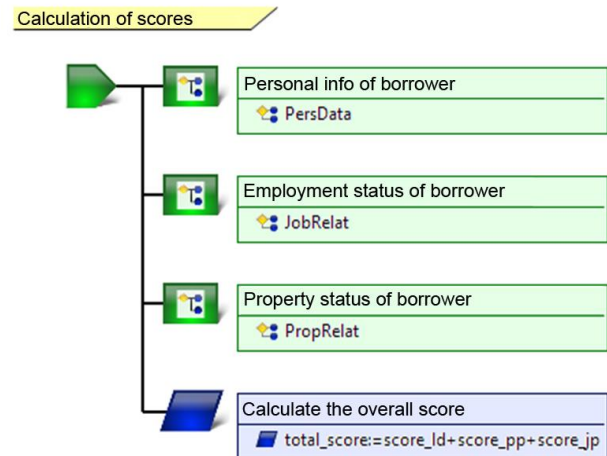
**Figure 2.** Rules flow “General requirements for the borrower”.

The objective of this step is to implement the first level of assessment within the overall process of analysis and automation of business decisions. If the set of rules is performed, then the processing continues. During the first stage, there is the analysis of the borrower's data according to the stop factors, for example, such as the excess of the age range, the absence of permanent registration or the presence of the credit debt. As according to the flow of rules, it leads to an automatic refusal to accept the application for processing and explanation of the reasons for refusal. The results of the application are saved in the database.

The presented set of compliance rules with general requirements for the borrower consists of the following tests: the presence of Russian citizenship, permanent residence, the borrower's age is not under 18 years and not more than 55 for women and 60 for men, work experience at least one year at the last workplace and the borrower cannot belong to the categories of students and unemployed. In the case of employment, he is to have the size of net income of not less than  $x$  \$, and the information about the relations between the borrower and the bank in the case of outstanding loans.

During the second stage, there is the analysis of the borrowers, who have passed the first stage, and there is an ordinary scoring of the borrowers, i.e. their rating in accordance with the scorecard, as it allows segmenting the borrowers according to the risk rate, identifying reliable and unreliable ones and therefore making a decision to accept (reject) or transfer to manual processing this application. As the in-depth analysis of scoring is beyond the theme of this article, it is expected to obtain the scoring results from the external predictive models, analytical tools and policy advice concerning the lending facility.

This stage involves the assessment of lending facility risk and determination of whether the risk is acceptable and whether it is necessary to continue the processing automatically or transfer it to manual processing. This step includes thorough analysis of the borrower according to three logical directions, shown in figure 3 as a flow of rules “Scoring”.



**Figure 3.** Rules flow “Scoring”.

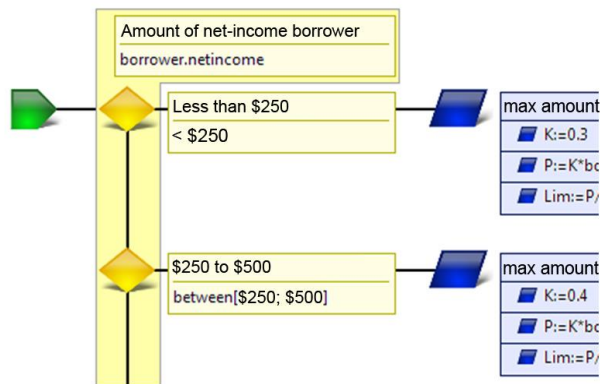
This personal data, among which such indicators as age, number of children, education, marital status; property status, amount of the average monthly income or the car; and official position, including the average monthly income, work experience, qualification, sphere of activity.

The final analysis includes the implementation of the general rule to all the scoring elements. The flow rules of “Scoring” shows the set of rules concerning the summation of scores according to the sub flows of rules in order to determine the borrower's rating.

The third stage of the analysis includes the determination of the maximum possible credit amount for the borrower [11]. It is calculated according to the interest rate assigned during the previous stage, the amount of net income, solvency ratios and the term, specified in the application (figure 4).

Decision tree “Calculation of the maximum credit amount, depending on the net income” shows the set of rules for determination of the size of the maximum credit amount. There is set the solvency ratio for each category of borrowers and the solvency is calculated depending on the amount of net income and credit term. Then, the maximum credit amount is determined in the form of solvency ratio to the rate and the ratio of interest rate multiplied by term and  $12 \cdot 100$ .

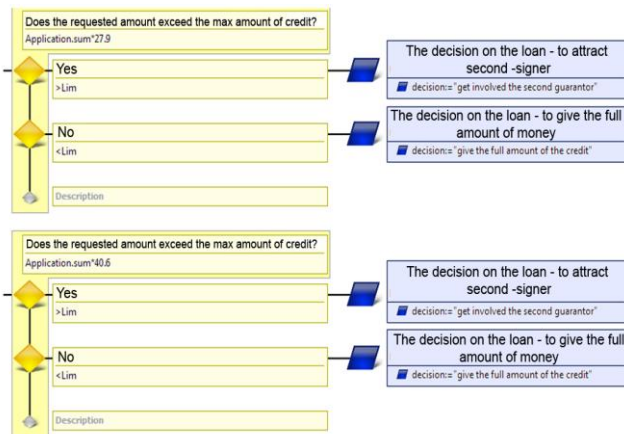




**Figure 4.** Set of rules flows “Calculation of the maximum credit amount for the borrower”.

Depending on the credit type and the requested amount (in the case of application in foreign currency, the amount is converted into rubles), there should be determined whether the requested amount accesses the lending facility limit, and then the final decision is made.

A fragment of flow of rules “Decision-making concerning the credit” is shown in figure 5.



**Figure 5.** Rules flow “Decision-making concerning the credit disbursement”.

The decision concerning a particular application is of advisory nature for a credit officer and there can be the following wordings: “Give the full amount of credit”, “Attract the second guarantor”, “Exceeding the maximum possible credit amount” etc.

The flow of rules “Decision-making concerning the credit disbursement” shows the set of decision-making rules for credit application, depending on the type of credit product and compliance of the requested credit amount with the borrower's financial possibilities. Decision-making concerning the credit disbursement is the final stage of credit application review, when the credit officer gets the recommendations for decision-making concerning the credit disbursement.

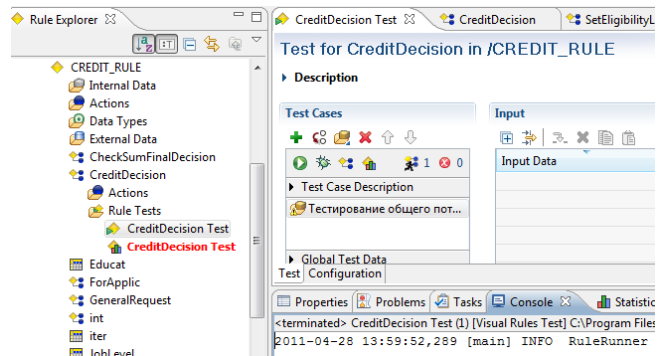
The scenario ends with the conferment of a variable decision with one of the values (true/false - 1/0), and credit data processing according to scenario is considered as completed.

## 5.2. Testing of the scoring model

For experimental testing, there have been developed several dozens of records with data of conventional borrowers and their credit applications.

Testing means that the developed rules are applied to the database records and there is the check of presence or absence of errors in the rules. The developed rules are applied to the borrower's data and there is the check of the conditions specified in the rules. In the case of incorrectly entered data or errors in the rules themselves, the project will not be completed and the console will display the information about errors.

Then, it is necessary to run the scenario. As it is shown in figure 6, the project has been made without errors and the scenario is successfully launched.



**Figure 6.** Scenario of rules implementation - testing.

In the tab “Statistic”, you can see a list of selected flows of rules without errors.

When testing is complete, the rules have to be written into the repository. It performed by Visual Rules Administrator.

During the experimental testing after the model launch, the program turns to the database and checks the implementation of conditions of the existing records in the database in relation to the model rules. In this case, you get the statistics concerning the quantity and percentage ratio of processed records, which meet the conditions of the specific rule.

In order to enter the data, there has been also used the component MySQLWorkBench. During the development of the records, there have been the attempts to reflect the different age groups, income groups, number of children.

This check is implemented for all the rules and all database records. The fact that there is specified the quantity and percentage ratio of records, which have responded to the condition, also allows checking the correctness of the rules and the database records.

During the processing of rules and database records, there can be entered a number of data related to the intermediate check steps such as status and description. Further, these results are used by other rules for the final decision-making. The result is the decision concerning the credit disbursement, which is stored in the database decision, as shown in Figure 7. Data about the made decisions are displayed as “approved”.

apl_id	id	crei	sum	time	curr	score	status	description
20	20	1	300000	12	rub	NULL	reject	reason: experience < 1year
21	21	2	230000	54	dol	NULL	reject	reason: borrower has unpa
22	22	1	20000	10	dol	NULL	reject	reason: income <15000
23	23	1	700000	33	rub	687	approve	risk - min
24	24	2	100000	24	rub	467	reject	risk-high
25	25	1	22000	54	eur	579	person - processing	risk - normal
26	26	1	100000	33	rub	804	approve	risk - min
27	27	2	700000	23	rub	355	reject	risk-high
28	28	1	35000	44	eur	777	approve	risk - min
29	29	1	100000	13	rub	626	approve	risk - min
30	30	2	80000	10	rub	NULL	reject	reason: age>60
31	31	1	9000	6	eur	756	approve	risk - min

**Figure 7.** Part of the test of flow of rules “Decision concerning the credit disbursement”.

Thus, scenario testing of implementation of business rules has required the installation, deployment and commissioning of interaction of MySQL (related components) and Visual Rules Modeler. The developed database has presented a limited number of records about the borrowers with different characteristics and different credit applications, which has allowed testing all the branches of the decision tree model. There has been implemented the testing of the developed rules and checking the entry into the database the result of intermediate testing as well as the final decision concerning the credit disbursement.

## 6. CONCLUSION

The use of BRMS in relation to banking sector will enable credit organizations, according to the authors' mind, to minimize their risks of non-repayment of credits, including the possibility of quick search of correct operational decision in the case of uncertain situations, thereby increasing the efficiency of credit application and generally increasing customer satisfaction with the bank work. The business rules concept is a dynamic developing sphere of IT, logic and mathematics, involving the applied case studies, which in the future, enables to get a set of ready templates of rules used by ad hoc.

Authors are planning to publish set of articles to clarify business rules concept in verity arias, such as telecom, insurance etc. The area of BRMS is innovative and practically useful all over the spheres.

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