Стохастические графовые модели для управления рисками

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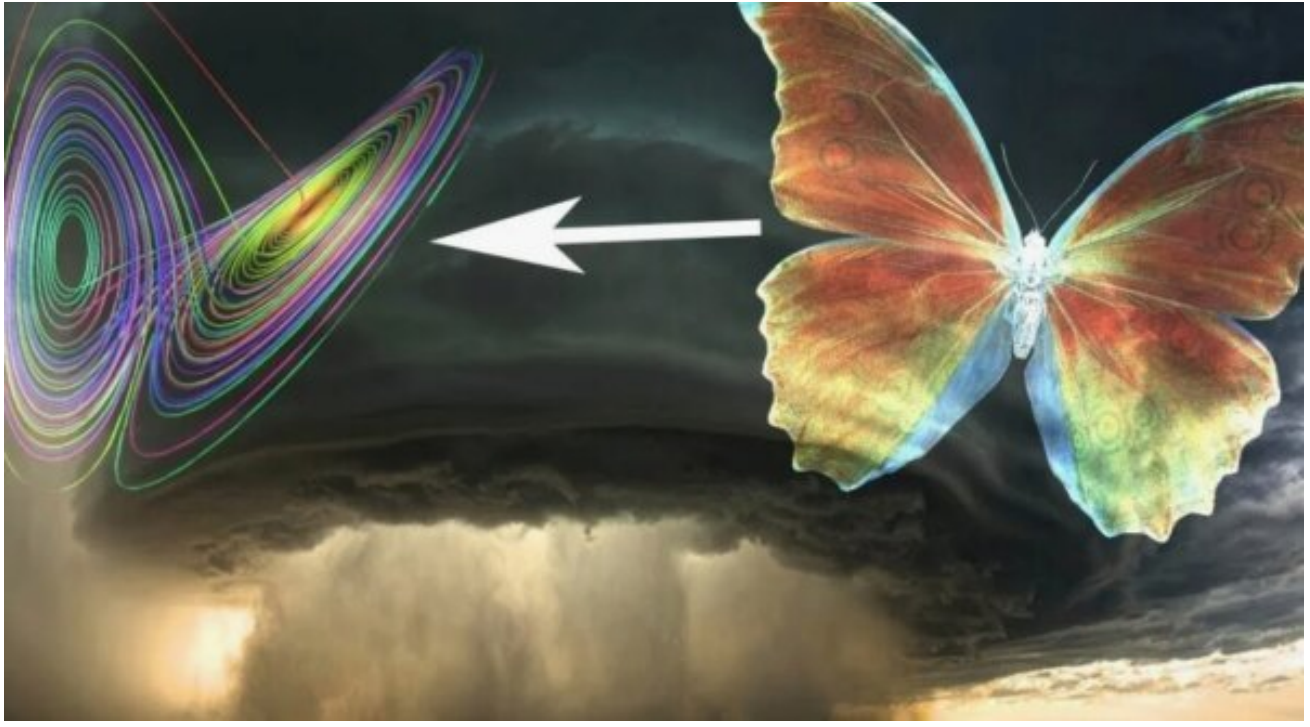
Тезисы выступления

- Риски – вероятностные величины, их анализ и управление требует количественного подхода на основе стохастических моделей
- Графовые модели – мощный и интуитивный инструмент для стохастического моделирования
- Графовые модели это **унифицирующий подход** к **количественному** анализу рисков (ГОСТ Р ИСО 31000)

Взаимосвязанность событий в глобальном быстро меняющемся мире



Ошибки в управлении рисками отнимают миллиарды

Популярные подходы

- **Реестры рисков**
- Риск матрицы
- Анализ Галстук-Бабочка

	A	B	C	D	E	F	G	H	I	J	K
1	LEVEL 2 - RISK REGISTER				Project Name:	Broken-Down Bridge		DIST- EA	13-12345	Project Manager	
2	Risk Identification							Risk Assessme			
3	Status	ID #	Type	Category	Title	Risk Statement	Current status/assumptions	Probability	Cost Impact	Cost Score	Time Impact
4	Active	1	Threat	Environmental	Access for studies	As a result of property owners denying access to the State and/or their consultants for the purpose of completing environmental or engineering studies, delays finalizing the DED and FED may occur which would lead to increased support costs and schedule delays.	Additional studies are needed for the next stage of this project which will require access to properties. PTEs will need to be requested.	3-Moderate	4 -Moderate	12	8 -High
5	Active	2	Threat	Environmental	Environmental constraints	As a result of unexpected environmental constraints that impact bridge construction, an increase in the number of working days may occur which would lead to an increase in construction support costs, increased construction capital costs, and delay construction contract acceptance.	The PDT to initiate early consultation with resource agencies in an effort to determine all feasible environmental constraints early in the process and to develop a realistic project schedule.	3-Moderate	4 -Moderate	12	8 -High
6	Active	3	Threat	Environmental	Public Opposition	As a result of public opposition to project alternatives that propose to replace the existing bridge, a significant number of comments following circulation of the DED and/or permit appeals prior to RTL may occur which would lead to increased support costs and schedule delays.	PDT to initiate public outreach with the community in an effort to gain broad support for preferred alternative.	4-High	4 -Moderate	16	4 -Moderate
7	Active	4	Opportunity	Environmental	Avoid Environmental Resources	There is an opportunity to adjust the project footprint to avoid resources. Wetland impacts are currently close to the acreage required for an Individual Permit from the USACE. Reducing these impacts would allow the project to obtain a NWP.	Current assumption is that design can be adjusted in order to reduce wetland impacts.	4-High	1 -Very Low	4	8 -High
8	Active	5	Threat	Environmental	Challenge to EIR	As a result of legal challenges to elements of the environmental document, it may become necessary to revise and recirculate the EIR which may delay PA&ED, permit submittals and R/W acquisition delaying RTL milestone.	There are currently no lawsuits pending for this project.	3-Moderate	4 -Moderate	12	4 -Moderate
9	Active	6	Threat	Design	Supplemental EIR	As a result of design changes that are outside of what was addressed in the Environmental Document, a supplemental EIR may be required which would lead to a delay for public comment period, delay in meeting the PA&ED milestone, increased support cost, delay R/W acquisition, RWC, and RTL milestones.	A rigorous alternatives analysis will be performed to accurately determine temporary and permanent impacts from full range of project alternatives under consideration. The geotechnical investigation and preliminary geotechnical design report is expected to be completed in the PA&ED phase which should serve to minimize design changes during the PS&E phase.	2-Low	2 -Low	4	2 -Low
10	Active	7	Threat	Environmental	Coastal Permits	As a result of the project falling within the State and Local coastal jurisdictions, coastal development permits are required, and a delay in application for and/or receipt of permits or appeals may occur, which would lead to a delay in the project and possible project changes to comply with permit conditions.	Environmental impacts from current alternatives under consideration cannot be determined until completion of preliminary studies. A consolidated permit is anticipated for the project.	4-High	4 -Moderate	16	8 -High

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- **Риск матрицы**
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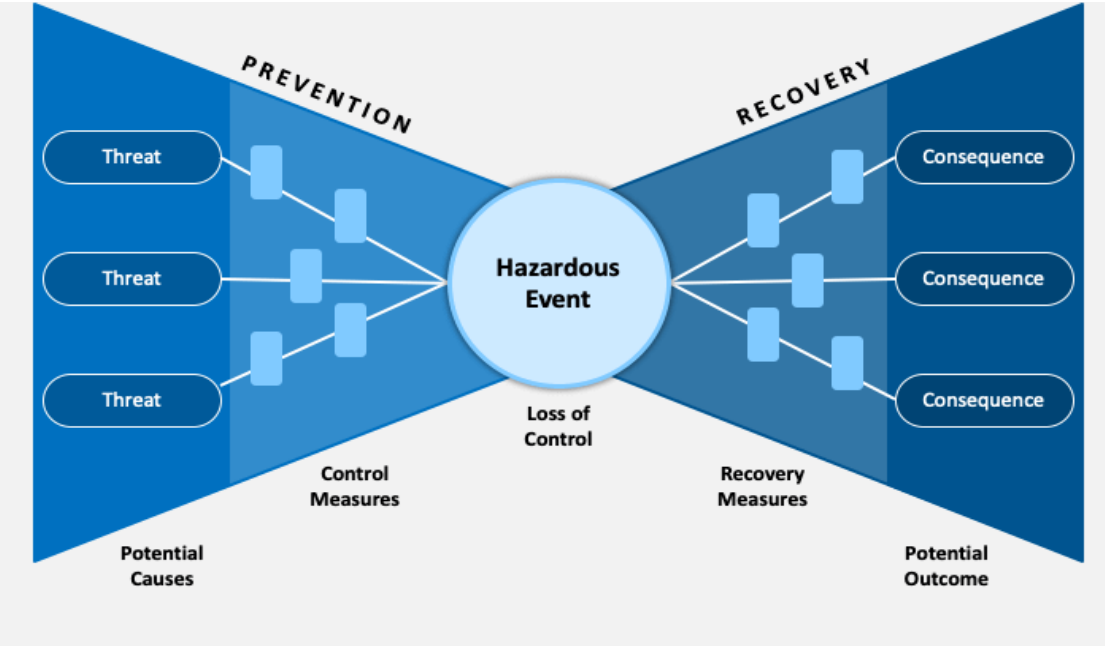


Популярные подходы

- Качественные/семи-количественные а **не количественные** оценки
- **Оценки** вероятностей или размера ущерба **не изменяются** при новой информации
- Не учитывают **взаимосвязей** между рисками
- Частные (ad-hoc) методы

Вместе: Система реактивна и не проактивна

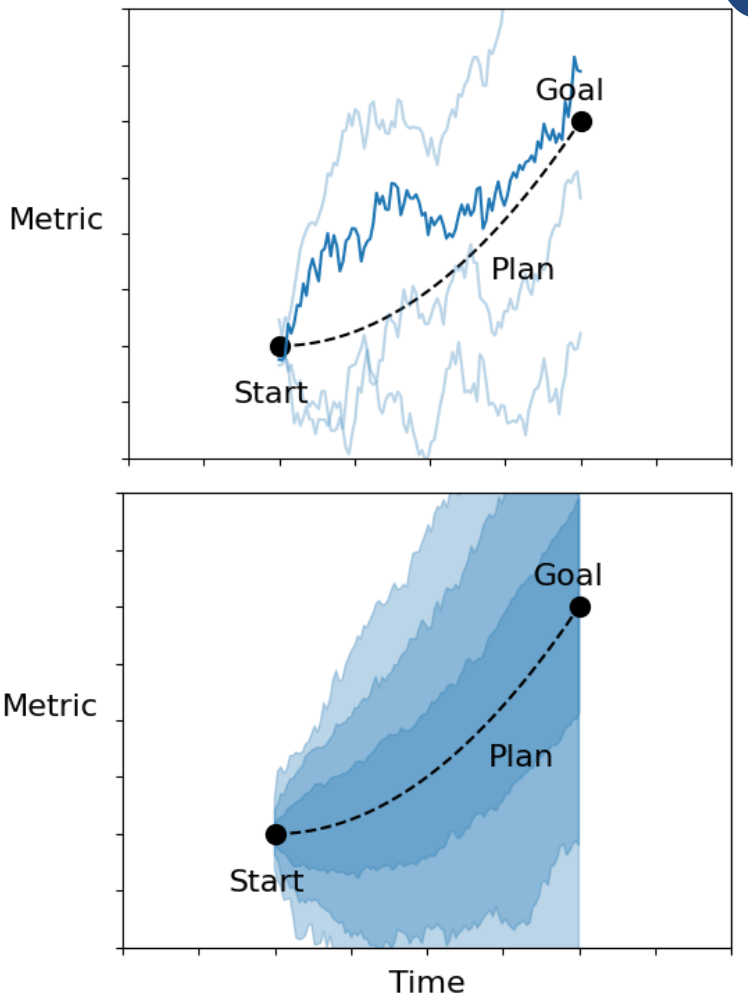
Серия ИСО 31000

Риск: влияние неопределенности на цели
(risk: effect of uncertainty on objectives)

- Последствия могут быть как отрицательным, так и положительным

- Источники риска
- Потенциальные события
- Последствия

Все это имеет **вероятностный характер**

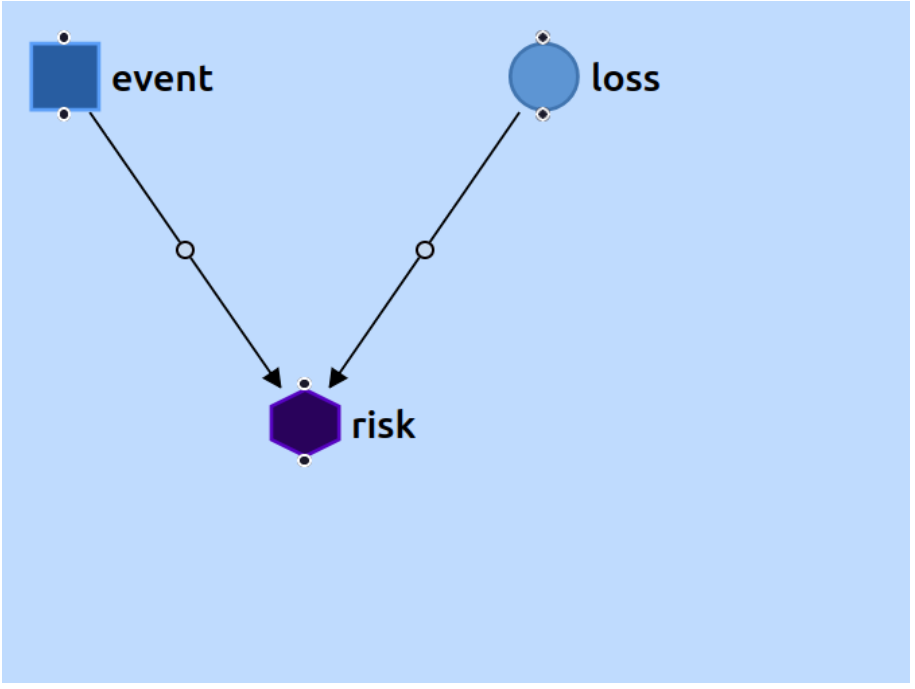


Байсовский подход к анализу рисков

- **Теорема Байеса** - как адаптировать оценки на основе прошлой информации и новых данных.

$$P(B|A) = \frac{P(A|B) \times P(B)}{P(A)}$$

- Заложена в **Стохастическую Графовую Модель** в основе **MBayes**



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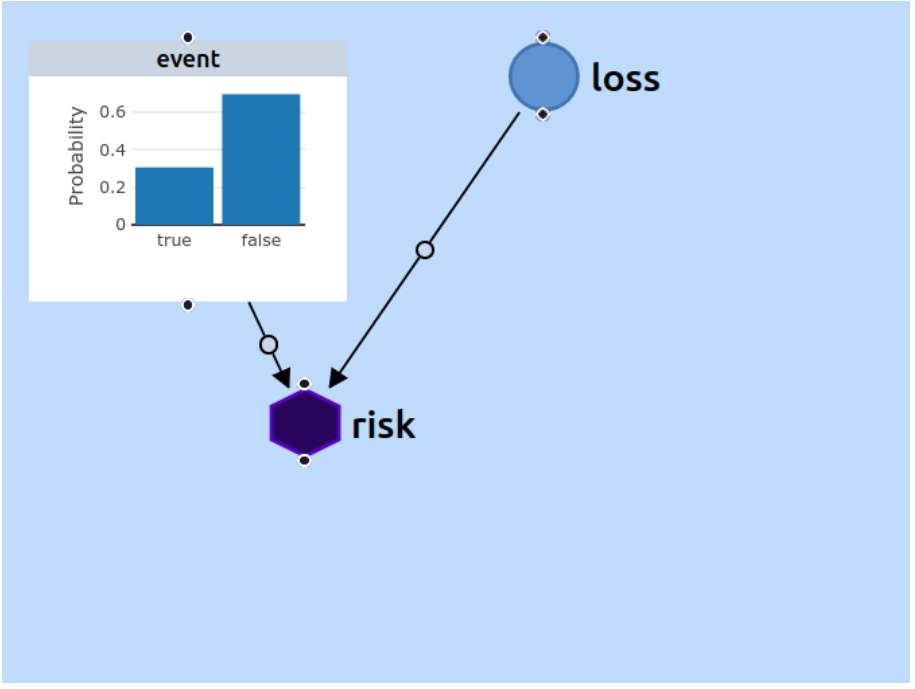

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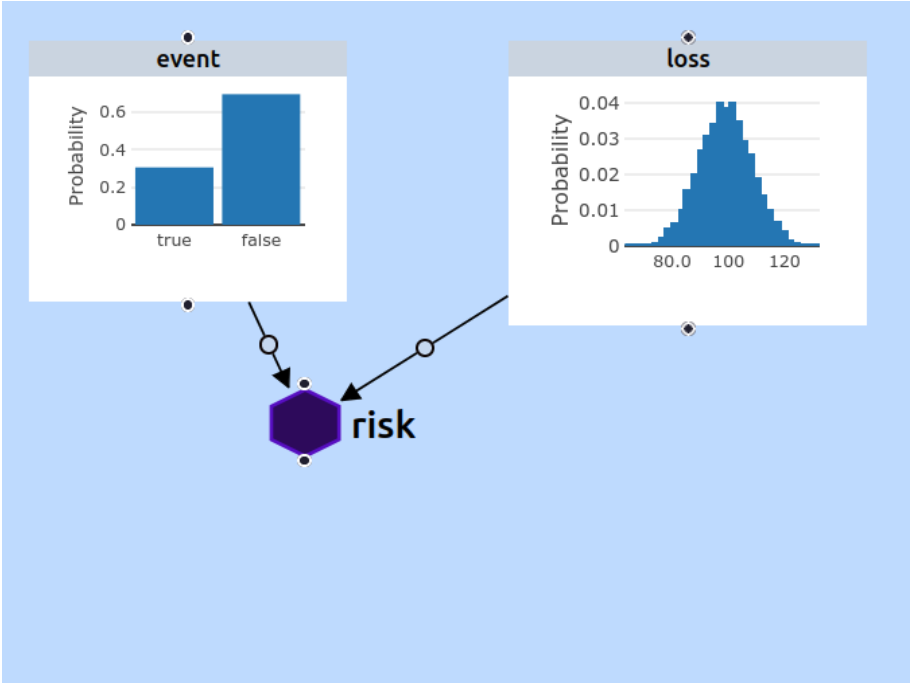

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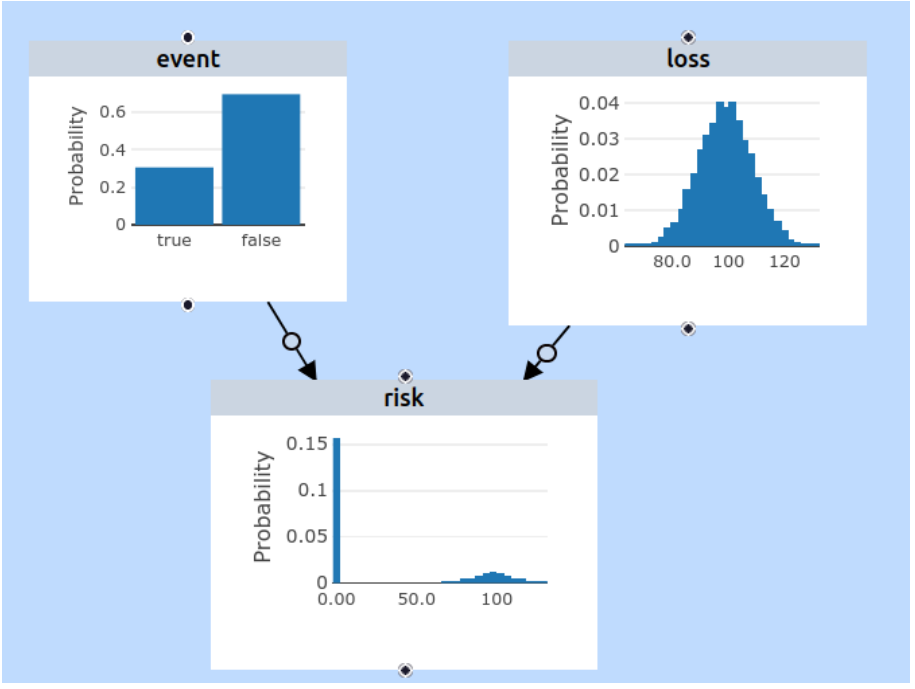

ИСО 31010 (2019) – Методы оценки рисков

B.1 Eliciting view from stakeholders and experts
- Brainstorming
- Delphi technique
- Nominal group technique
- Structure/semi-structured interviews
- Surveys

B.2 Identification of risks
- Checklists/classifications/taxonomies
- Failure models & effects analysis (FMEA,FMECA)
- Hazard and operability (HAZOP)
- Scenario Analysis

B.3 Determing sources, causes and drivers of risk
- Cindynic approach
- Ishikawa analysis

B.4 Analyse existing controls
- Bow tie analysis
- Hazard analysis (HACCP)
- Layers of protection (LOPA)

B.5 Understanding impact and likelihood
- Bayesian analysis, Bayesian networks
- Business impact analysis
- Cause-consequence analysis
- Event-tree & Fault tree analysis
- Human reliability analysis
- Markov Analysis
- Monte Carlo simulation

B.6 Analysing dependencies and interactions
- Causal mapping
- Cross impact analysis

B.7 Providing measures of risk
- Toxicological risk assessmenta
- Value at risk (VaR)
- Conditional value at risk (CVar)

B.8 Evaluating the significance of risk
- ALARP & SFAIRP
- Frequency diagrams
- Pareto charts
- Reliability centered maintenance (RCM)
- Risk indices

B.9 Selecting between options
- Cost/benefit analysis
- Decision tree analysis
- Game theory
- Multi-criteria analysis

B.10 Recording and reporting
- Risk registers
- Risk matrix
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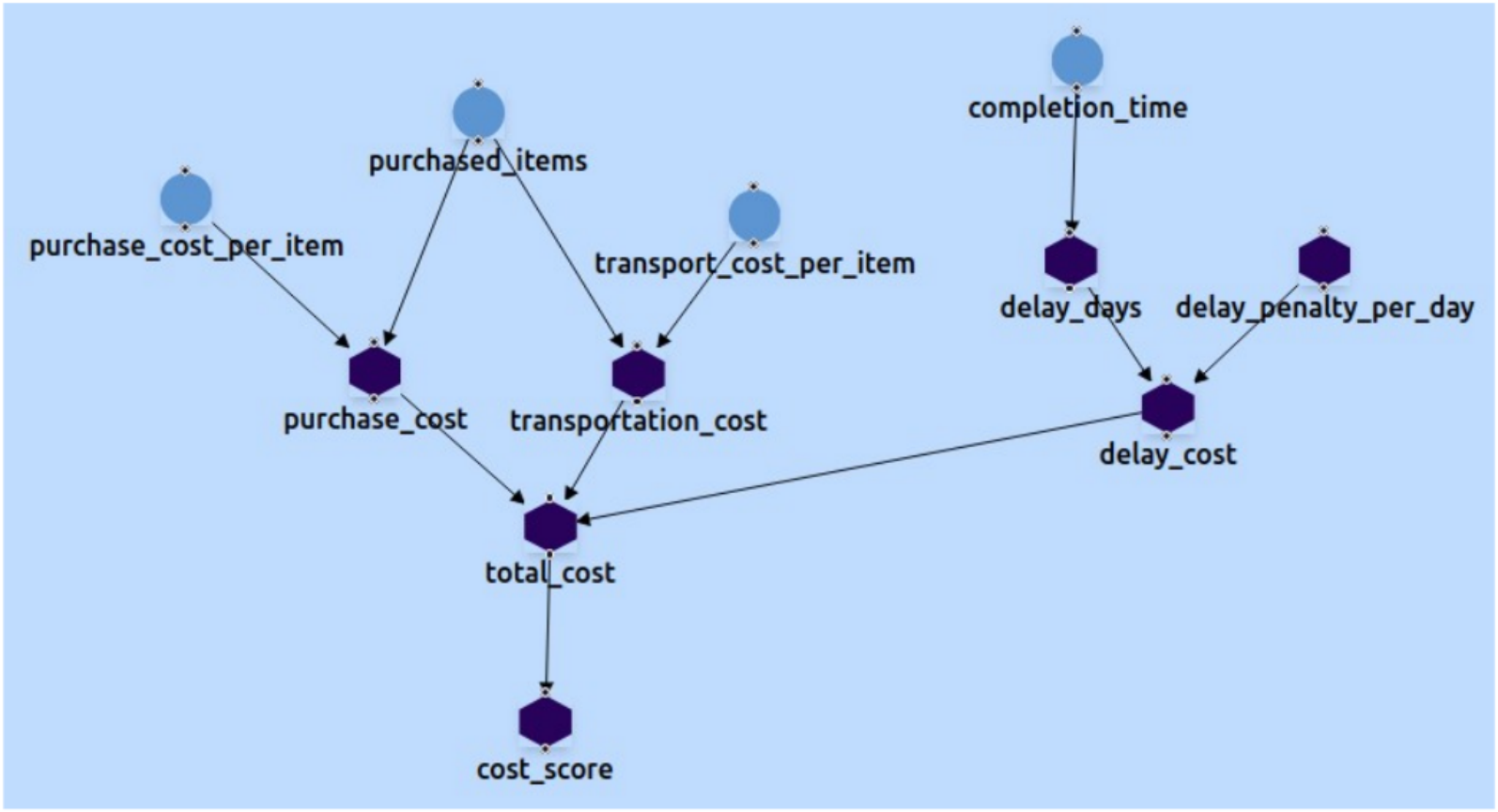
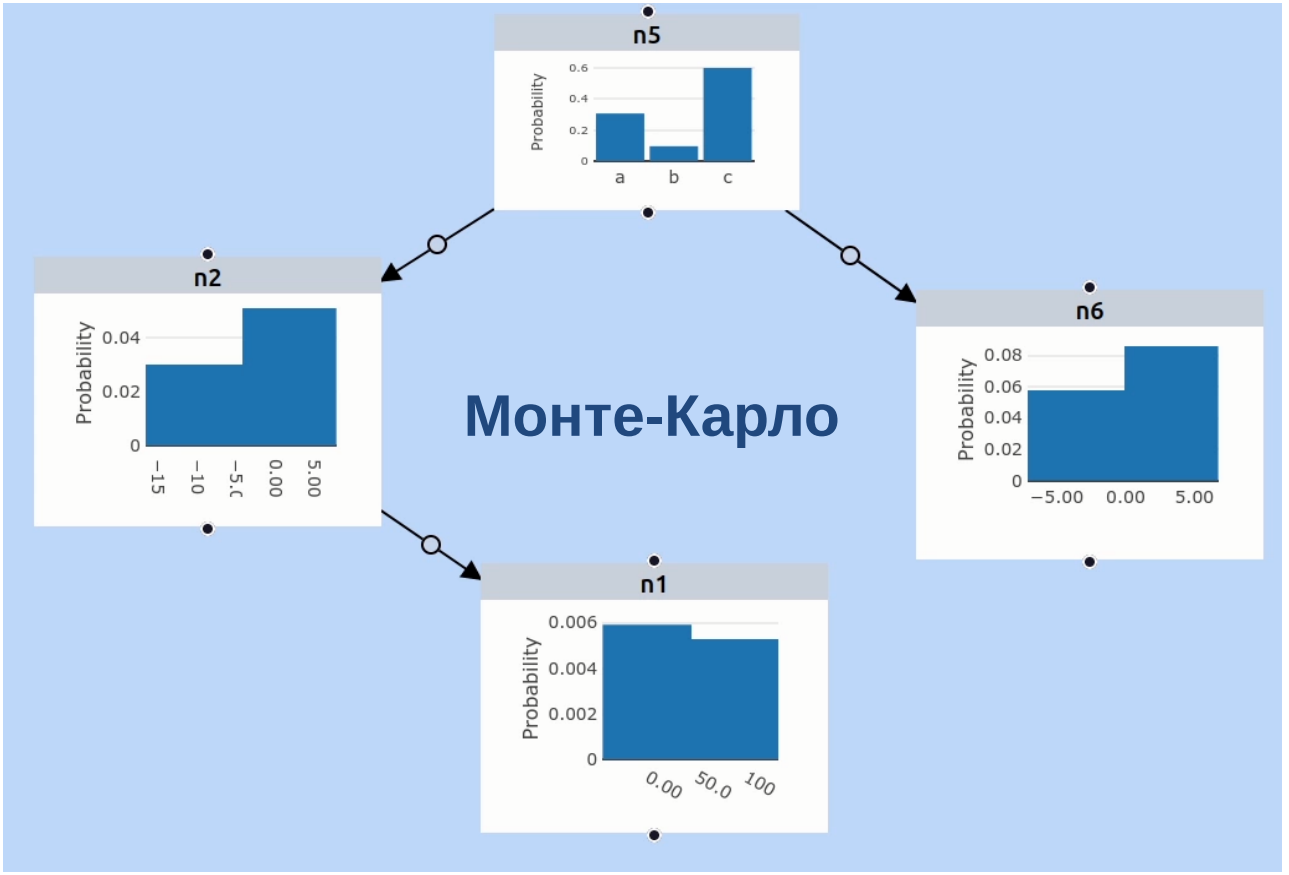
Модели могут быть многоуровневые



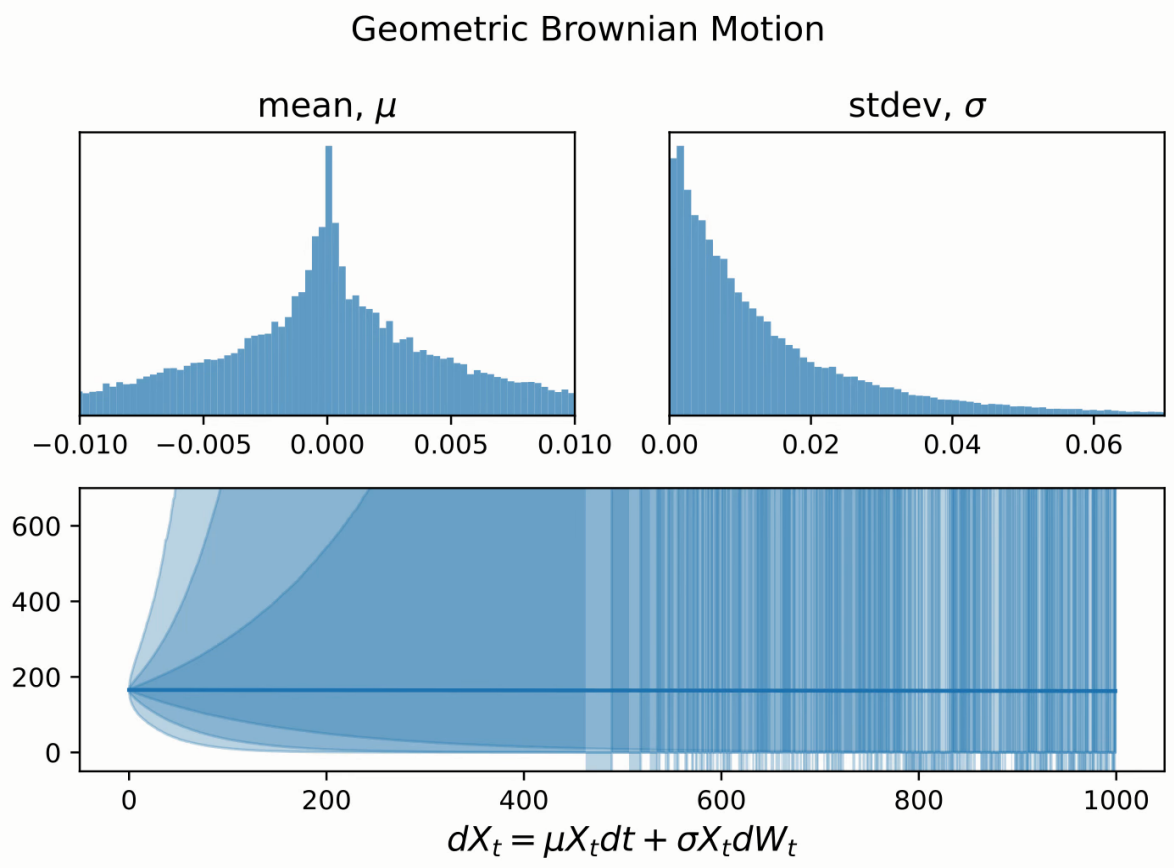
Можно запускать различные алгоритмы



Сложно ли создавать такие модели? - Нет

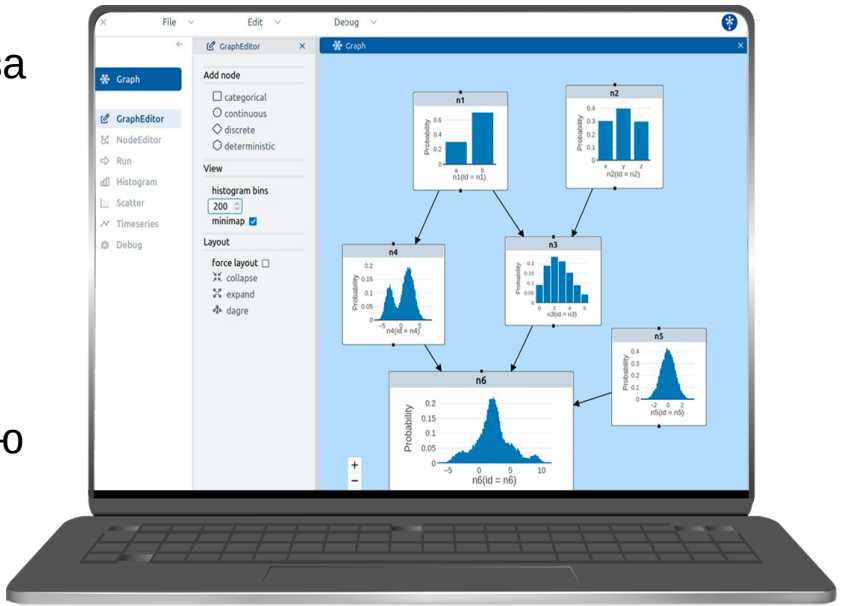
Видео пример работы системы

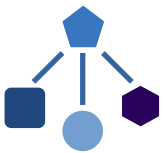
Динамическая адаптация прогнозов



MBayes

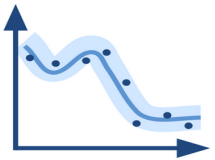
- **Цель:** Упрощение применения стохастического моделирования и Байесовских методов для анализа рисков
- Позволяет пользователю **сфокусироватся на моделировании** а не реализациий алгоритмов
  - Сокращает количества ошибок в коде и ускоряет разработку прикладных моделей
  - Упрощает обслуживание моделей и их адаптацию под новые условия эксплуатации



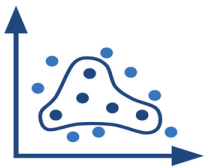


Low Code редактор моделей

Библиотеки графовых алгоритмов



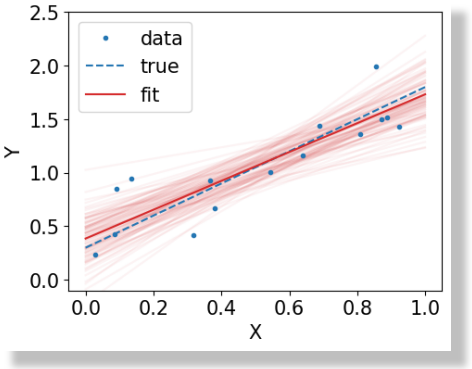
Библиотеки обучения моделей на данных



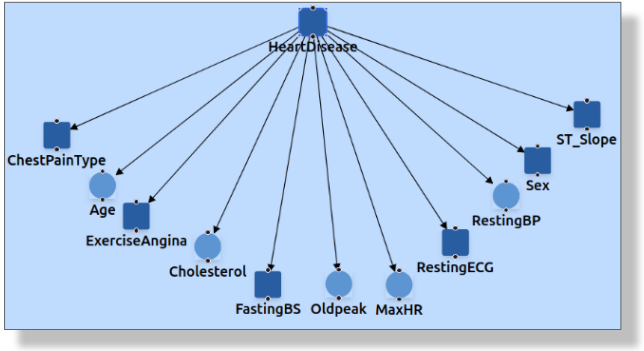
Вычислительные движки

Другие примеры моделей

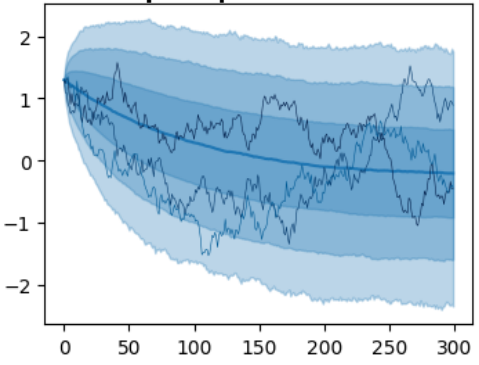
Регрессионные модели



Анализ медицинских рисков и системы диагностики

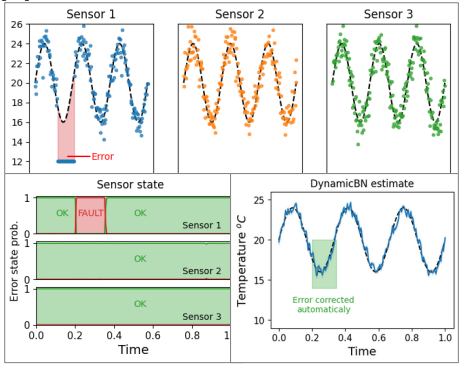


Стохастические модели процессов



BM, GBM, Mean reversion etc.

Интеграция сенсорных данных и диагностика поломок



Спасибо за внимание!

Вопросы?

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