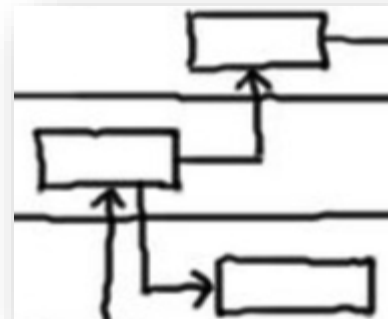


# KALASIM

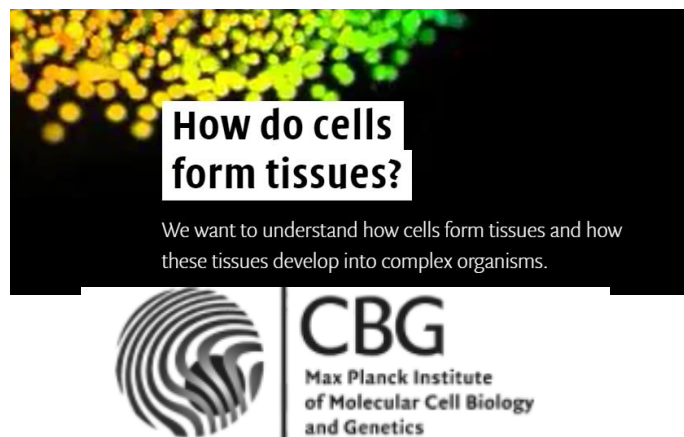
## DISCRETE EVENT SIMULATOR



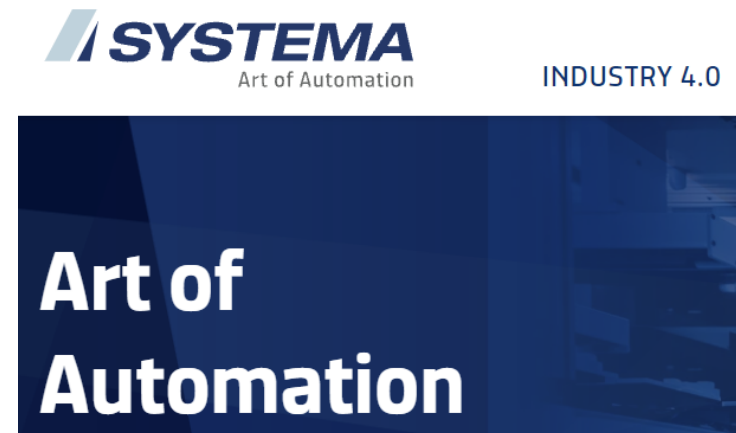
# ABOUT ME



2010



2015



2020



kscript

krangl

kravis

kalasim



INDUSTRY 4.0

COMPANY

INDUSTRIES

CAREER



Digital Transformation

Smart Manufacturing

SYSTEMA Portfolio

SAP Portfolio

Resources

Integration

Automation

Optimization

Visualization

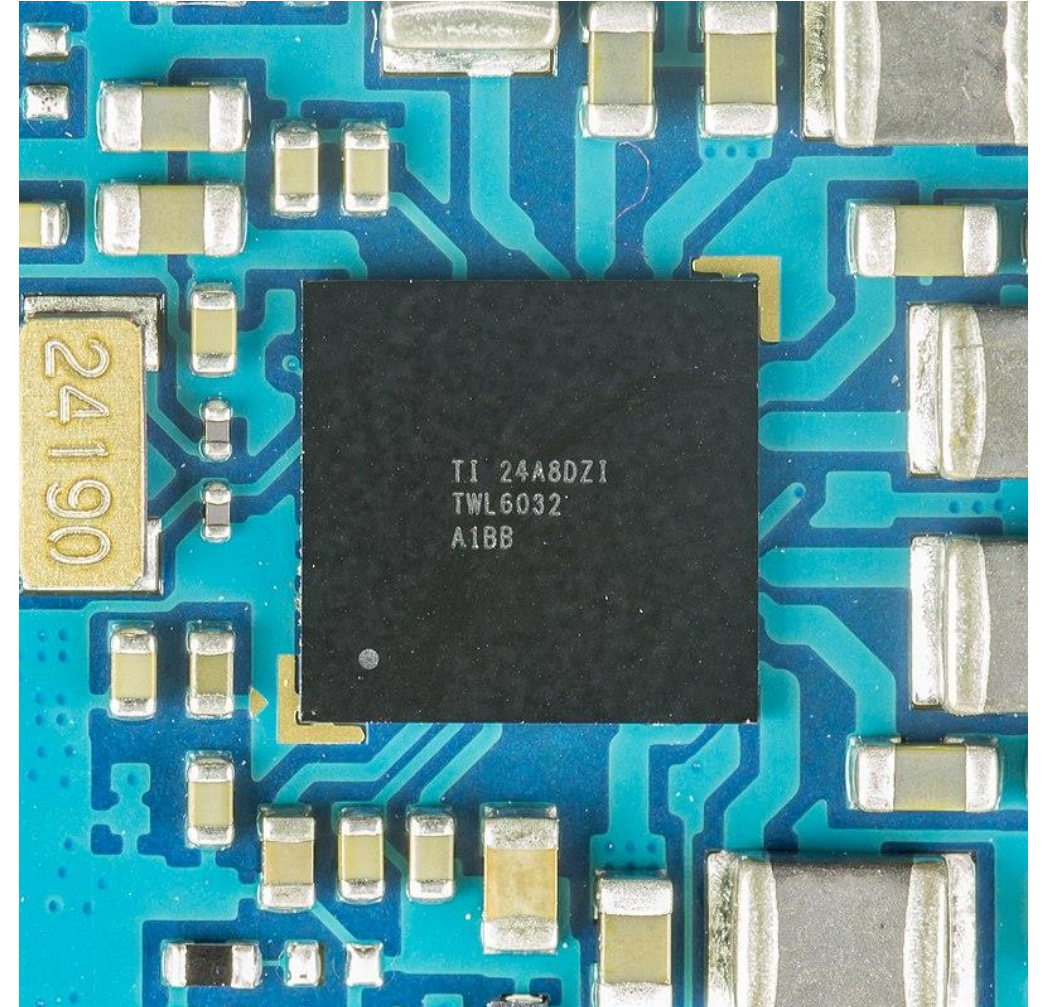
Migration



Optimization is the art of maximizing manufacturing efficiency, throughput, OEE, yield, and quality by monitoring, analyzing, and iteratively tuning manufacturing processes.

# EXAMPLE: SEMICONDUCTOR PRODUCTION

- Cycle Time: ~ 6 Months
- > 1000 Steps
- Product routes reiterate processes to add more layers on top of raw silicon wafer
- 30 floor “sky” scraper built with nanometer precision



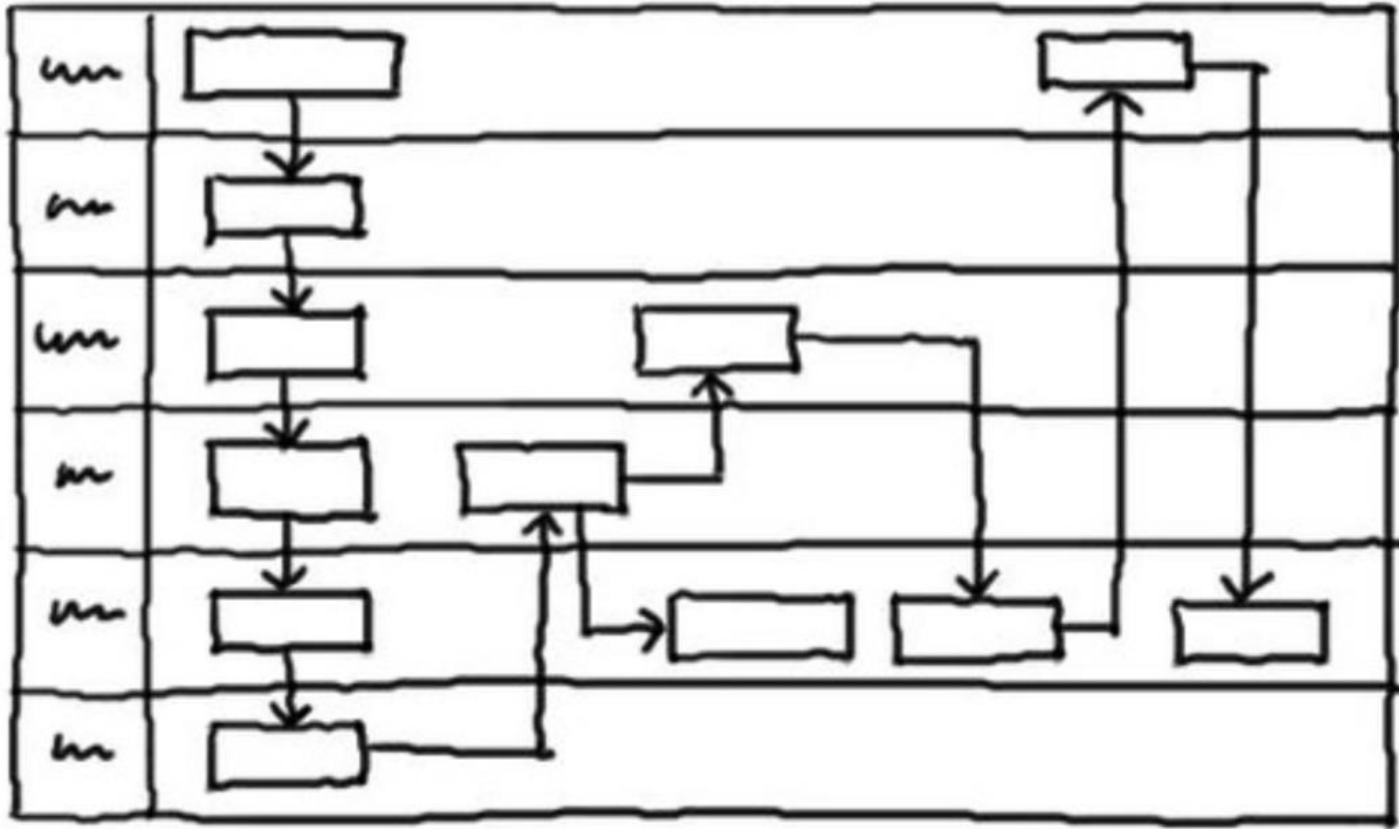




HOW TO MAKE MORE MONEY?

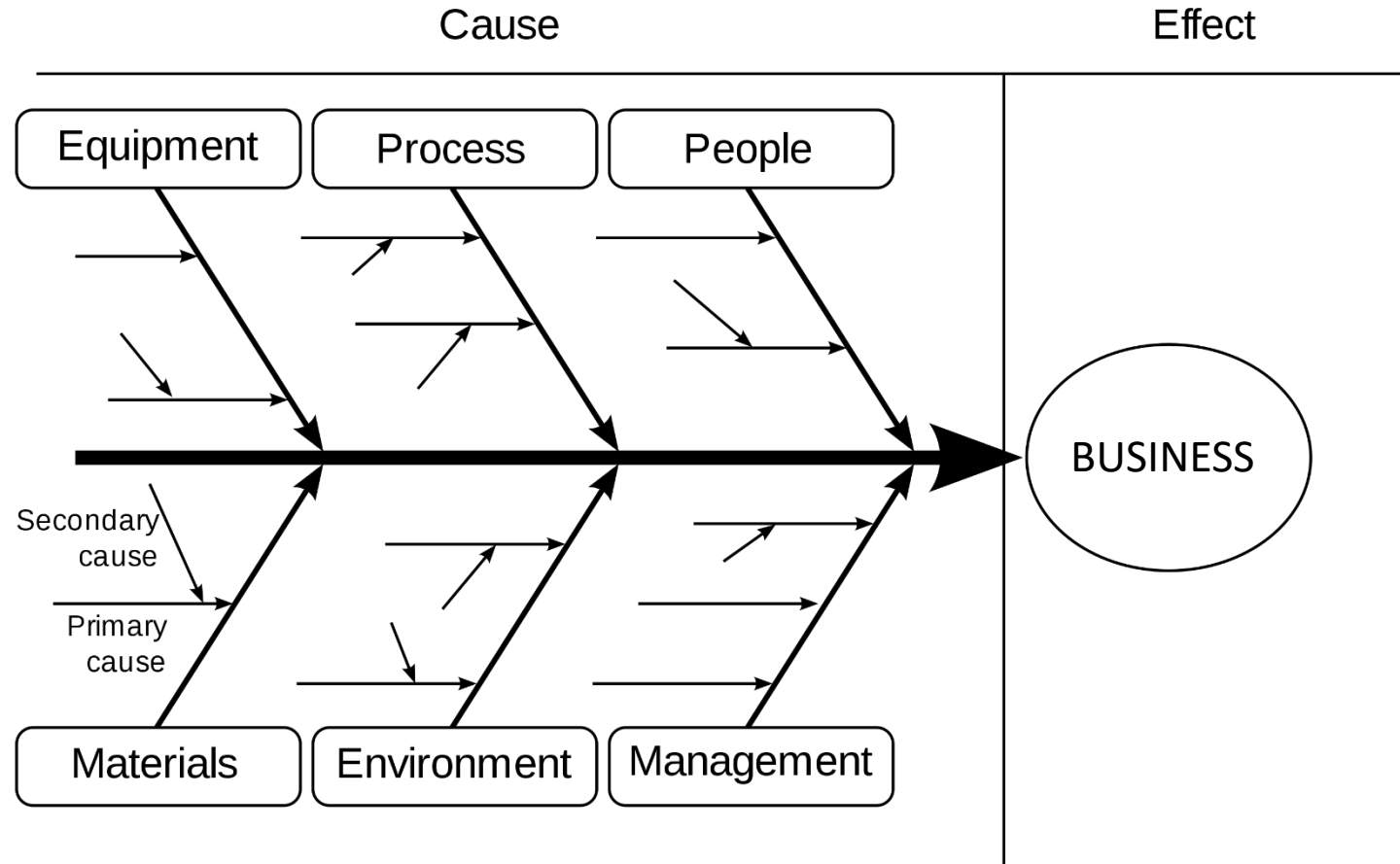


# MODEL THE BUSINESS PROCESS!



# NICE, BUT WHERE IS THE BOTTLENECK?

# CAUSE AND CONSEQUENCE

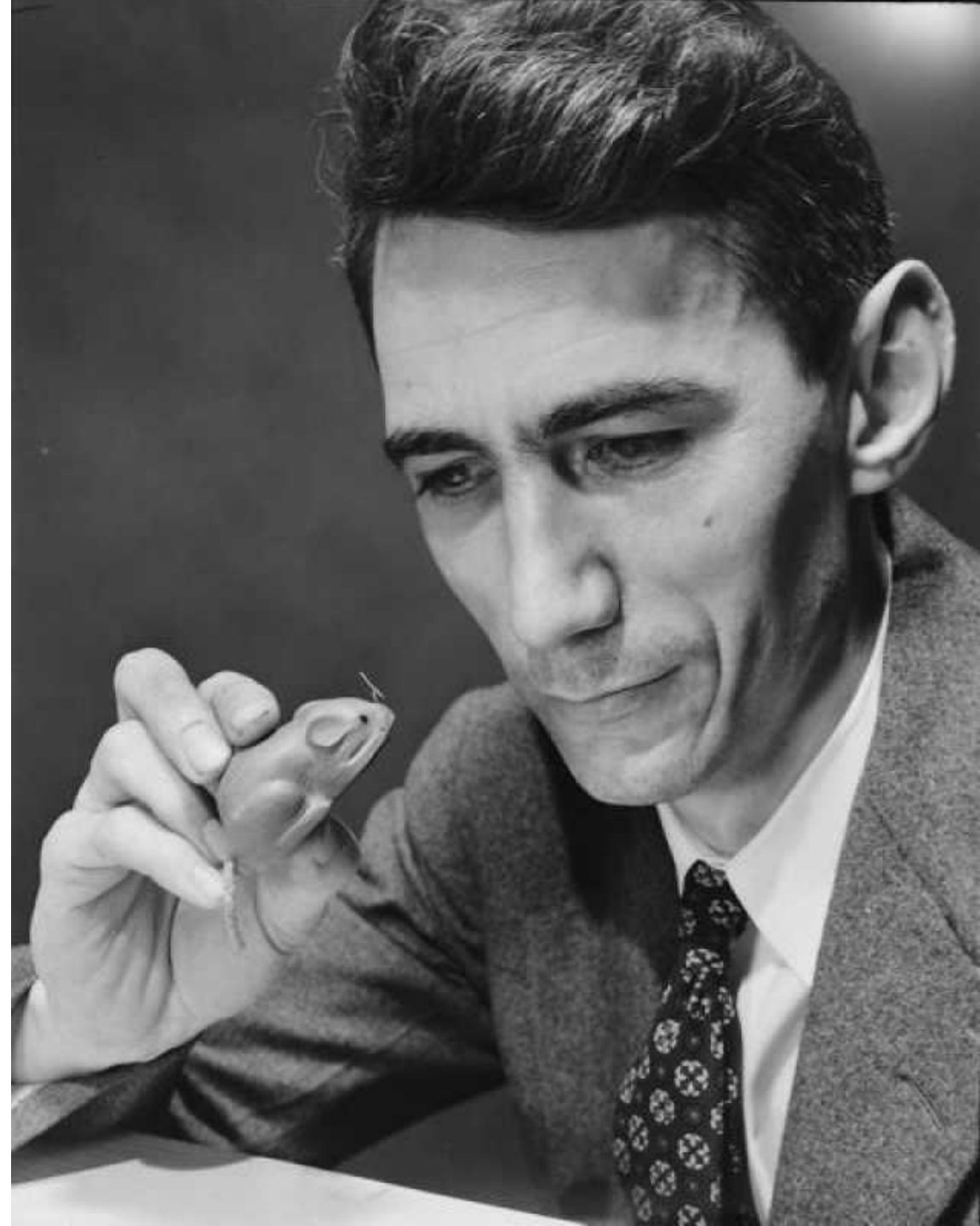


- Complex interplay of human, machine, material and methods
- Not always following intuition
- Applies to all businesses from service industry to manufacturing

# WHAT IS SIMULATION?

A simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or a set of criteria) for the operation of the system.

Claude Shannon (1975)





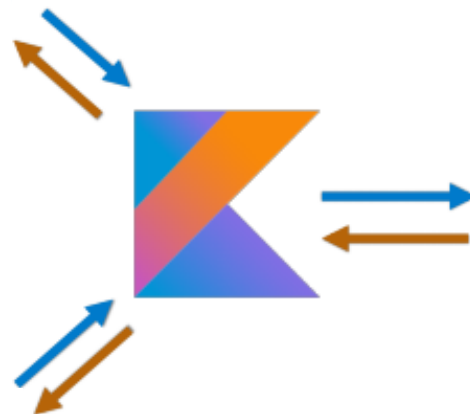
# WHY ANOTHER DISCRETE SIMULATION ENGINE?

- Simmer, Salabim, SimJulia, SimPy, DSOL, ...
- Low-code commercial tooling such as AnyLogic or SIMIO

**One language, One Codebase, One Platform**

Process Specialist

Data Scientist



Software Engineer

# Welcome to kalasim



## Table of contents

[Core Features](#)[First Example](#)[How to contribute?](#)[Support](#)

release v0.7.95  build passing  kotlinlang slack kalasim  discuss kalasim

kalasim is a [discrete event simulator](#). It provides a statically typed API, dependency injection, modern persistence, structured logging and automation capabilities.

kalasim is designed for simulation practitioners, process analysts and industrial engineers, who need to go beyond the limitations of existing simulation tools to model and optimize their business-critical use-cases.

In contrast to many other simulation tools, kalasim is neither low-code nor no-code. It is *code-first* to enable change tracking, scaling, refactoring, CI/CD, unit-tests, and the rest of the gang that makes simulation development fun.



[Pull requests](#) [Issues](#) [Marketplace](#) [Explore](#)[holgerbrandl / kalasim](#) Public[Unpin](#)[Unwatch](#) 1[Fork](#) 5[Starred](#) 21[Code](#) [Issues](#) 13 [Pull requests](#) [Discussions](#) [Actions](#) [Projects](#) [Security](#) [Insights](#) [Settings](#)

master

4 branches 31 tags

[Go to file](#)[Add file](#)[Code](#)

## About



### Discrete Event Simulator

[data-science](#) [simulation](#) [optimization](#)  
[agent-based-modeling](#) [process-modeling](#)  
[visulization](#) [discrete-event-simulation](#)[Readme](#)[MIT License](#)

21 stars

1 watching

5 forks

### Releases

 29[v0.7.95](#) Latest  
yesterday[+ 28 releases](#)**holgerbrandl** Continued call-center article

✓ e505375 23 hours ago 673 commits

📁 .github/workflows	Improved documentation	12 months ago
📁 .idea/codeStyles	Fixed #27: More informative resource events	17 days ago
📁 docs	Continued call-center article	23 hours ago
📁 gradle/wrapper	Matched letsplot display support API as much as possible	2 months ago
📁 modules	Continued elevator animation	yesterday
📁 simulations	Fixed naming	6 days ago
📁 src	Continued call-center article	23 hours ago
📄 .gitattributes	override github language stats	17 days ago
📄 .gitignore	share codestyle in repo	last month
📄 CHANGES.md	Improved documentation	12 months ago

# CORE FEATURES

`kalasim` is a generic process-oriented discrete event simulation engine

- Simulation entities have a generative **process description** that defines the interplay with other entities
- There is a well-defined rich process **interaction vocabulary**
- An **event trigger queue** maintains future action triggers and acts as sole driver to progress simulation state
- Built-in **monitoring and statistics** gathering across the entire API



# FIRST EXAMPLE

## Key Types

- Component
- Resource
- State

## Used Interaction Methods

- `request()` – Ask (and wait) for resource
- `hold()` – Suspend execution
- `wait()` – Wait for specific state

```
////Cars.kts
import org.kalasim.*

class Driver : Resource()
class TrafficLight : State<String>("red")

class Car : Component() {

    val trafficLight = get<TrafficLight>()
    val driver = get<Driver>()

    override fun process() = sequence {
        request(driver) {
            hold(1.0, description = "driving")

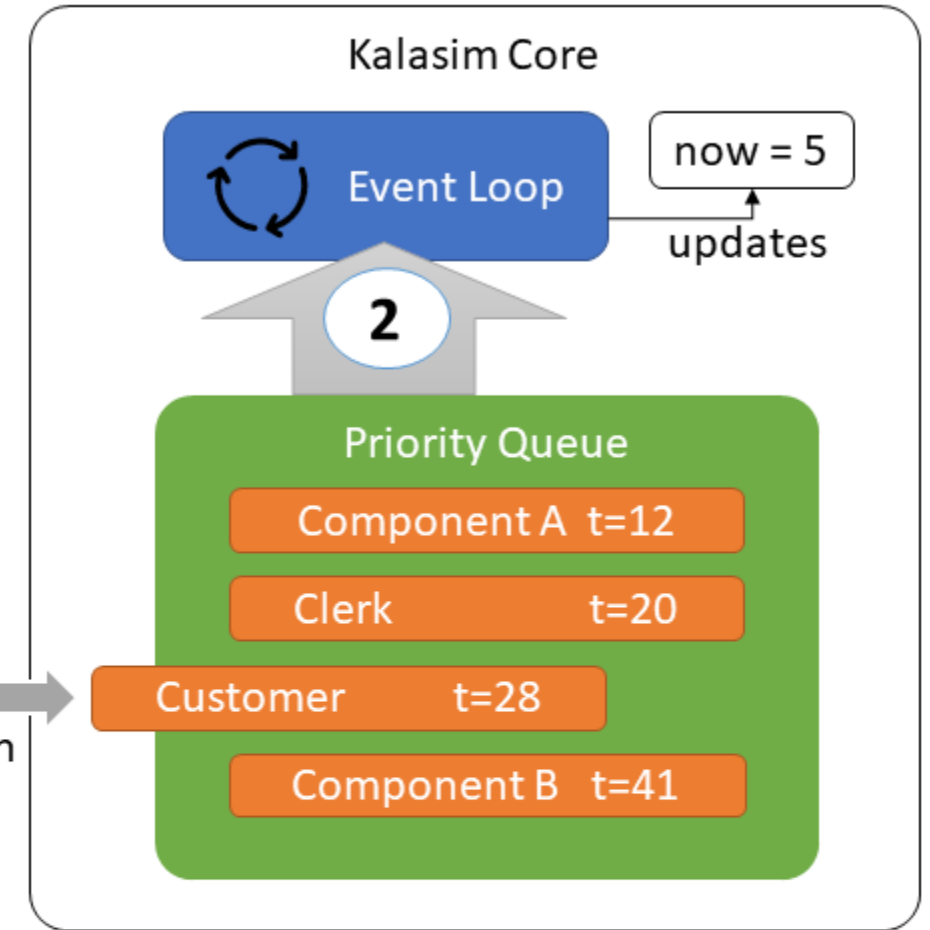
            wait(trafficLight, "green")
        }
    }
}

createSimulation(enableConsoleLogger = true) {
    dependency { TrafficLight() }
    dependency { Driver() }

    Car()
}.run(5.0)
```

# EVENT LOOP ARCHITECTURE

```
class Customer(val clerk: Resource) : Component() {  
    override fun process() : Sequence<Component> = sequence {  
        // do shopping  
        hold(ticks = 23.0)  
        // wait for an empty counter  
        request(clerk)  
        // billing process  
        hold(ticks = 2.0, priority = HIGH)  
    }  
}
```



1

Stall customer's process execution and insert it into event queue by time (and optional priority to resolve ambiguities)

2

Poll, while queue is not empty and resume (or start) process

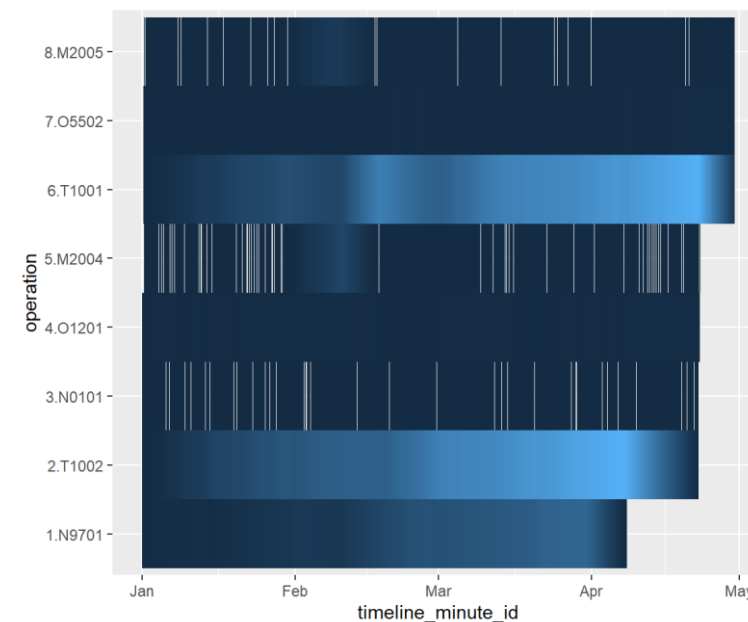
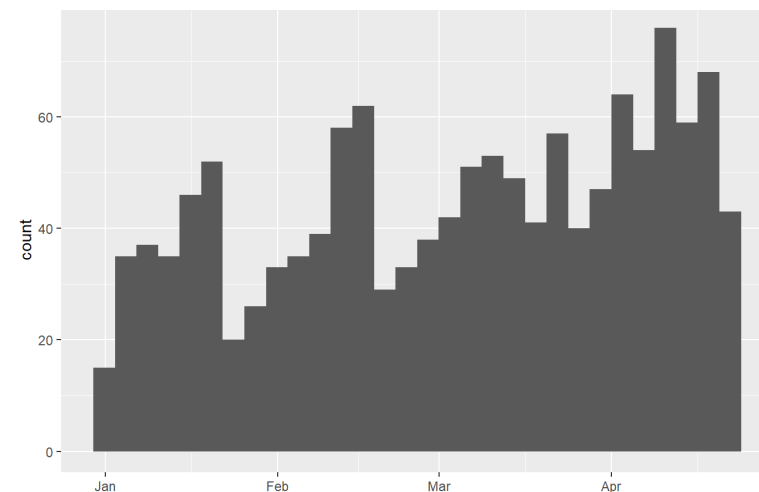
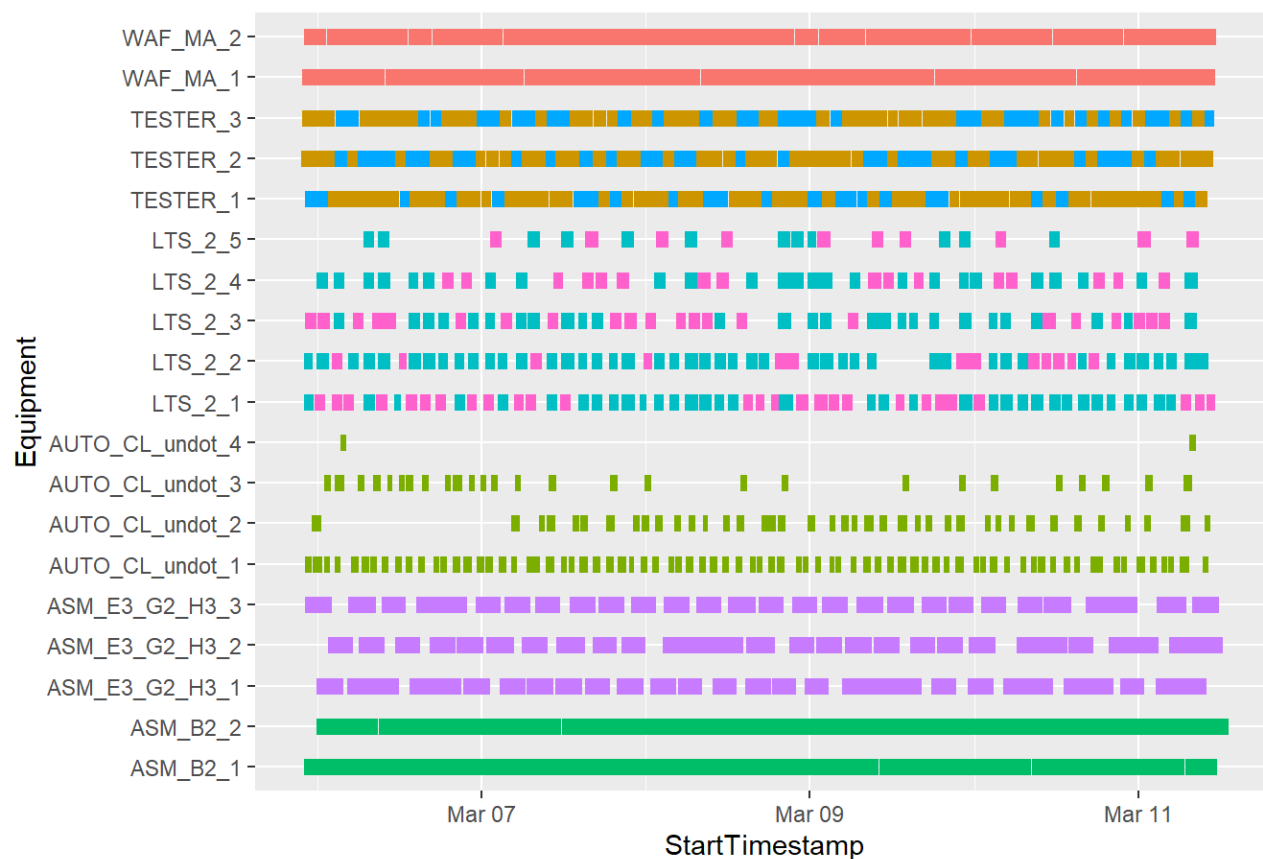
3

Event loop will continue execution here. Components are terminated once process end has been reached



# CAN WE MODEL AN ENTIRE FACTORY WITH `kalasim`?

- Yes, we can!
- Can we study its dynamics? Sure.
- Can we discuss it here? Nope.



# LUNAR MINING PROCESS

Mining robots scan the surface of the moon for depletable water ice deposits. It is a complex business process, and the lives of thirsty astronauts are at stake.

Base	
m approveSearchCoordinates(GridPosition)	Boolean
m reportScanCompleted(GridPosition)	Unit
m consumeWater()	Sequence<Component>
m registerDeposit(Deposit)	Unit
m requestAssignment(Harvester)	Deposit?
p knownDeposits	List<Deposit>
p refinery	DepletableResource
p position	GridPosition
p scanHistory	Map<GridPosition, TickTime>
p waterConsumption	ExponentialDistribution

DepositMap	
m restrictToMap(GridPosition)	GridPosition
p deposits	List<Deposit>
p depletionRatio	Double
p gridDimension	Dimension

Harvester	
m searching()	Sequence<Component>
m harvesting()	Sequence<Component>
m unload()	Sequence<Component>
p currentState	HarvesterState
p currentDeposit	Deposit?
p state	State<HarvesterState>
p tank	DepletableResource
p gridPosition	GridPosition

Deposit	
p gridPosition	GridPosition
p miningShaft	Resource

LunarMining	
p harvesters	List<Harvester>
p map	DepositMap
p base	Base

```
fun unload() = sequence {
    moveTo(base.position)

    val unloadingUnitsPerHours = 20 // speed of unloading

    // unloading time correlates with load status
    currentState = UNLOADING
    hold((tank.level / unloadingUnitsPerHours).roundToInt().hours,
        "Unloading ${tank.level} water units")

    // put the water into the refinery of the base
    put(get<Base>().refinery, tank.level)

    // empty the tank
    take(tank, tank.level)

    activate(process = Harvester::harvesting)
}
```

# PROCESS ANALYTICS TOOLBOX INCLUDED

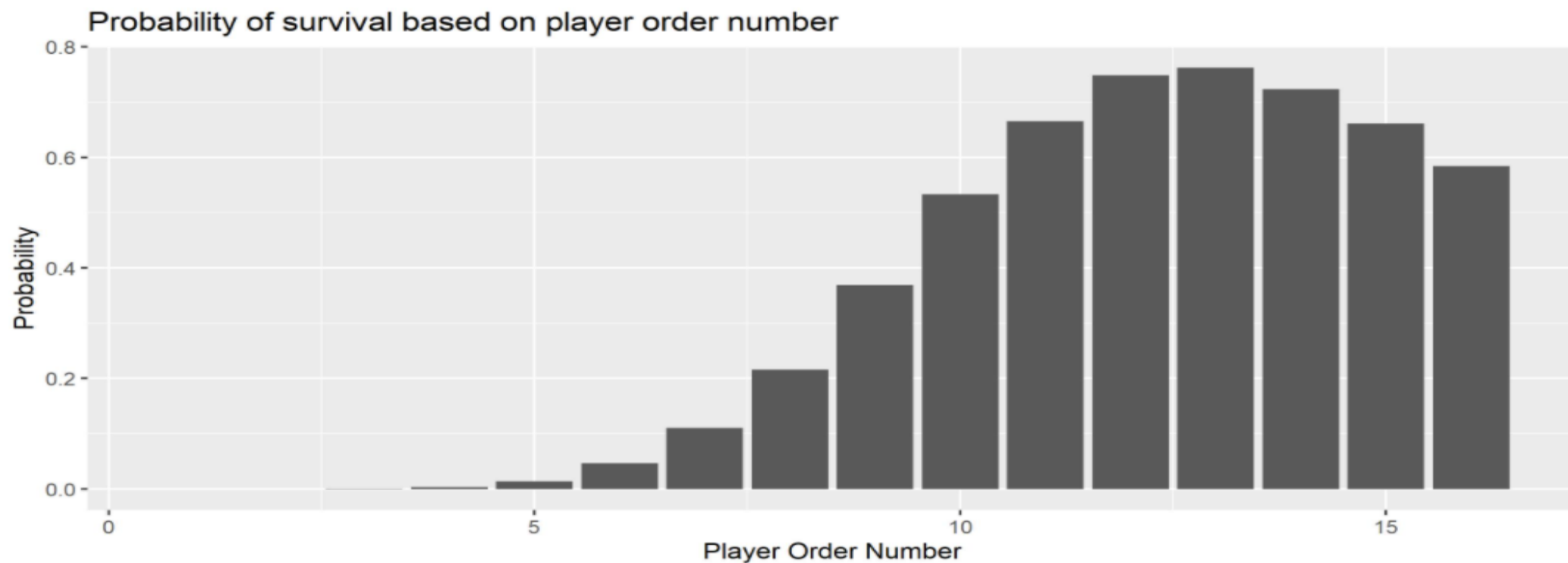
`kalasim` offers various means to analyze data created by a simulation

- The **Event Log** tracks events in a simulation
- **Monitors** track state and statistics of the basic elements within a simulation, and may be used for domain-specific entities as well
- **Lifecycle Records** summarize a component's states history
- **Visualization** to inspect complex spatio-temporal patterns

```
In [92]: val survivalProbByNo = (1..manyGames.first().numPlayers).map { playerNo ->
  playerNo to manyGames.count { it.playerSurvived(playerNo) }.toDouble() / manyGames.size
}

survivalProbByNo.plot(x = { it.first }, y = { it.second }).geomCol().labs(
  title = "Probability of survival based on player order number",
  x = "Player Order Number",
  y = "Probability"
)
```

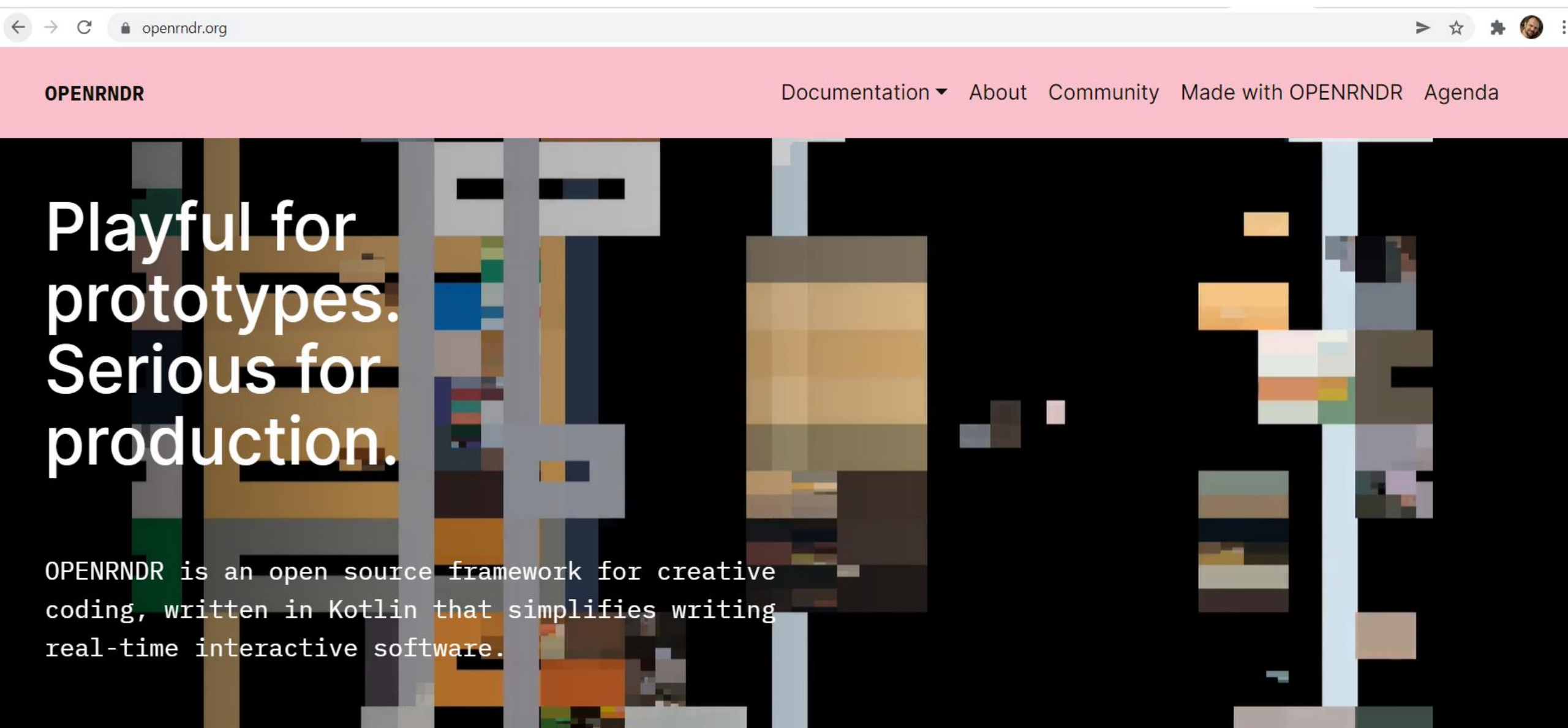
Out[92]:



So indeed there seems a strategy to maximize your odds of survival in the game. Simply pick **No13**, and you may live more likely compared to any other starting number.



# PROCESS ANIMATION → OPENRNDR

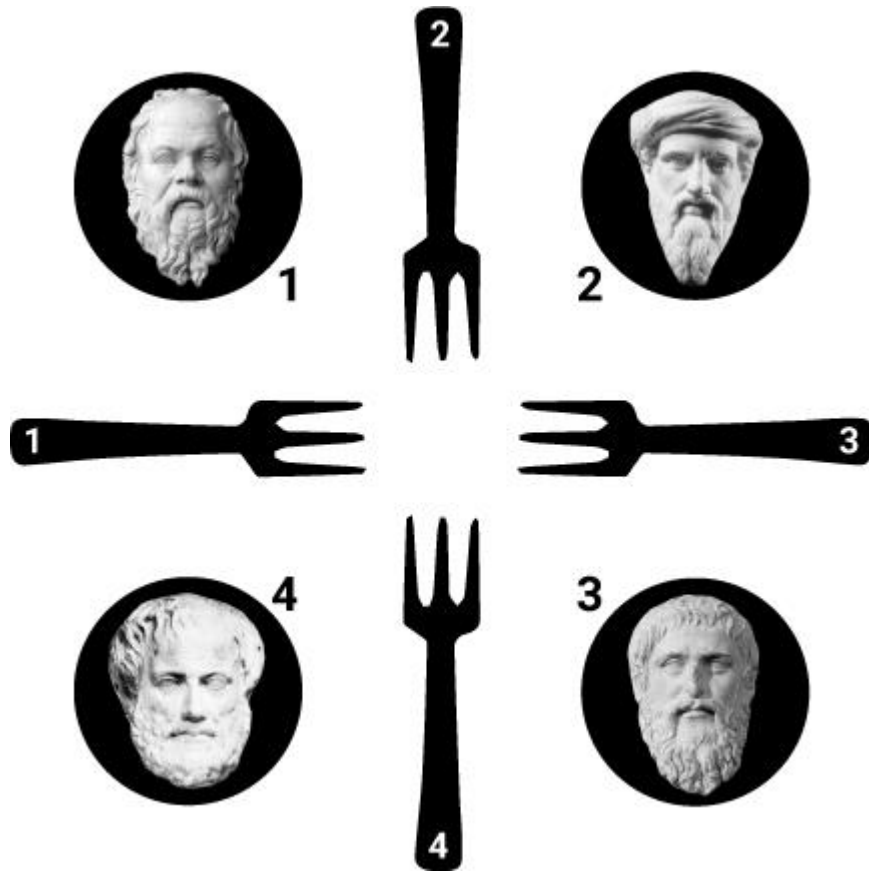


Playful for  
prototypes.  
Serious for  
production.

OPENRNDR is an open source framework for creative coding, written in Kotlin that simplifies writing real-time interactive software.

LIVE-CODING SESSION

# HAVE FOOD & FUN WITH DINING PHILOSOPHERS



@



# KALASIM APPLICATIONS

Optimization

Integration  
Testing

AI Research

Games & Fun

Bottleneck  
Analytics

Capacity  
Planning



# WHAT'S NEXT?

You:

The screenshot shows the website [kalasim.org/examples/](https://www.kalasim.org/examples/). The browser address bar is at the top. The website has a blue header with the title "kalasim - discrete event simulator" and a navigation menu with links: Home, Basics, Analysis, Articles, Examples, Advanced, and About. The "Examples" link is highlighted with a red circle labeled "2". Below the header, there is a section titled "Examples" with a sub-section "Overview" highlighted with a red circle labeled "3". A list of examples follows: Car, Traffic, Bank Office, Movie Theater, Car Wash, ATM Queue, Gas Station, Bridge Game, Machine Parts, Machine Shop, Dining Philosophers, Office Tower, The Ferryman, Emergency Room, and Lunar Mining. To the right of the examples list is a section titled "Overview" which contains text and a list of examples categorized as "Simple" and "Moderate".

kalasim - discrete event simulator

Home Basics Analysis Articles Examples Advanced About

Examples

Overview

Car

Traffic

Bank Office

Movie Theater

Car Wash

ATM Queue

Gas Station

Bridge Game

Machine Parts

Machine Shop

Dining Philosophers

Office Tower

The Ferryman

Emergency Room

Lunar Mining

Overview

There's nothing more intriguing than a good example. Categorization is opinionated and just tries to pave an

Simple

- [Car](#) - A single car, a driver, and red traffic light in the road. The example is documented with an extensive code-walkthrough.
- [Traffic](#) - Car navigate through a simple traffic model with a limited number of slots as the gas station.
- [Bank Office with 1 clerk](#) - A classic queue, where customers arrive and wait for a clerk to serve them.
- [Bridge Game](#) - A survival analysis of murderous game.

Moderate

- [Movie Theater](#) - A big cinema, great movies. How many people can watch a movie at the same time?
- [Car Wash](#) - A car wash with limited throughput, and a queue of cars waiting to be washed.

Me

- Evolve Process Animation API
- Environment snapshotting & branching (based on kryo)
- Agent-based modeling
- Evolve process mining toolbox
- (Help others to) Make more money

<https://www.kalasim.org/articles/2021-11-27-kalasim-v07/>



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- OPENRNDR <http://openrndr.org>
- Kotlin Features <https://github.com/thomasniel/kotlinconf-datascience-talk>
- Claude Shannon [https://commons.wikimedia.org/wiki/File:Claude Shannon 1776.jpg](https://commons.wikimedia.org/wiki/File:Claude_Shannon_1776.jpg)
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THANKS TO THE ORGANIZERS OF FOSDEM-2022

LET'S STAY IN TOUCH!

DO YOU WANT TO MAKE MORE MONEY WITH YOUR  
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