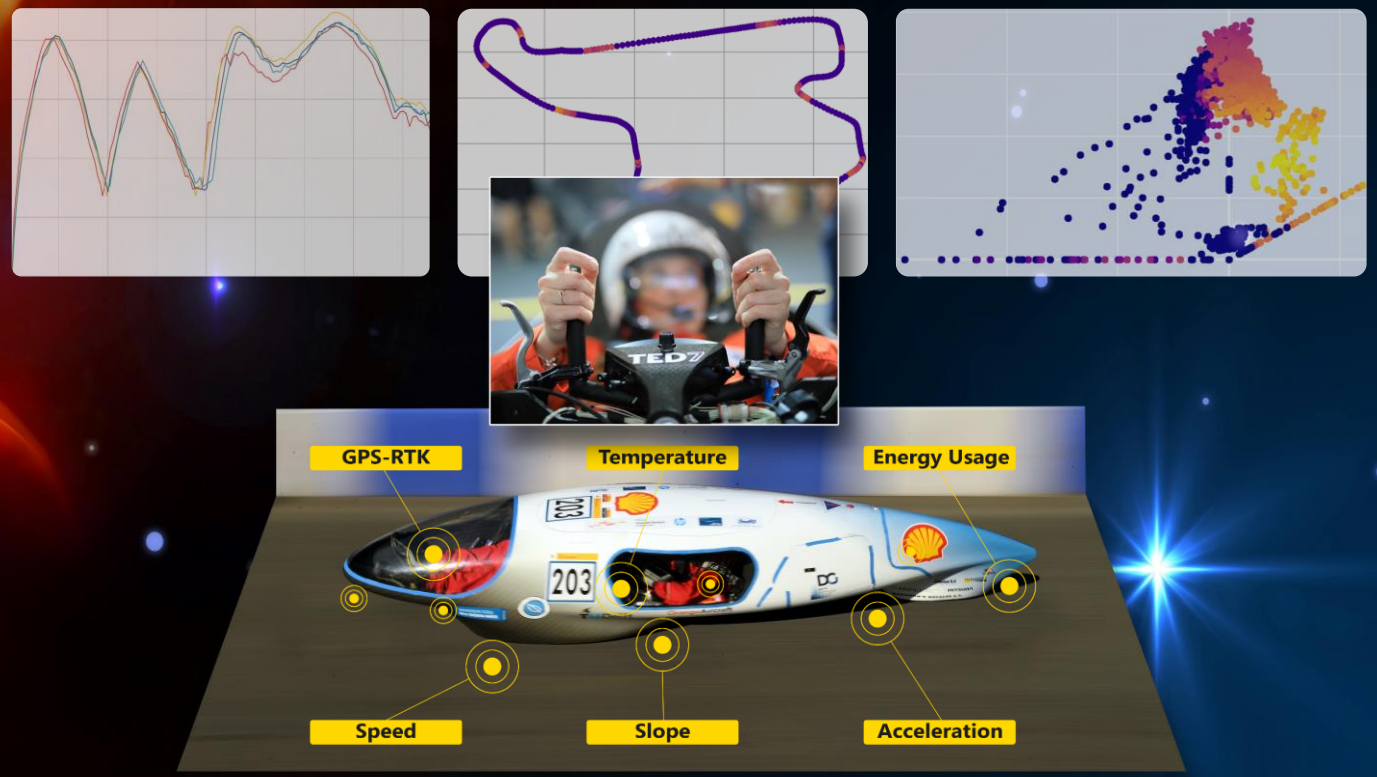
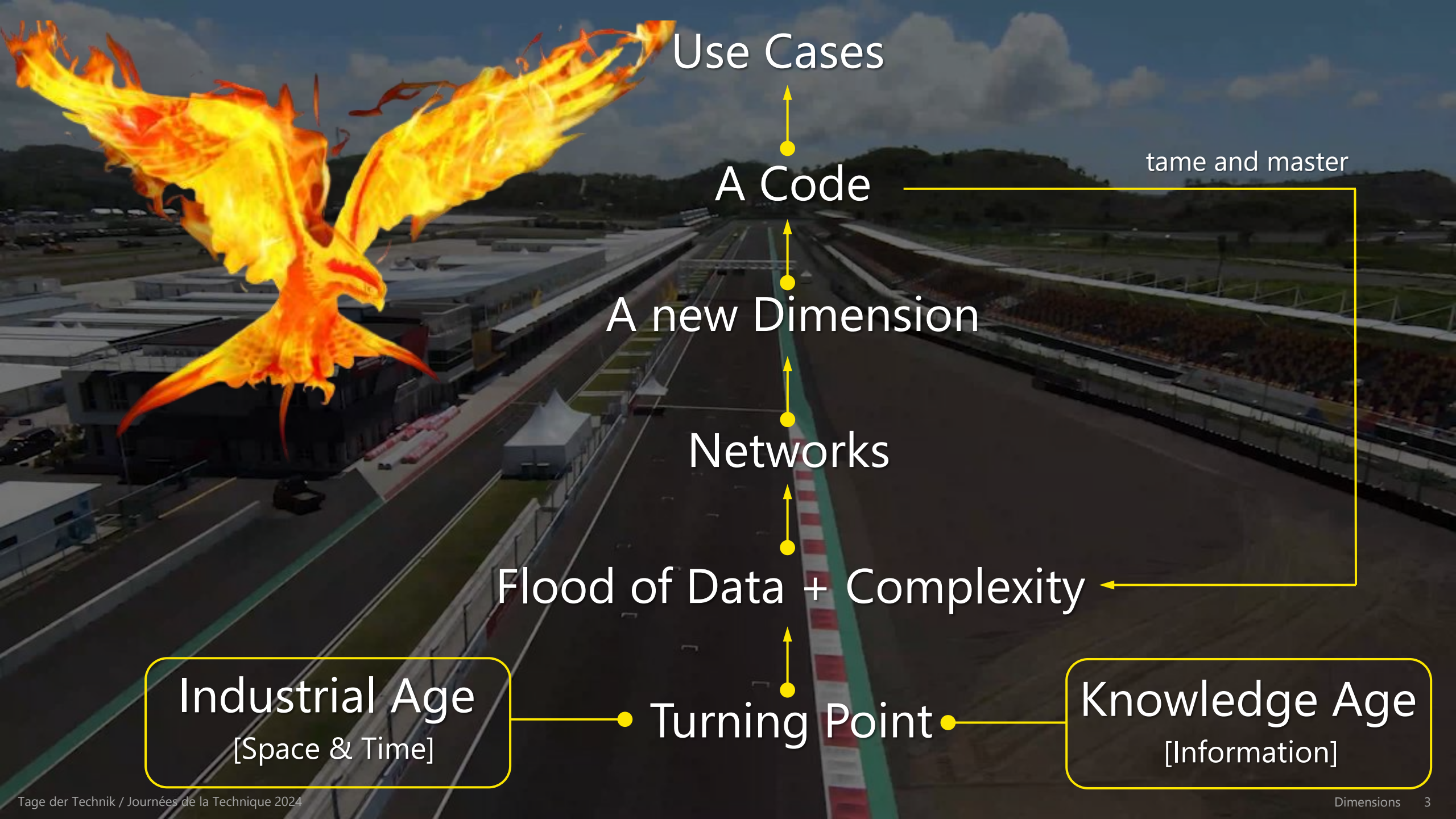
Thinking and acting in Dimensions



Journée de la Technique
2.October 2024
Marco Schmid

SCHMID Elektronik

Covering the distance from London to Rome and back on just one litre of fuel


Use Cases
A Code
tame and master
A new Dimension
Networks
Flood of Data + Complexity
Industrial Age
[Space & Time]
Turning Point
Knowledge Age
[Information]

The Shell Eco-marathon Telemetry System

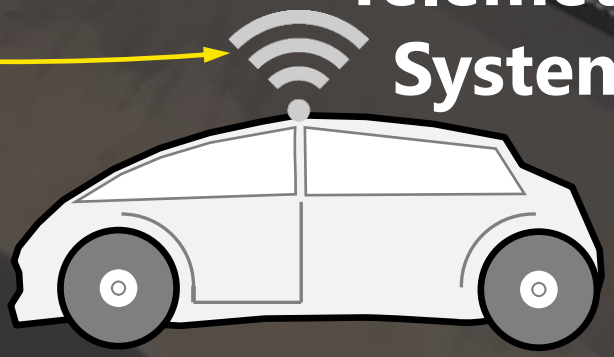
- Energy Usage
- Speed, Acceleration
- GPS Position
- Orientation (Heading, Pitch, Roll)

Data

IOT
Services

Data Transport

Telemetry System



Data

- Reset
- Shutdown

SCHMID Elektronik

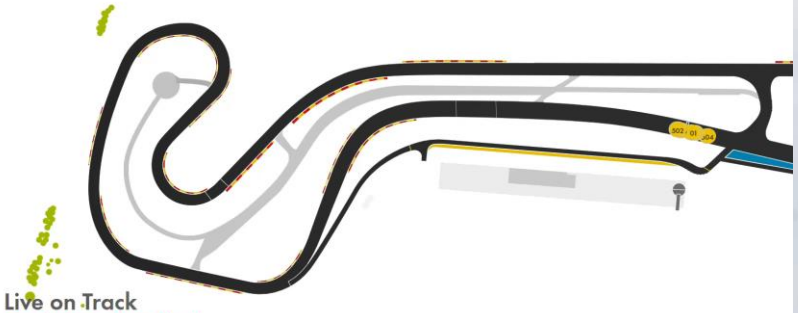
Shell Eco-marathon Partner

Live **Data** during **Championship**

REGIONAL CHAMPIONSHIP | Leaderboard | Final Race (Replay)

Rank	Country	#	Team Name	Energy Left	Lap
1		502	Schluckspecht Urban Conc...	96.9%	1/6
2		501	DTU Roadrunners	95.7%	1/6
3		505	H2politO - Molecole Urbane	96.7%	1/6
-		701	SZEnergy Team	100.0%	-
-		614	La Joliverie Polytech Nantes	100.0%	-
-		702	TUfast Eco Team	100.0%	-
-		703	TIM UPS INSA	100.0%	-
-		604	ENSEM Eco-Marathon	100.0%	-

Shell Eco-marathon



Live on Track
Final Race (Replay)

Marco Schmid

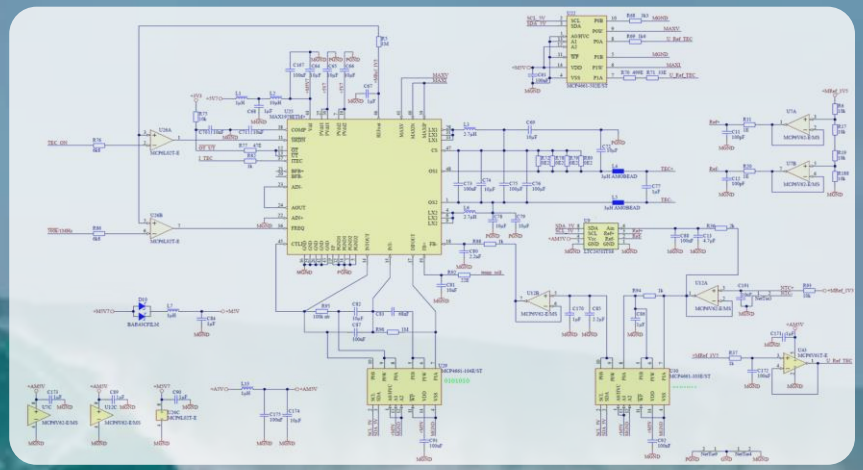
- Telemetry Inspection
- Troubleshooting
- Data-Driven Racing Bootcamps

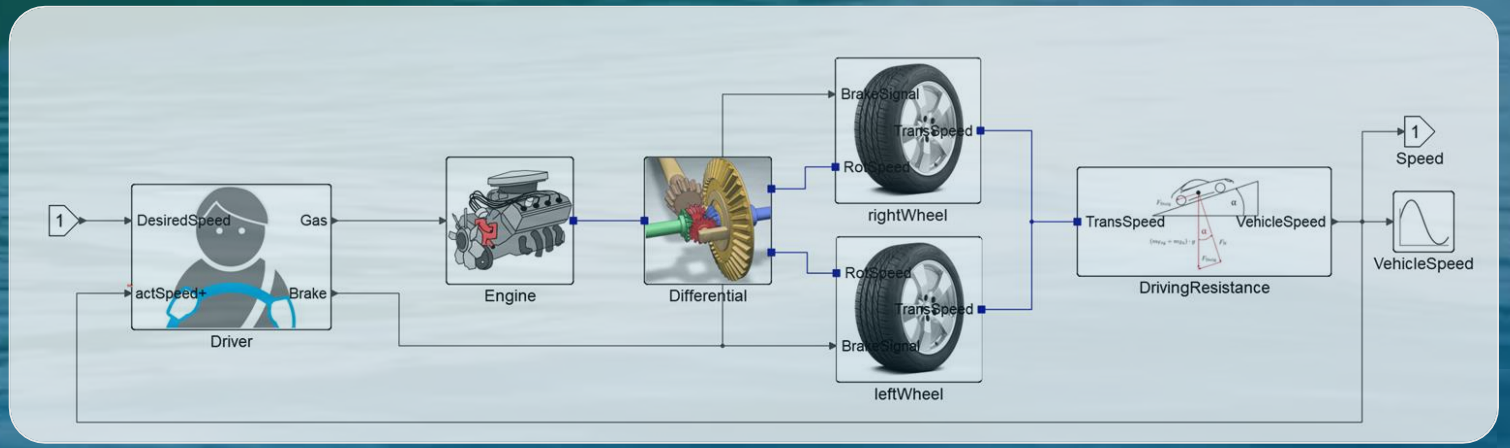
Thinking and Acting in Dimensions

SPACE
Dimension

TIME

Dimension





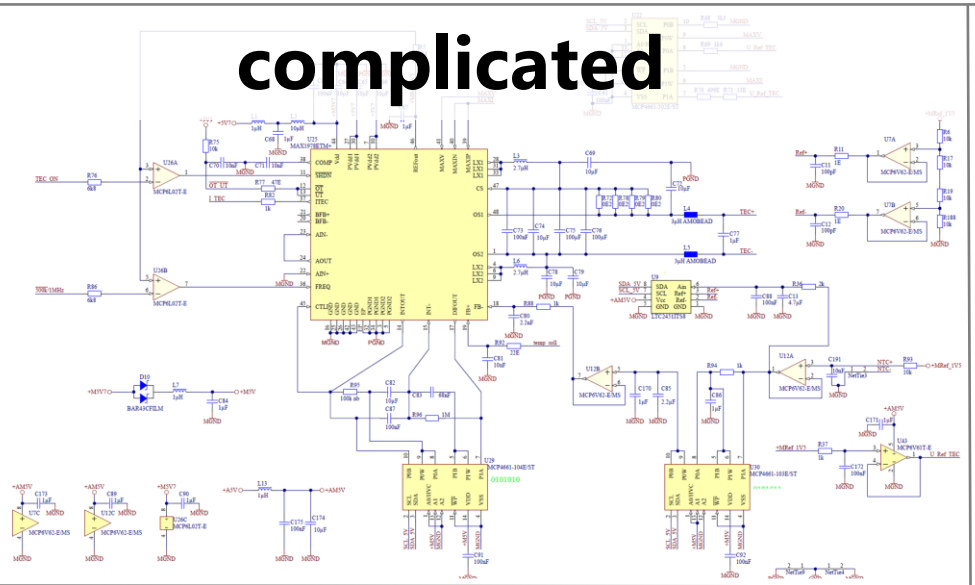
Classify Systems in **Space** and **Time**

Space

connected

linear

complicated



simple

Time

static

variable

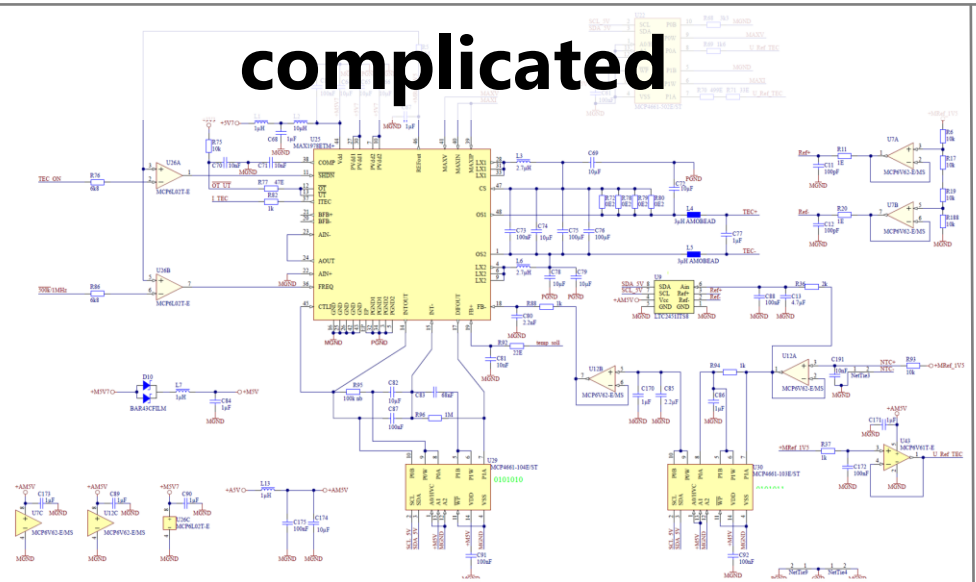
Classify Systems in **Space** and **Time**

Space

connected

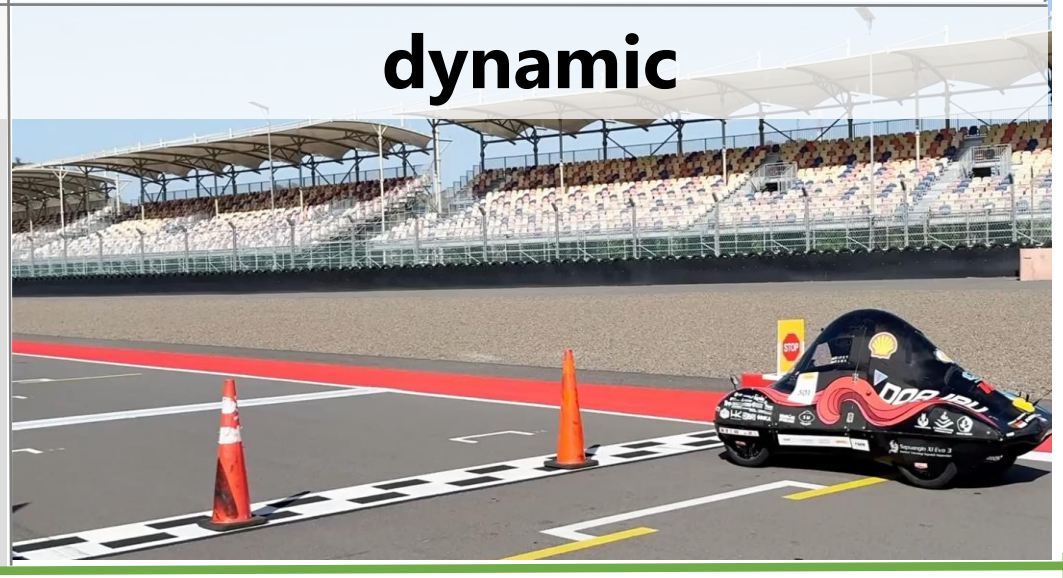
linear

complicated



simple

dynamic



Time

static

variable

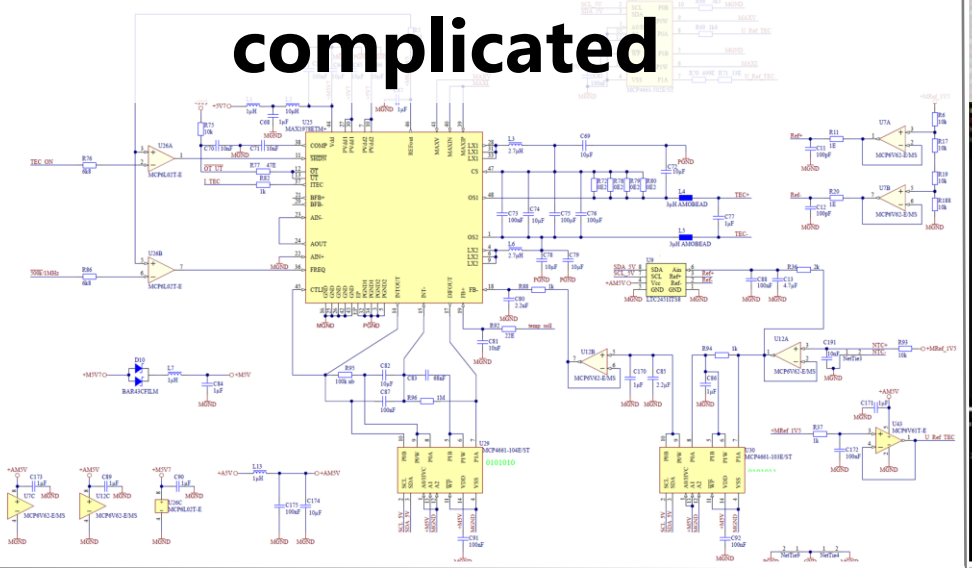
Classify Systems in **Space** and **Time**

Space

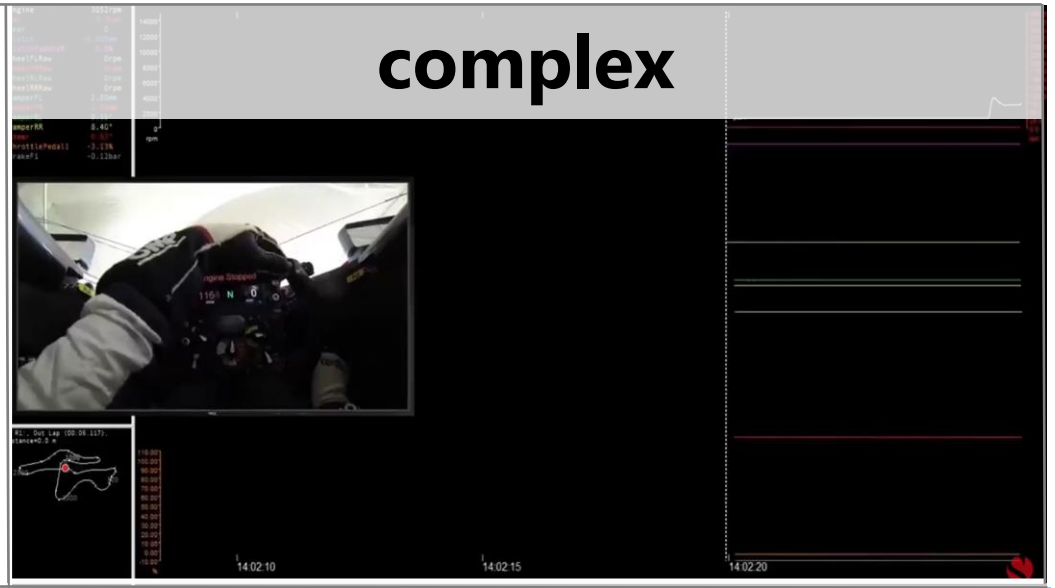
connected

linear

complicated



complex



simple

dynamic

Time

static

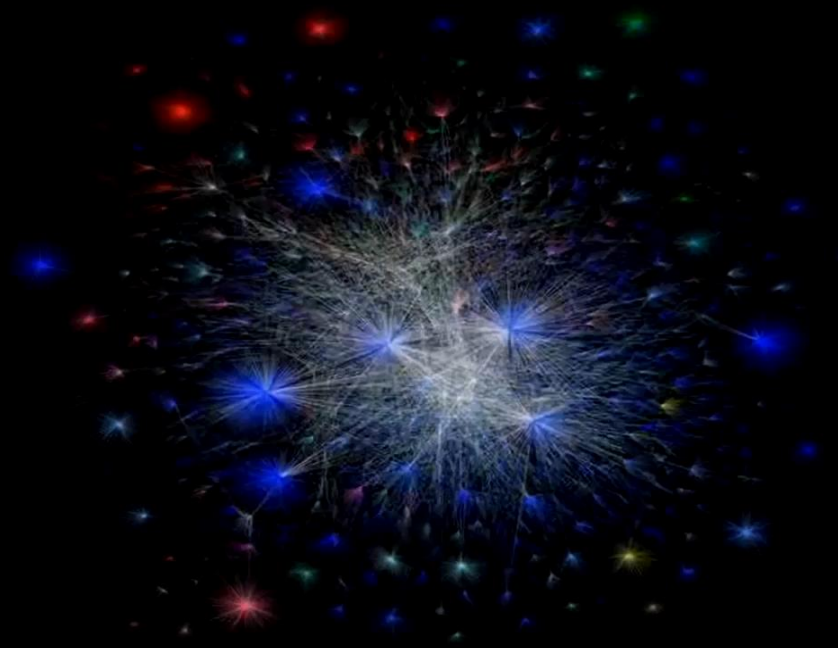
variable

New Dimension

INFORMATION

The Nature of **Complex Systems**

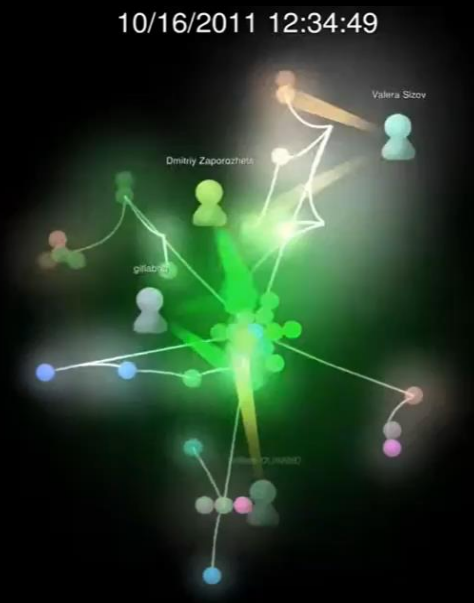
Internet



1998

VOIC- -ARRETT L- - OPTE PROJE- - -OUNDE-

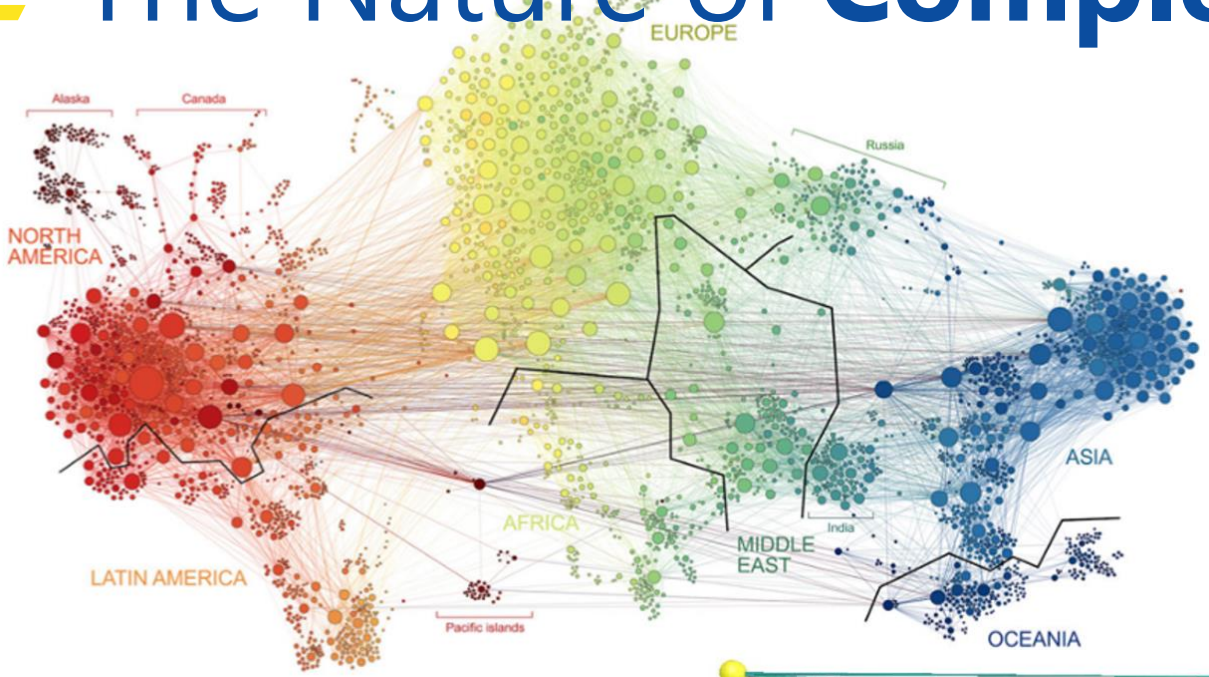
Github

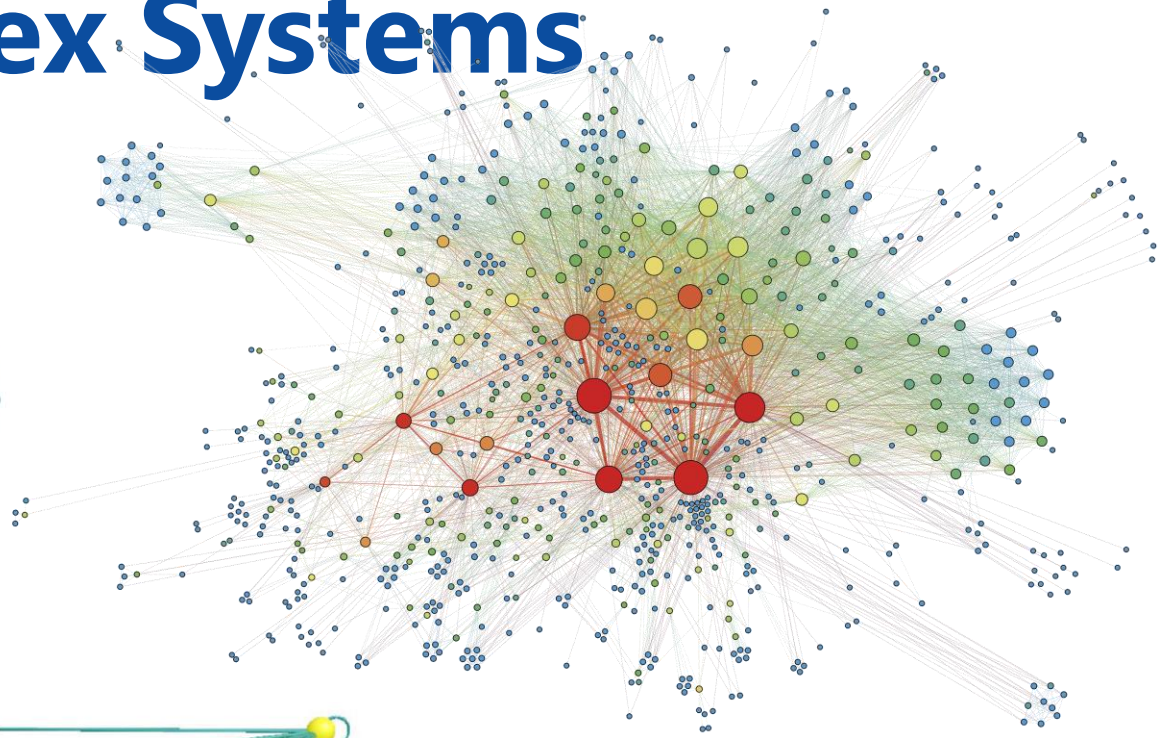


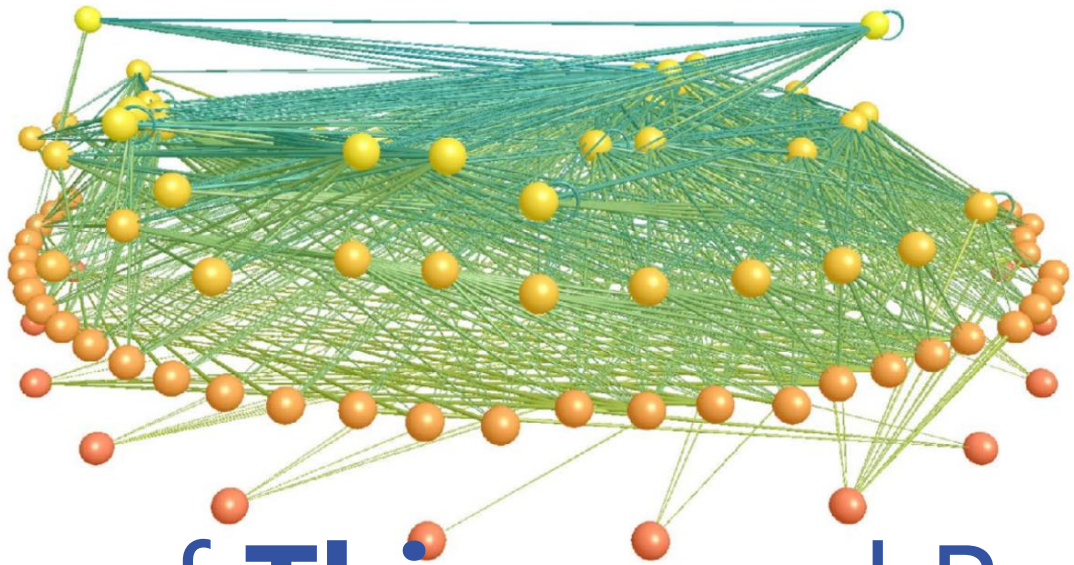
Evervone Who Has Contributed

GitLab

The Nature of **Complex Systems**

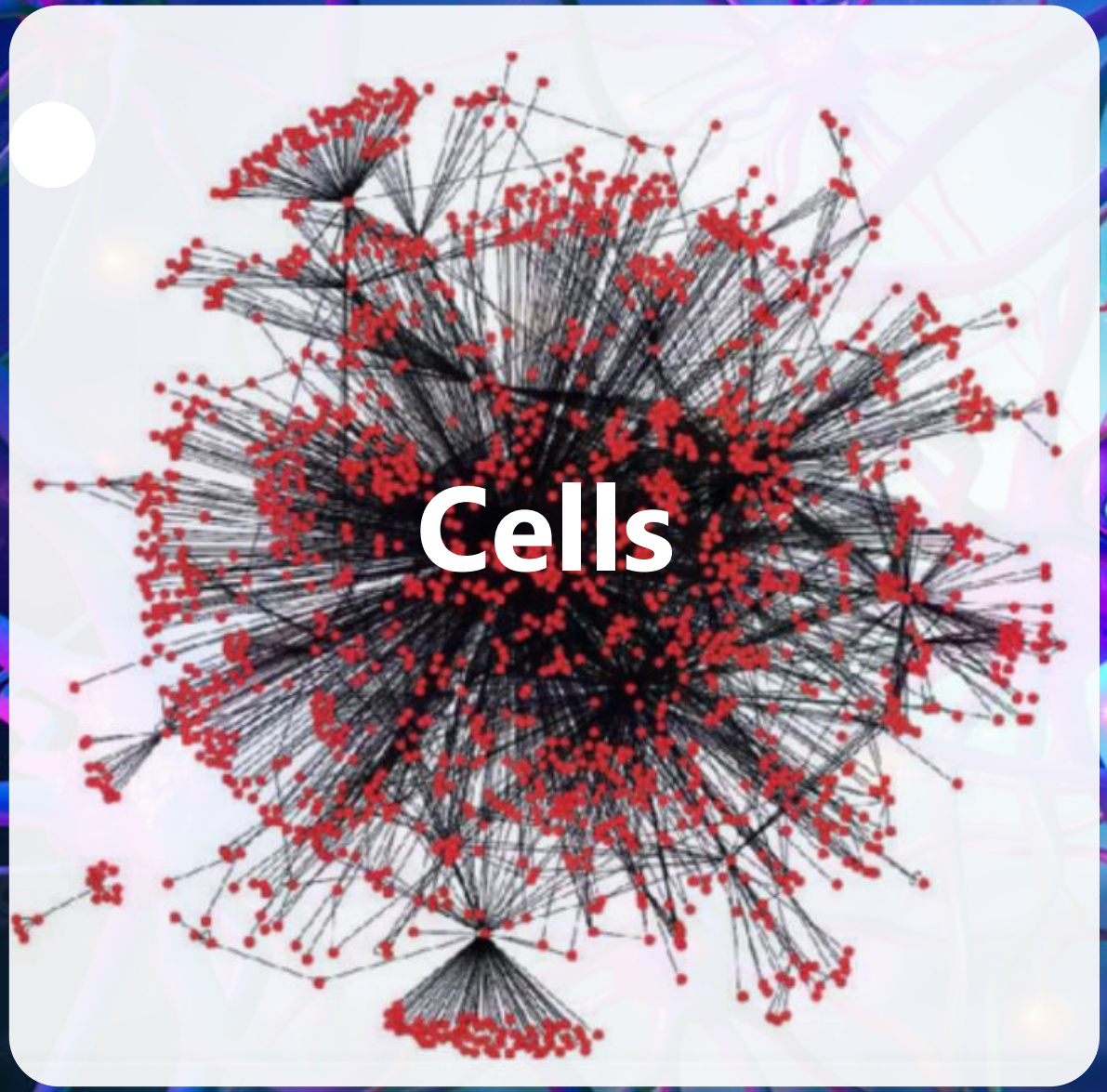






► Networks of **Things** and Relationships

Network = the natural **structure** of our world?



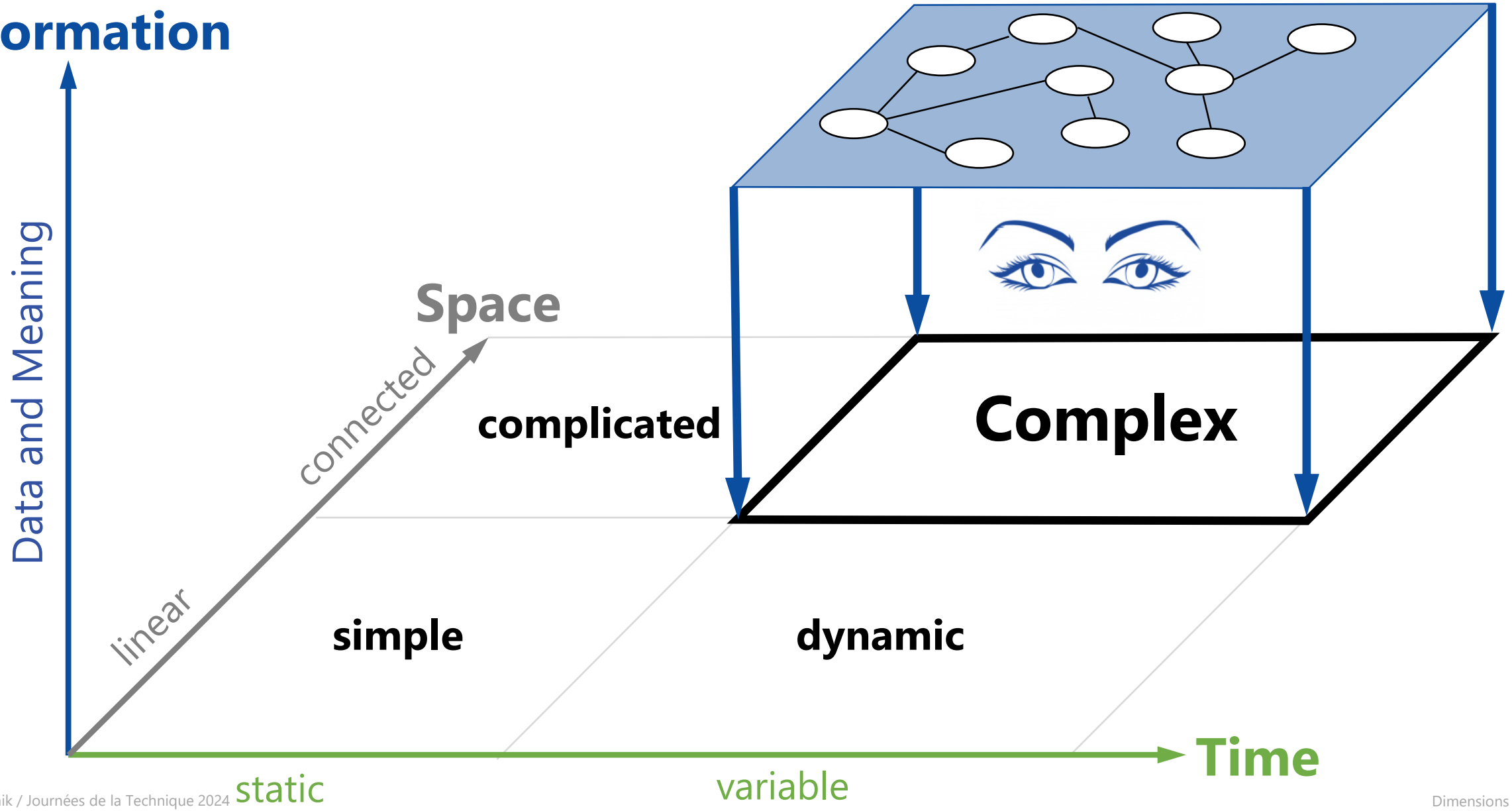
Cells

Neurons

Synapses

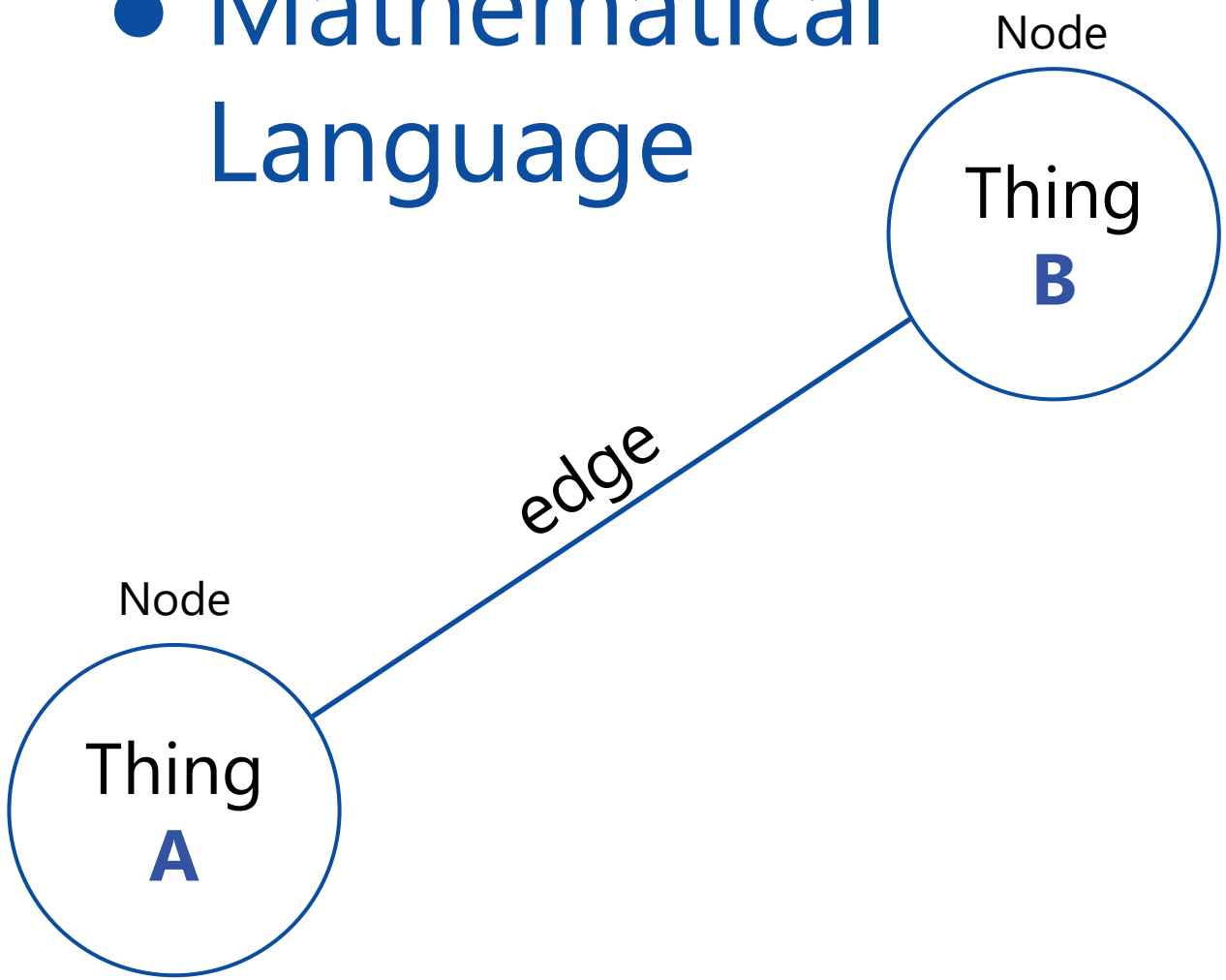

A Code
for Networks

A **Code** with Vocabulary and math. Language



Graphs as a **Code** for Things & Relationships

- Vocabulary
- Mathematical Language



Graphs as a **Code** for Things & Relationships

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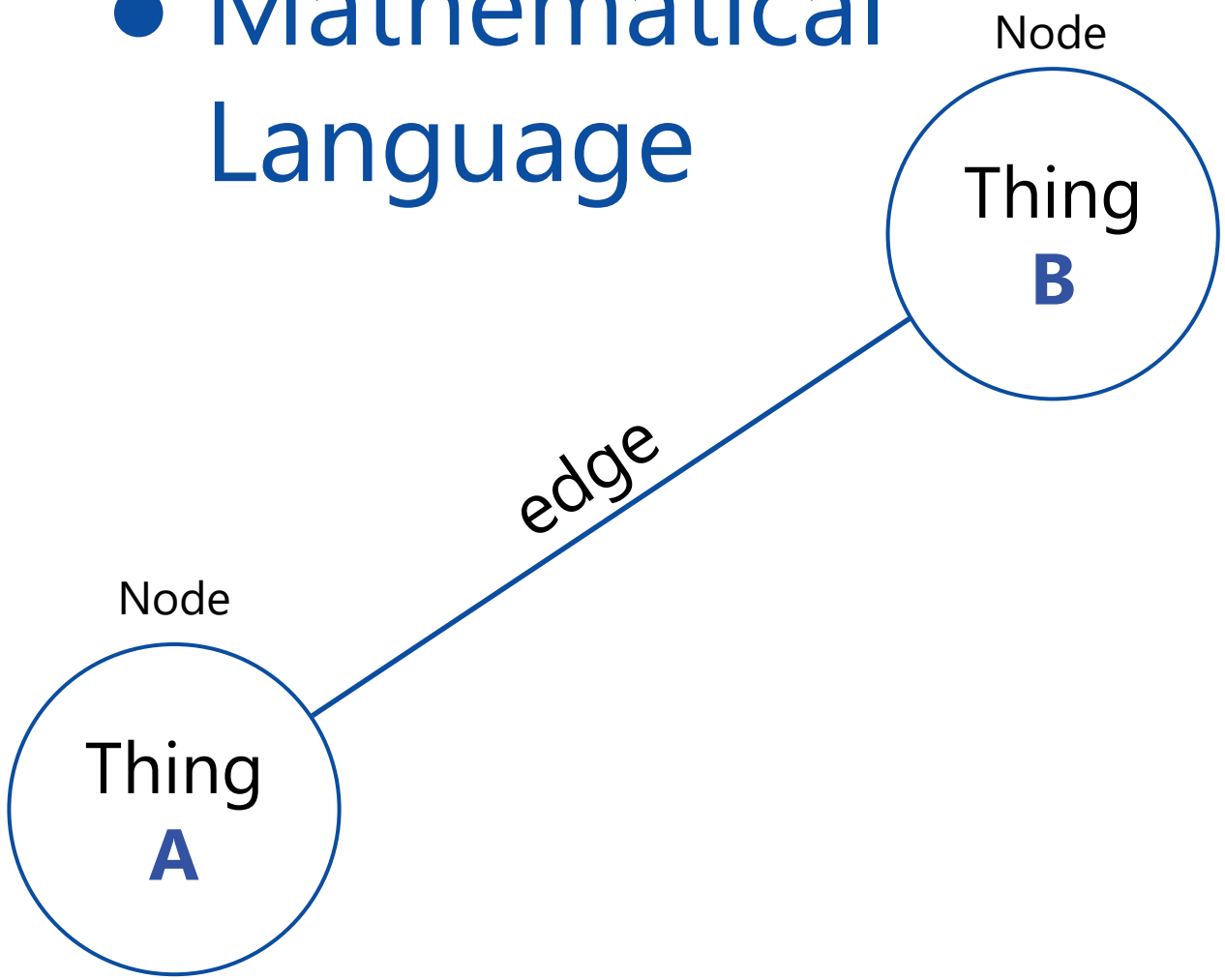
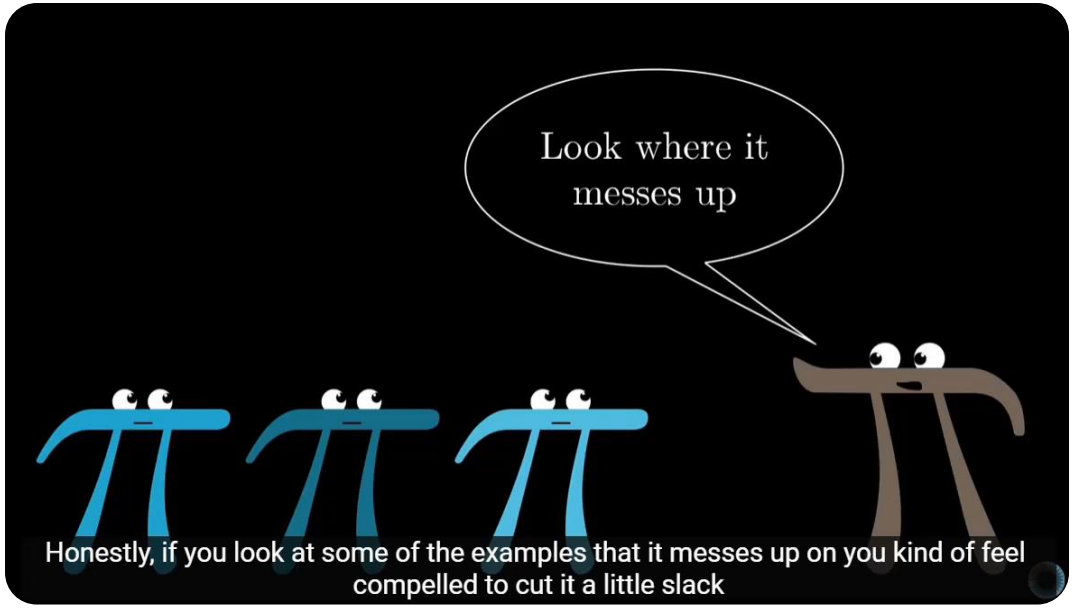
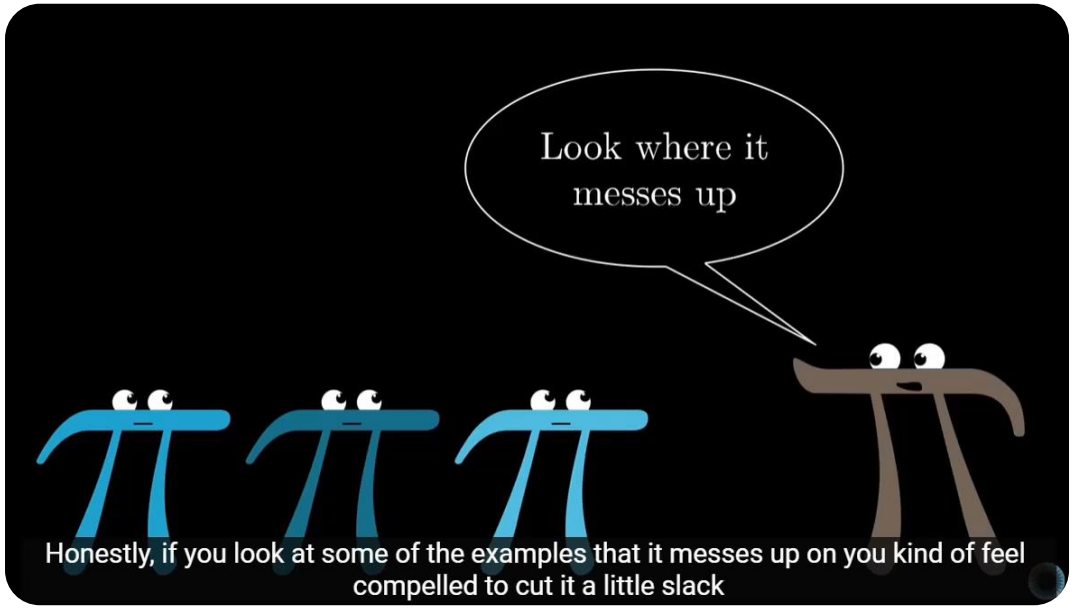
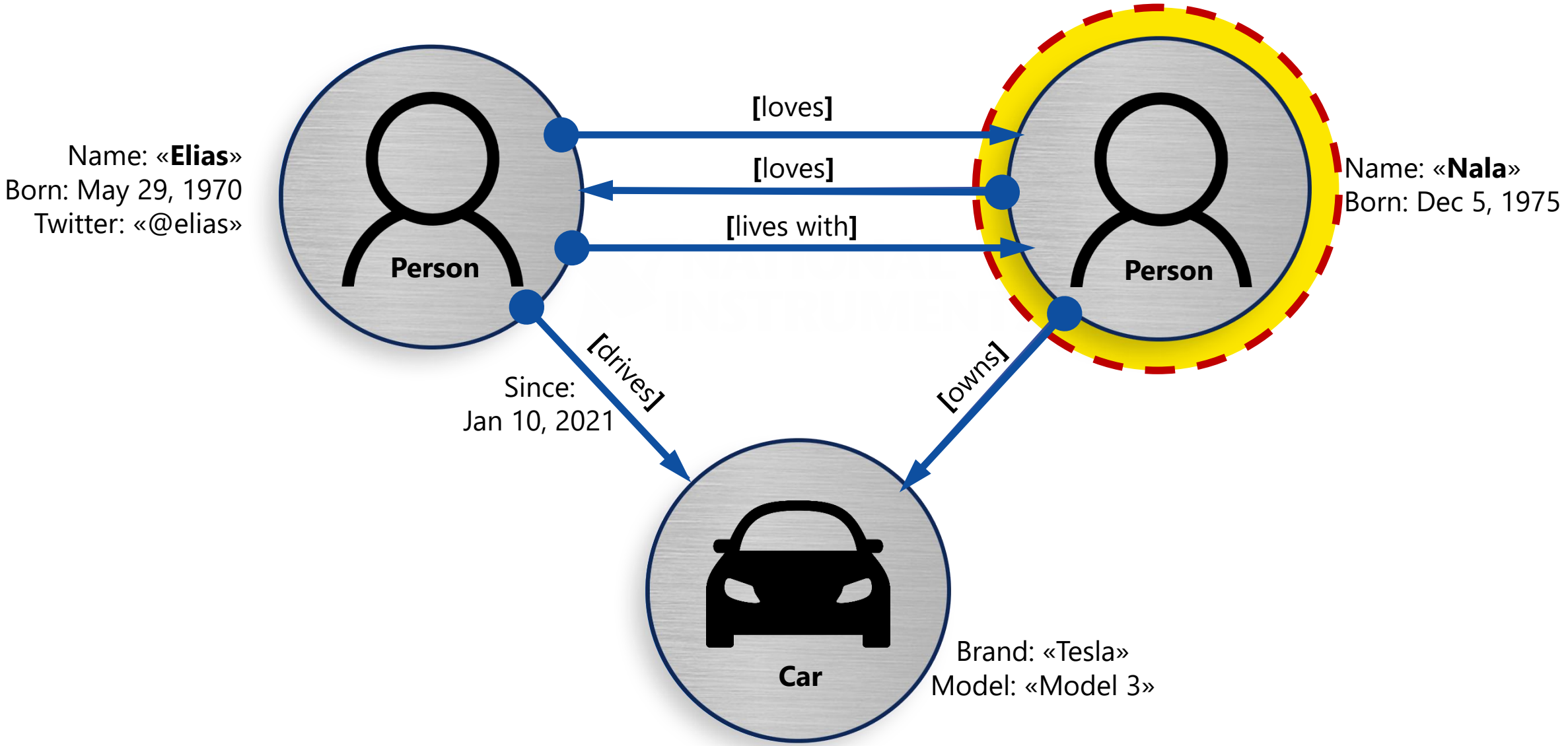




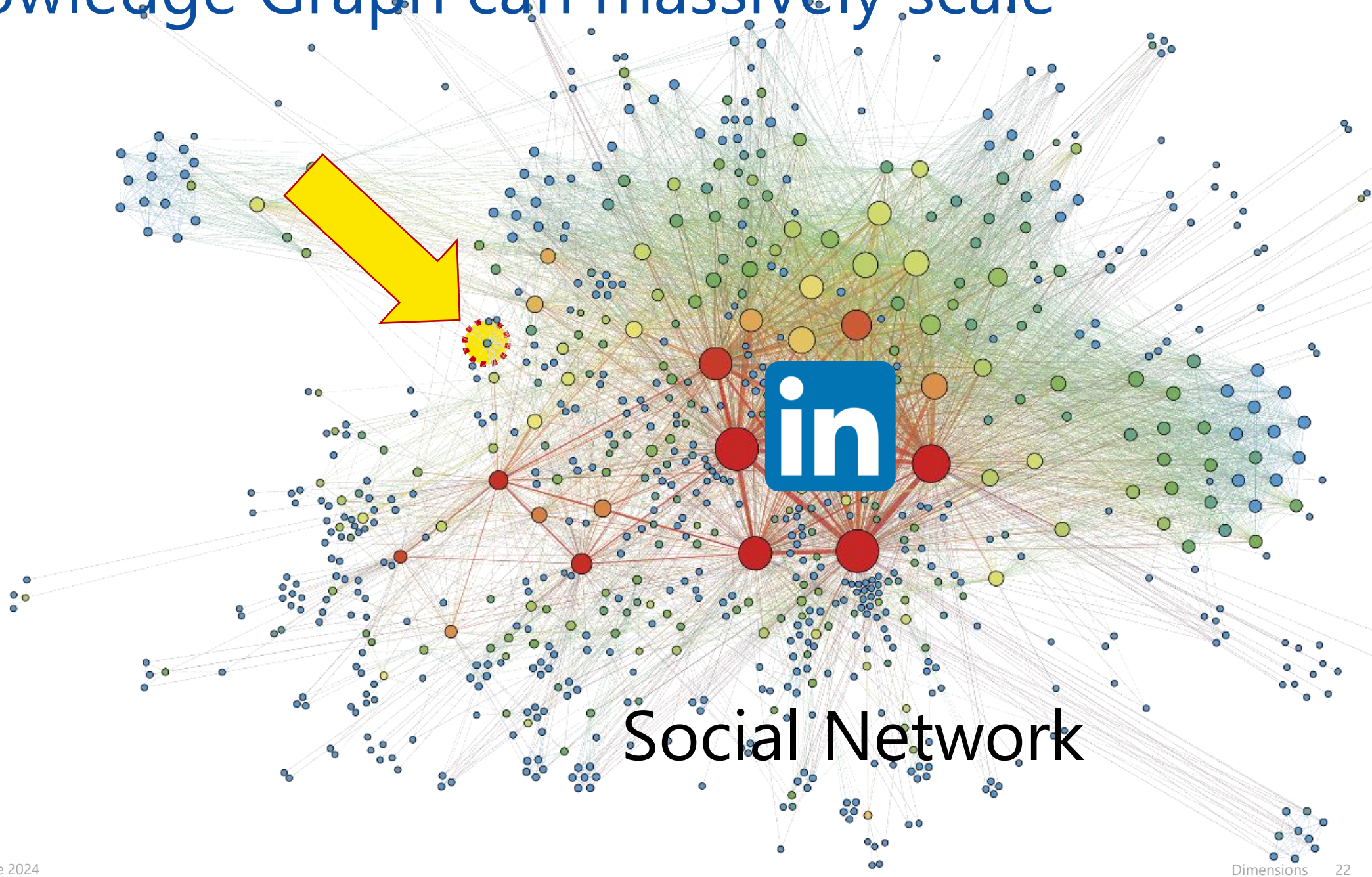


A Knowledge Graph with Nodes and Edges

Understanding the «**Essence of Things**»



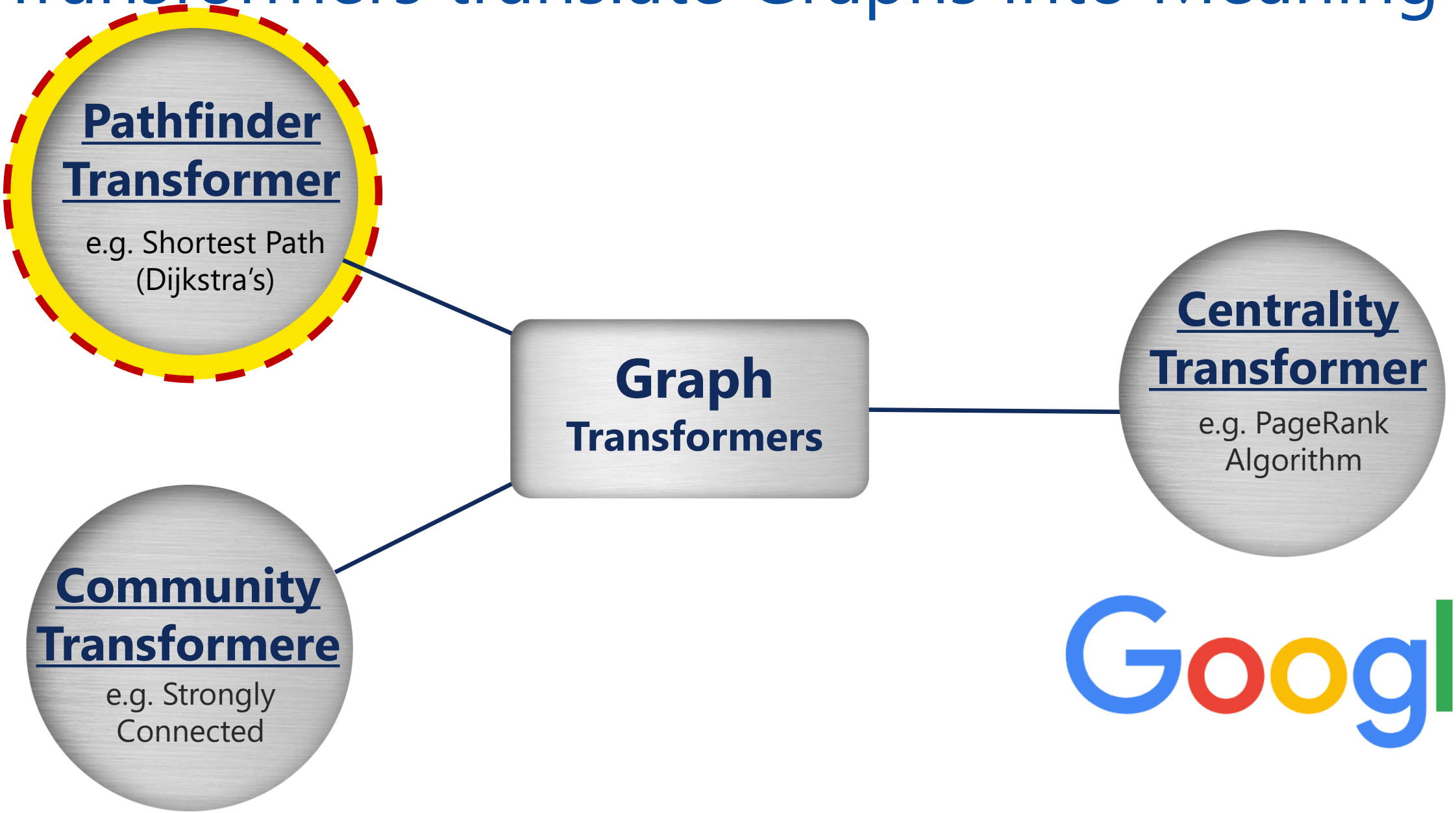
A Knowledge Graph can massively scale



A Knowledge Graph can massively scale

Social Network

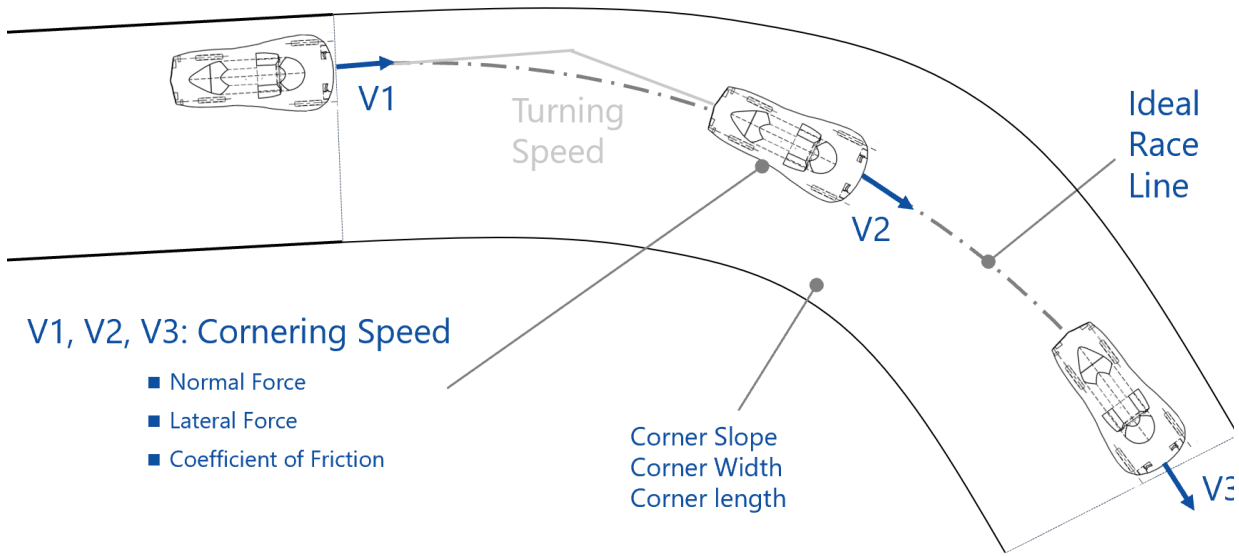
Transformers translate Graphs into Meaning



Use Case
Data-driven Racing

Solving Multigoal Physical Problems in a whole new Way

Tricky physical (multigoal-) problem to solve…



$$\begin{bmatrix} m & & \\ & m & \\ & & \theta \end{bmatrix} \begin{bmatrix} \ddot{p}_1 \\ \ddot{p}_2 \\ \ddot{\alpha} \end{bmatrix} = \begin{bmatrix} m\omega^2(2l + p_1) \\ -m\tilde{g} \\ 0 \end{bmatrix}.$$

The constraints enforce the connection of body 1 and body 2:

$$0 = \begin{bmatrix} p_1 - l\sin\alpha \\ p_2 + l\cos\alpha \end{bmatrix}.$$

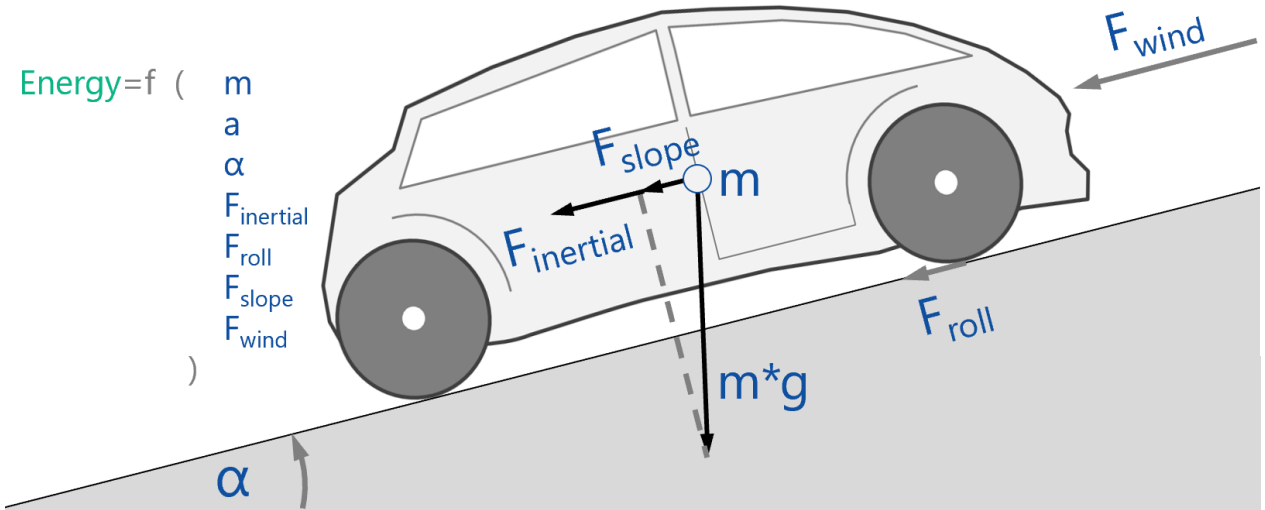
This yields the equations of motion for the rotating pendulum

$$\begin{bmatrix} m & & \\ & m & \\ & & \theta \end{bmatrix} \begin{bmatrix} \ddot{p}_1 \\ \ddot{p}_2 \\ \ddot{\alpha} \end{bmatrix} = \begin{bmatrix} m\omega^2(2l + p_1) \\ -m\tilde{g} \\ 0 \end{bmatrix} - \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -l\cos\alpha & -l\sin\alpha \end{bmatrix} \begin{bmatrix} \lambda_1 \\ \lambda_2 \end{bmatrix}$$

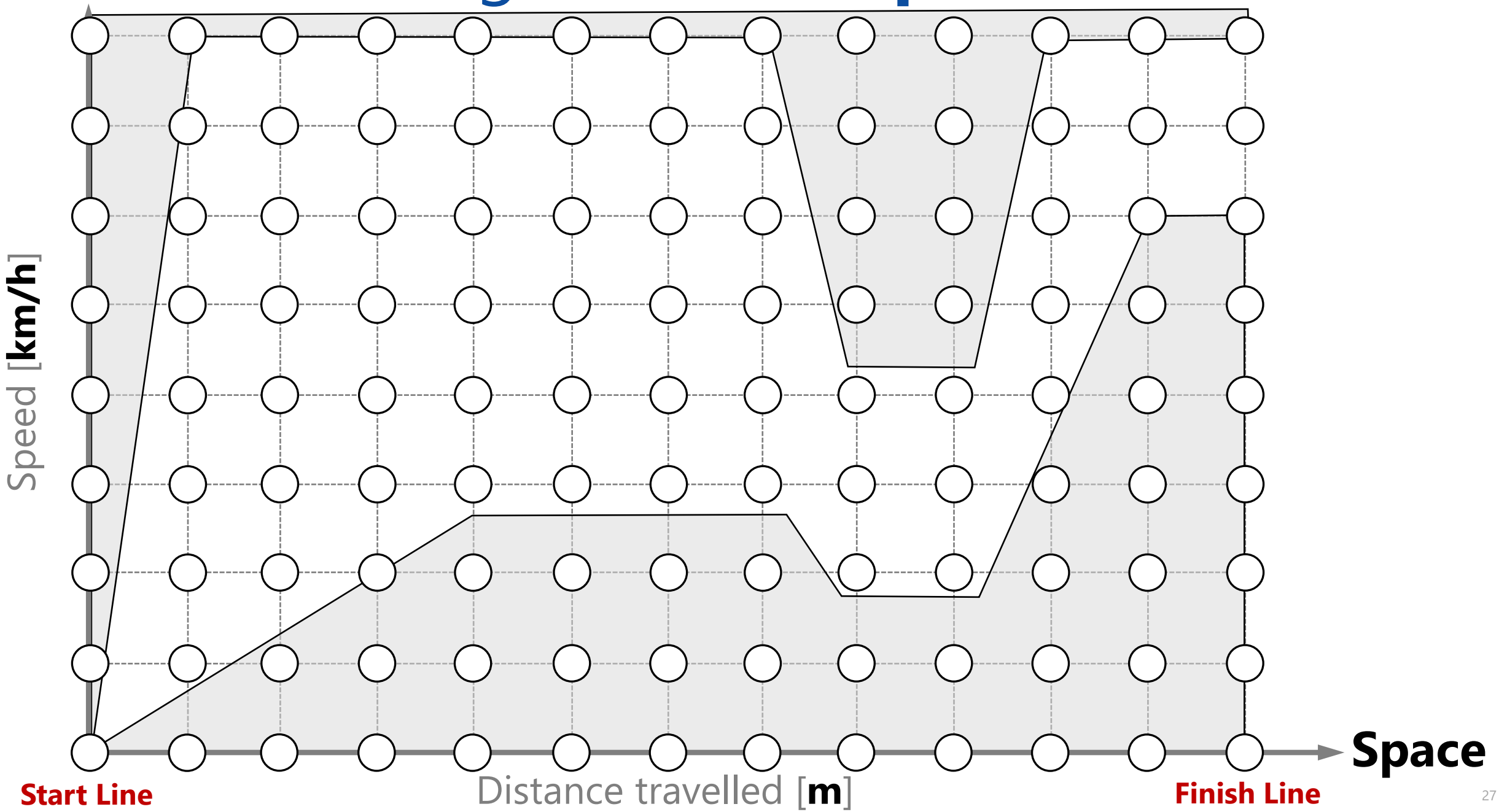
$$0 = \begin{bmatrix} p_1 - l\sin\alpha \\ p_2 + l\cos\alpha \end{bmatrix}$$

where $\begin{bmatrix} \lambda_1 \\ \lambda_2 \end{bmatrix}$ stands for the generalized constraint forces.

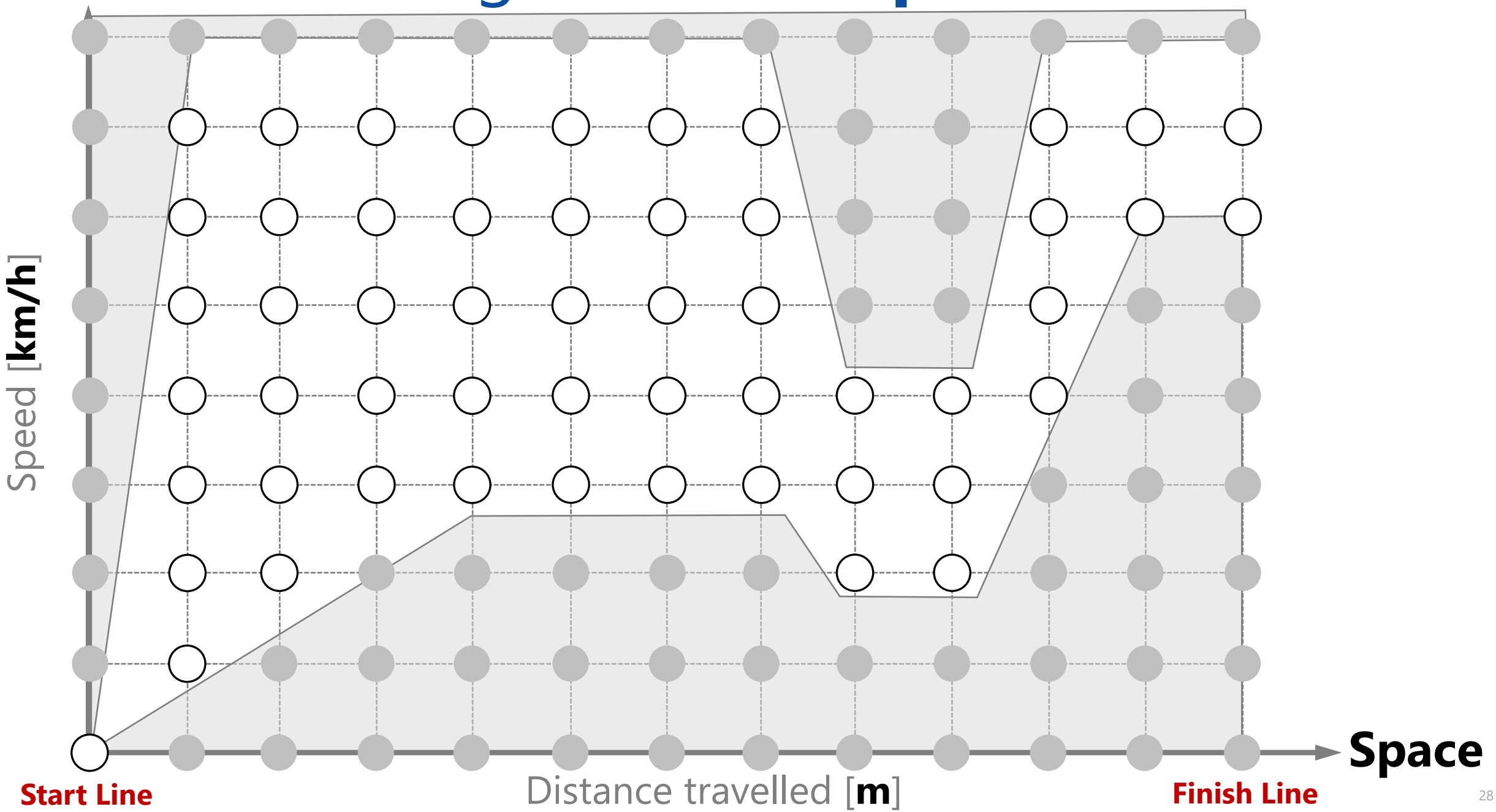
Energy=f (m
a
α
$F_{inertial}$
F_{roll}
F_{slope}
F_{wind}
)



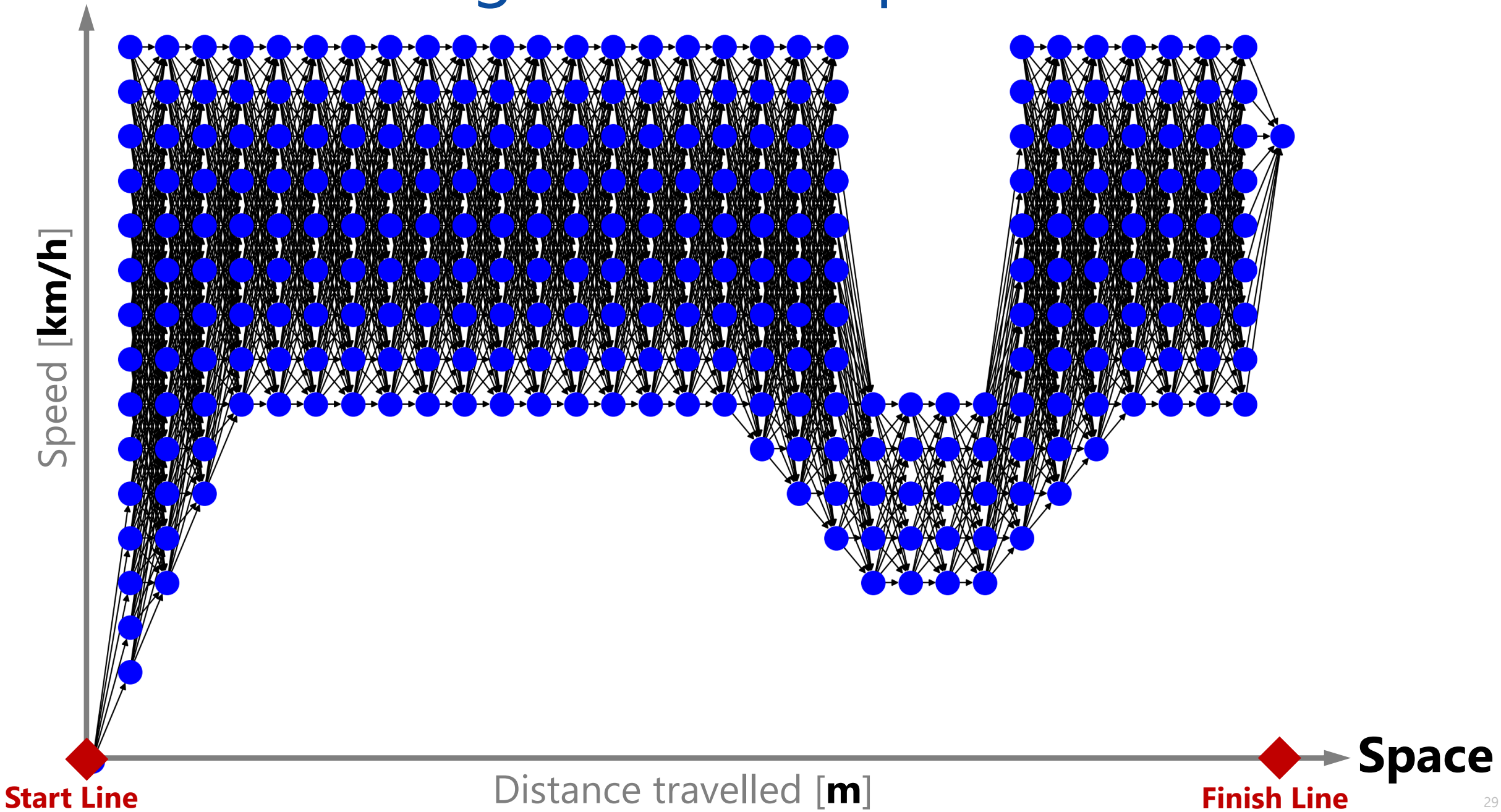
Defining the **State Space** Nodes



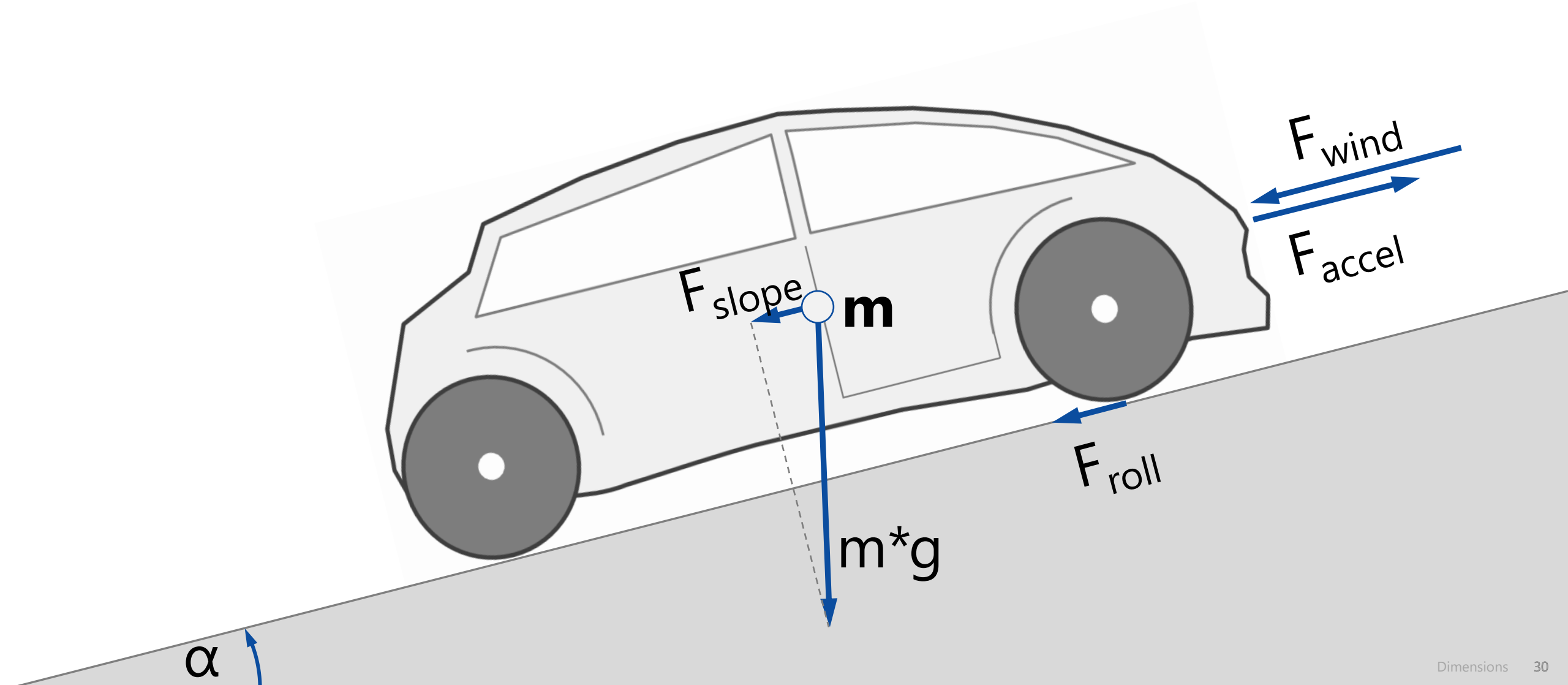
Defining the **State Space** Nodes



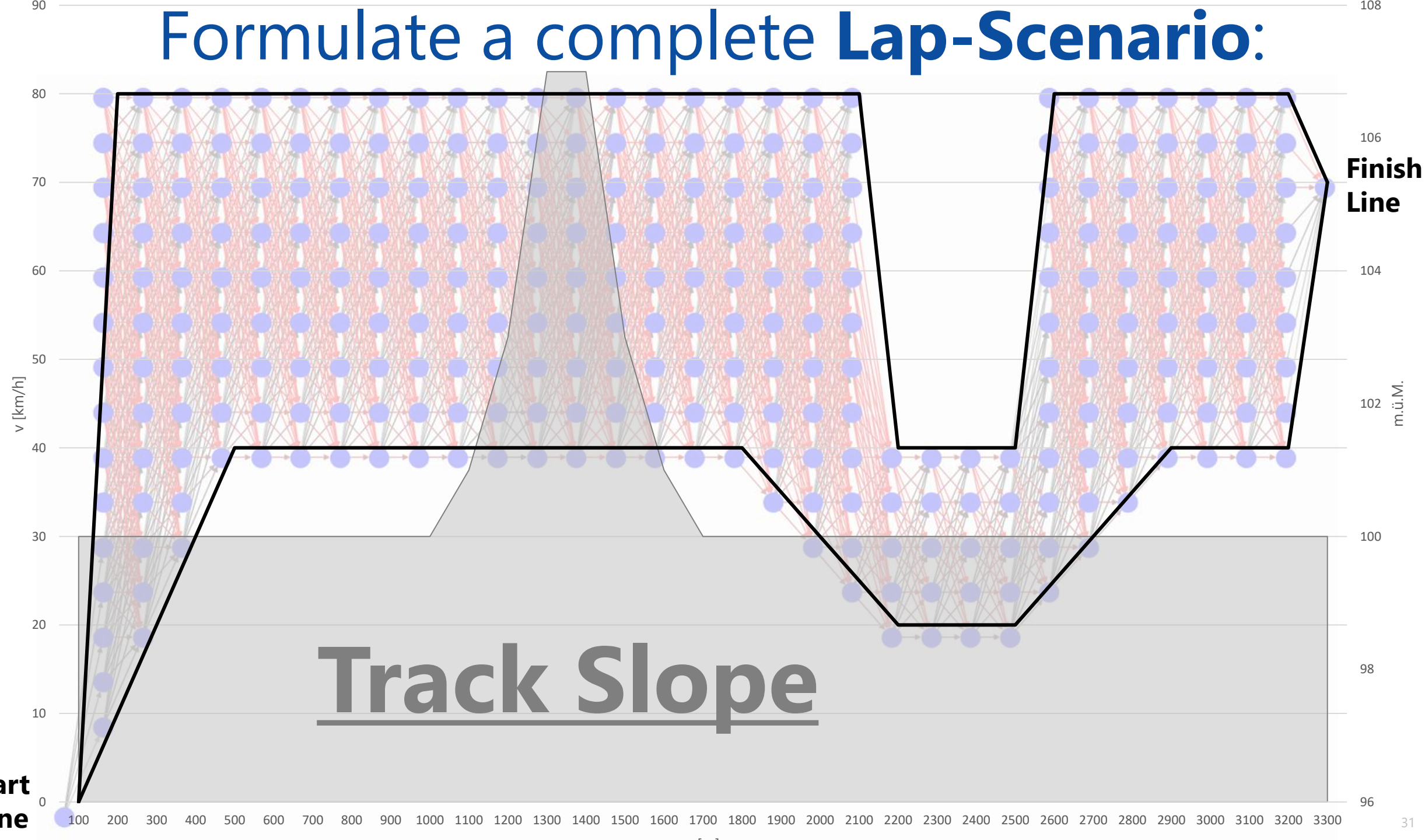
Defining the State Space **Nodes**



$$F_{total} = F_{roll} + F_{slope} + F_{accel} + F_{wind}$$

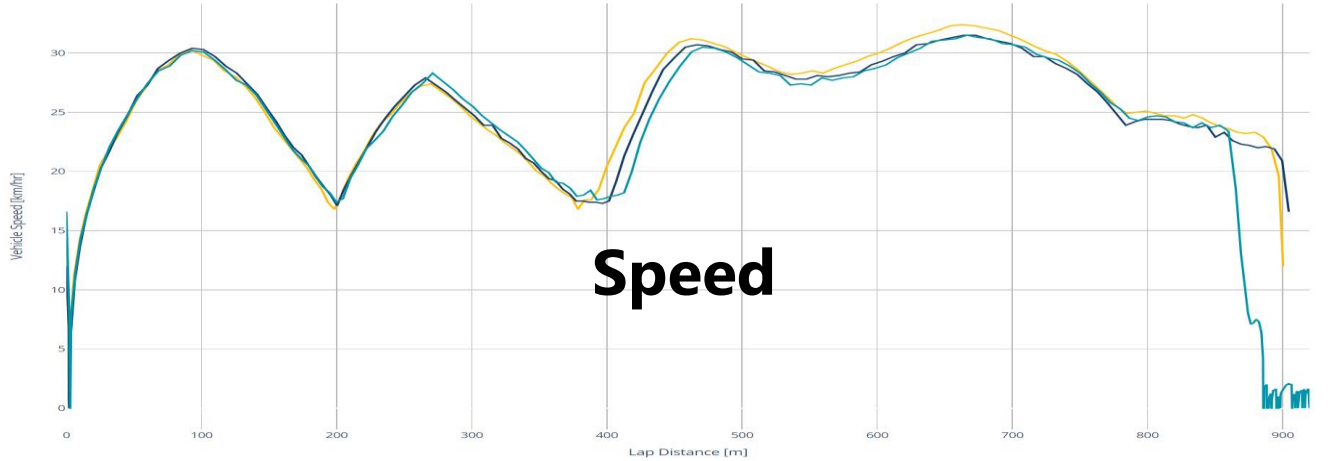


Formulate a complete **Lap-Scenario**:



grey = **cheap** edges

red = **expensive** edges



Finding the **Path** with the **lowest Cost**

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0.45333333	0.50416667	0.57	0.65083333	0.74666667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0.42333333	0.46666667	0.525	0.59833333	0.68666667	0.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0.39333333	0.42916667	0.48	0.54583333	0.62666667	0.7225	0.83333333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0.36333333	0.39166667	0.435	0.49333333	0.56666667	0.655	0.75833333	0.87666667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0.33333333	0.35416667	0.39	0.44083333	0.50666667	0.5875	0.68333333	0.79416667	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0.33333333	0.31666667	0.345	0.38833333	0.44666667	0.52	0.60833333	0.71166667	0.83	0.96333333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0.33333333	0.31666667	0.3	0.33583333	0.38666667	0.4525	0.53333333	0.62916667	0.74	0.86583333	1.00666667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0.33333333	0.31666667	0.3	0.28333333	0.32666667	0.385	0.45833333	0.54666667	0.65	0.76833333	0.90166667	1.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0.33333333	0.31666667	0.3	0.28333333	0.26666667	0.3175	0.38333333	0.46416667	0.56	0.67083333	0.79666667	0.9375	1.09333333	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0.31666667	0.3	0.28333333	0.26666667	0.25	0.30833333	0.38166667	0.47	0.57333333	0.69166667	0.825	0.97333333	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0.3	0.28333333	0.26666667	0.25	0.23333333	0.29916667	0.38	0.47583333	0.58666667	0.7125	0.85333333	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0.28333333	0.26666667	0.25	0.23333333	0.21666667	0.29	0.37833333	0.48166667	0.6	0.73333333	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.26666667	0.25	0.23333333	0.21666667	0.2	0.28083333	0.37666667	0.4875	0.61333333	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0.25	0.23333333	0.21666667	0.2	0.18333333	0.27166667	0.375	0.49333333	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0.23333333	0.21666667	0.2	0.18333333	0.16666667	0.2625	0.37333333	0	0	0	0	0	0	0	0	0	0	0	0	0
0								0	0	0	0	0	0	0.48	0.54583333	0.62666667	0.7225	0.83333333	0	0	0	0	0	0	0	0
0								0	0	0	0	0	0	0.435	0.49333333	0.56666667	0.655	0.75833333	0.87666667	0	0	0	0	0	0	0
0								0	0	0	0	0	0	0.39	0.44083333	0.50666667	0.5875	0.68333333	0.79416667	0.92	0	0	0	0	0	0
0								0	0	0	0	0	0	0.345	0.38833333	0.44666667	0.52	0.60833333	0.71166667	0.83	0.96333333	0	0	0	0	0
0								0	0	0	0	0	0	0.3	0.33583333	0.38666667	0.4525	0.53333333	0.62916667	0.74	0.86583333	1.00666667	0	0	0	0
0								0	0	0	0	0	0	0.3	0.28333333	0.32666667	0.385	0.45833333	0.54666667	0.65	0.76833333	0.90166667	1.05	0	0	0
0								0	0	0	0	0	0	0.3	0.28333333	0.26666667	0.3175	0.38333333	0.46416667	0.56	0.67083333	0.79666667	0.9375	1.09333333	0	0
0								0	0	0	0	0	0	0.3	0.28333333	0.26666667	0.25	0.30833333	0.38166667	0.47	0.57333333	0.69166667	0.825	0.97333333	0	0
0								0	0	0	0	0	0	0.3	0.28333333	0.26666667	0.25	0.23333333	0.29916667	0.38	0.47583333	0.58666667	0.7125	0.85333333	0	0
0								0	0	0	0	0	0	0	0.28333333	0.26666667	0.25	0.23333333	0.21666667	0.29	0.37833333	0.48166667	0.6	0.73333333	0	0
0								0	0	0	0	0	0	0	0	0.26666667	0.25	0.23333333	0.21666667	0.2	0.28083333	0.37666667	0.4875	0.61333333	0	0
0								0	0	0	0	0	0	0	0	0	0.25	0.23333333	0.21666667	0.2	0.18333333	0.27166667	0.375	0.49333333	0	0
0								0	0	0	0	0	0	0	0	0	0	0.23333333	0.21666667	0.2	0.18333333	0.16666667	0.2625	0.37333333	0	0
0								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.44083333	0.50666667
0								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.38833333	0.44666667
0								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33583333	0.38666667
0								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28333333	0.32666667
0								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28333333	0.26666667
0								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28333333	0.26666667
0								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28333333	0.26666667
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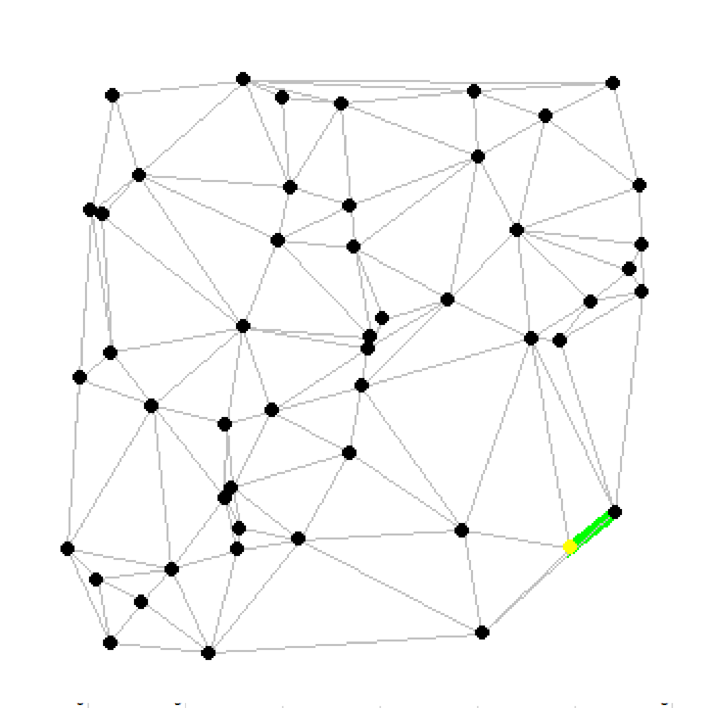
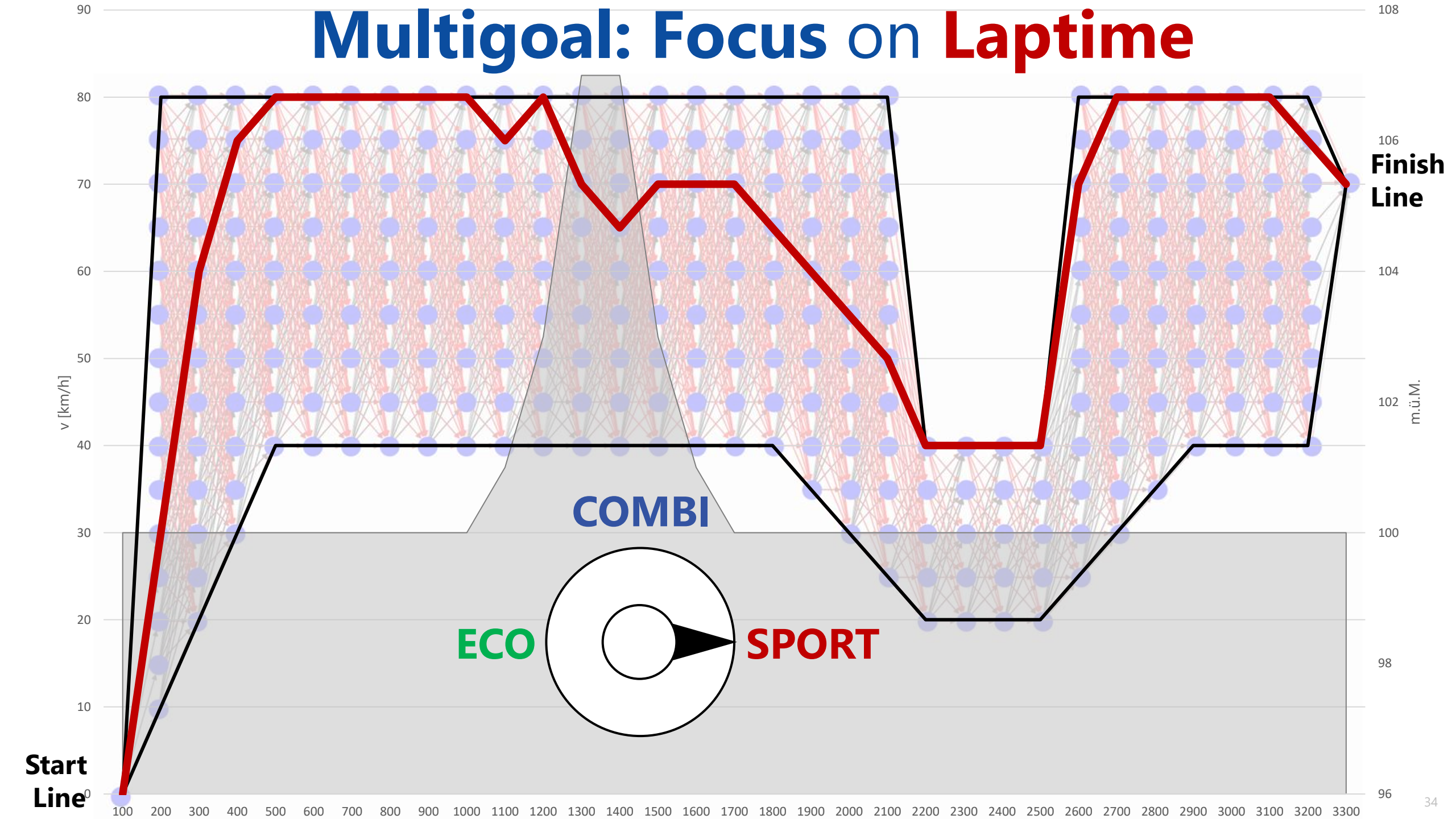
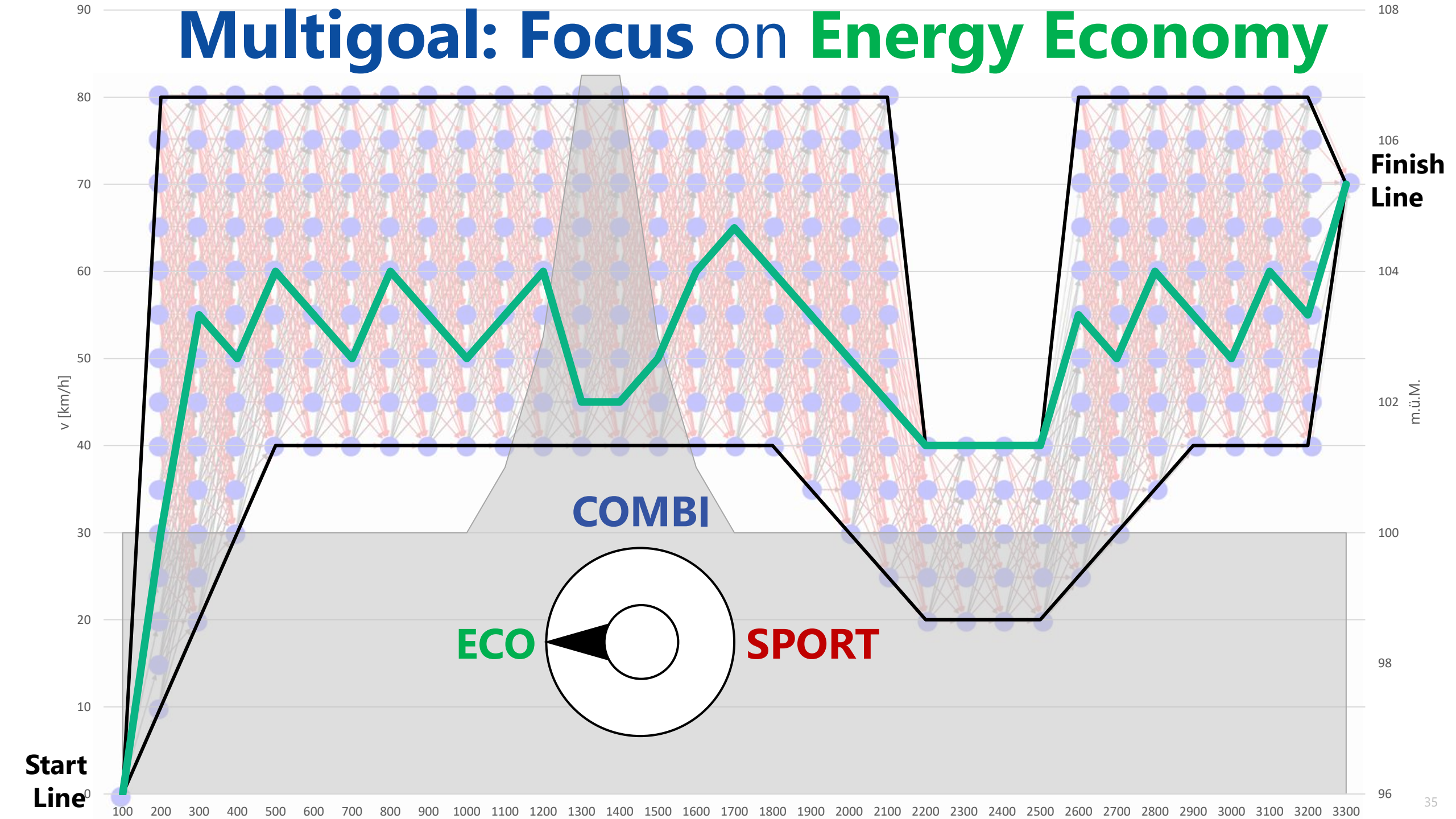


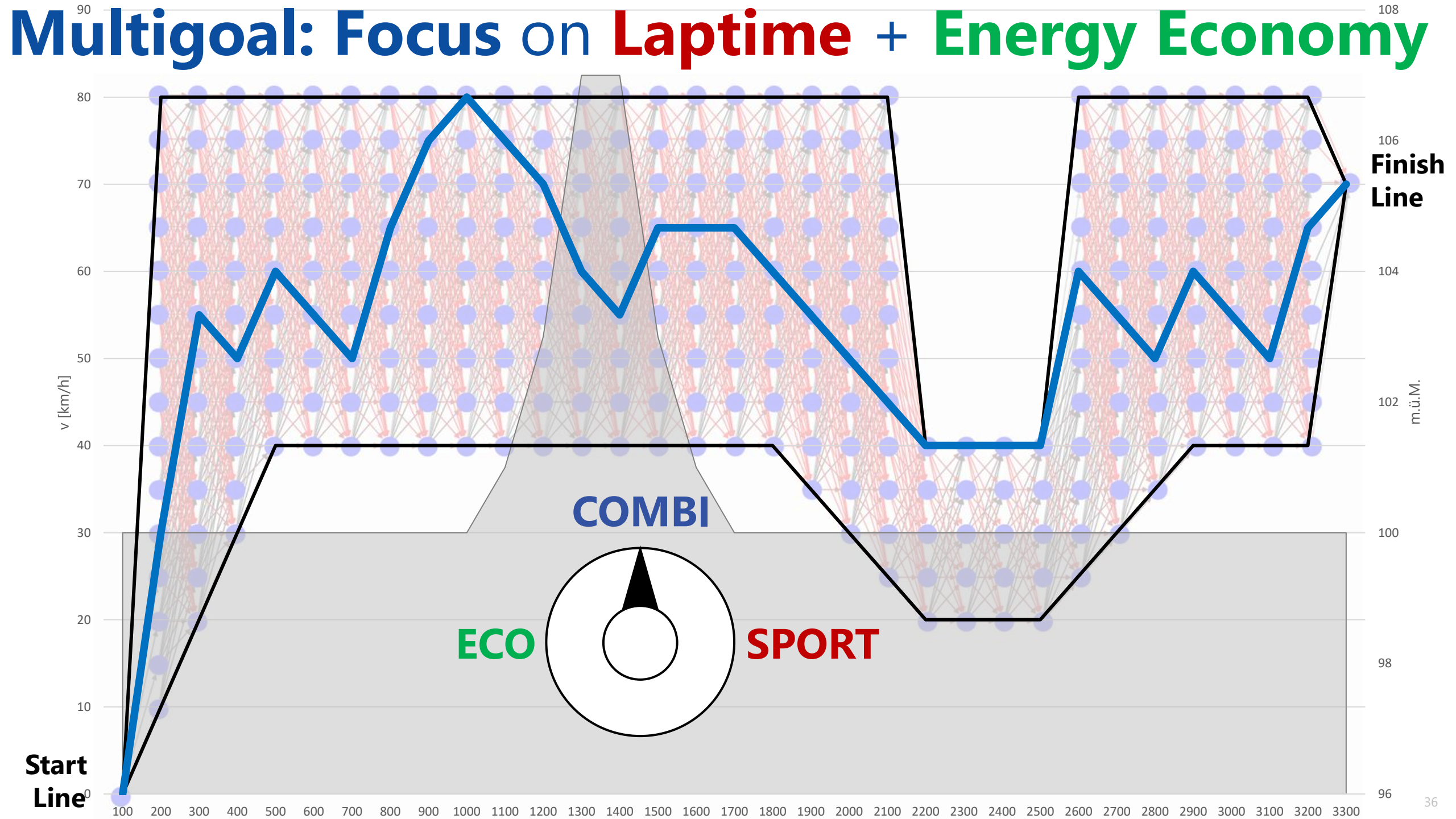
Multigoal: Focus on Laptime



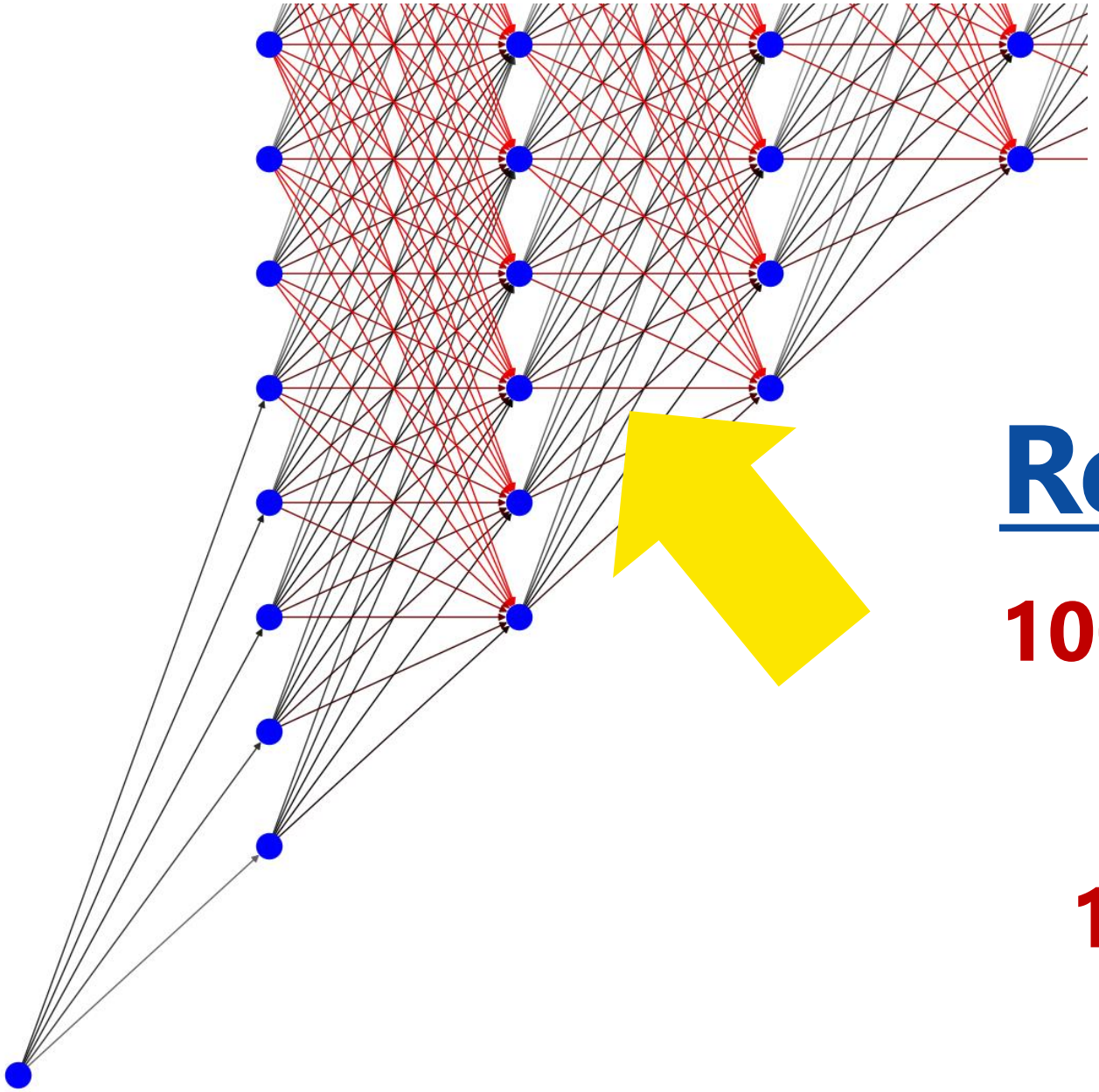
Multigoal: Focus on Energy Economy



Multigoal: Focus on Laptime + Energy Economy



Collecting **Knowledge** in the Nodes and Edges



Result:

100% Accident-free Attempts

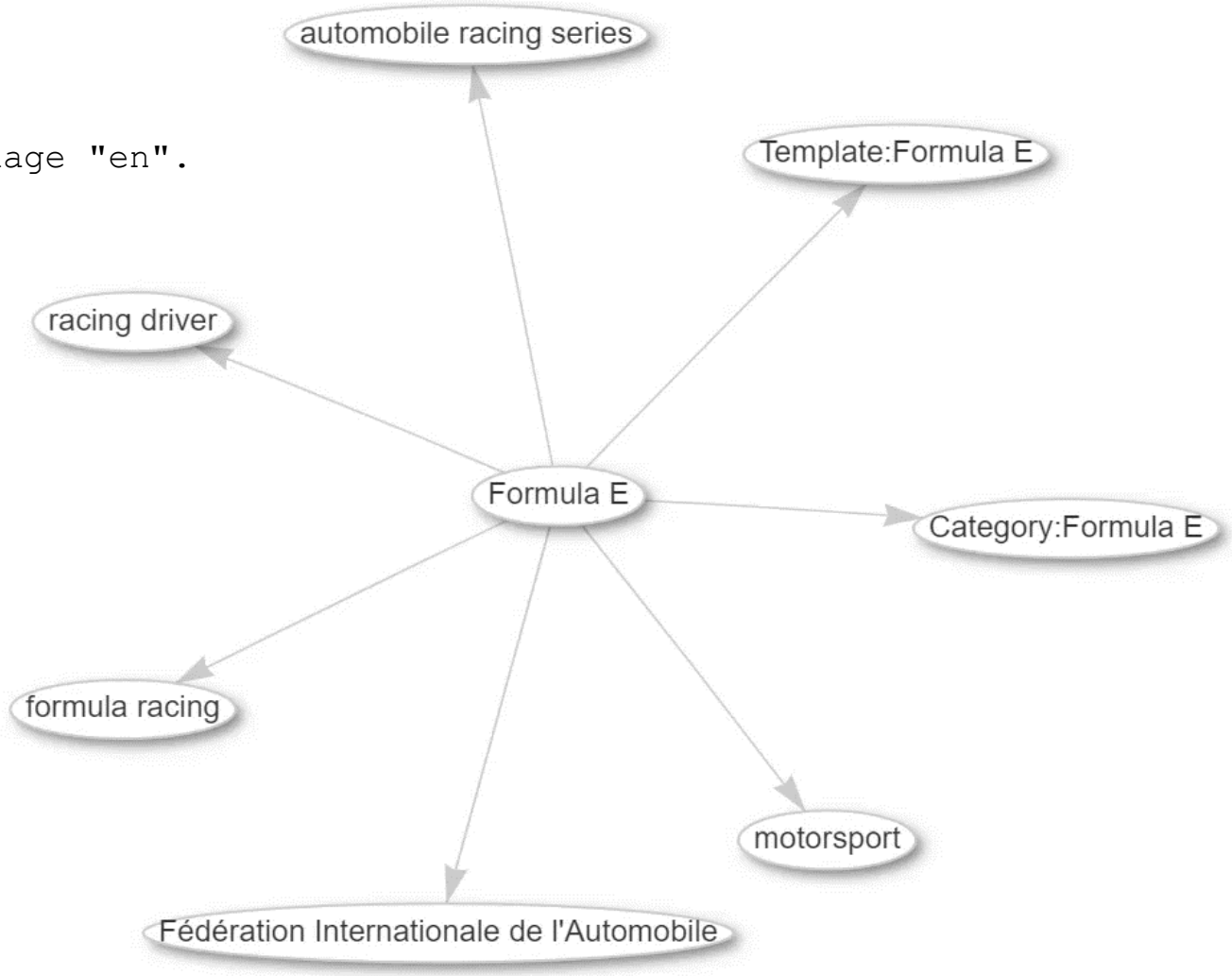
8% Shorter Lap Times

17% Higher Energy Efficiency


Practical
Examples from
day-to-day business

Exploring Large Subjects with WIKIDATA

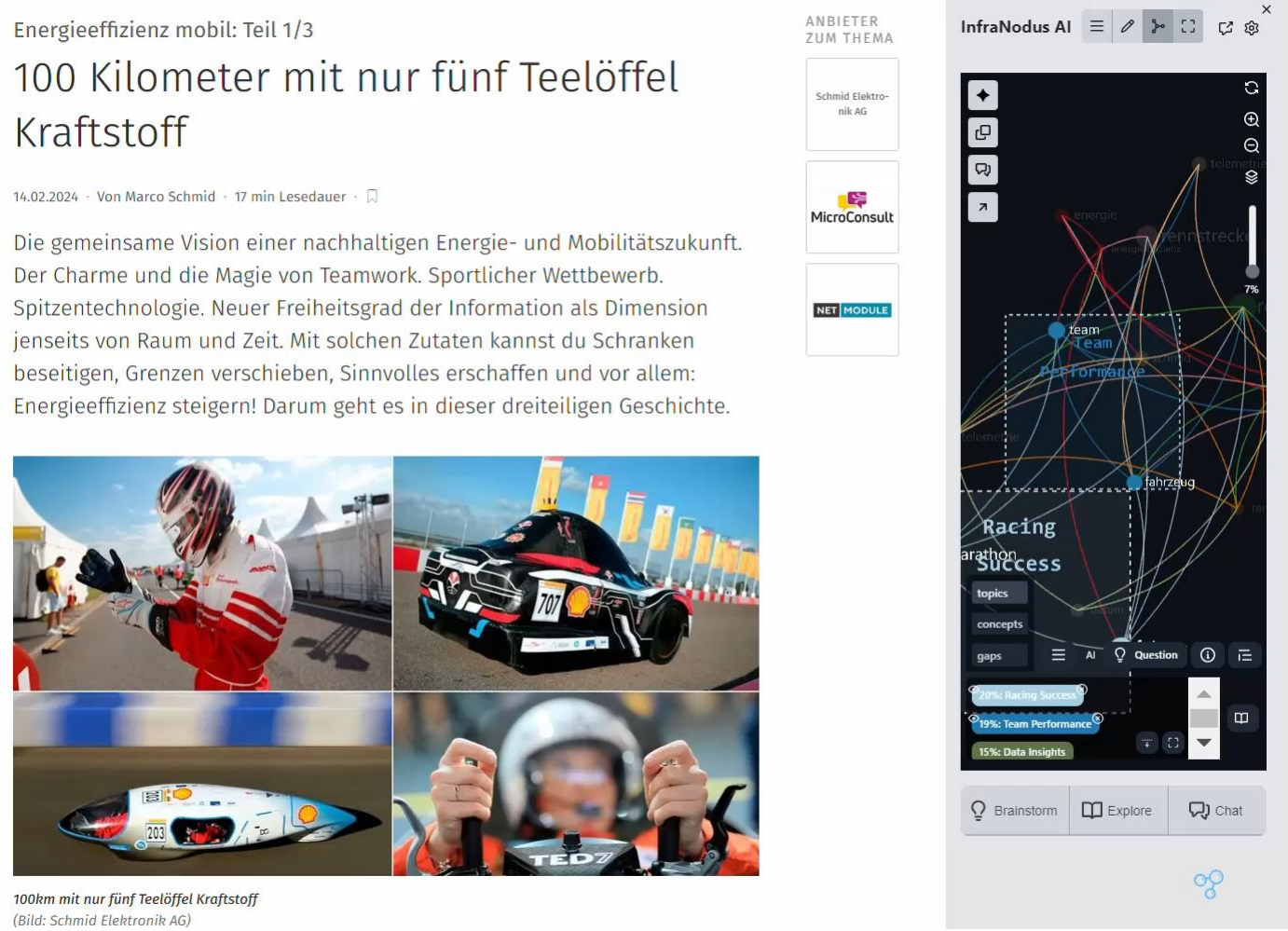
```
SELECT DISTINCT ?subject ?subjectLabel ?object
?objectLabel WHERE {
  VALUES ?subject {wd:Q319565}
  ?subject ?property ?object.

  SERVICE wikibase:label {
    bd:serviceParam wikibase:language "en".
  }
}
#defaultView:Graph
```



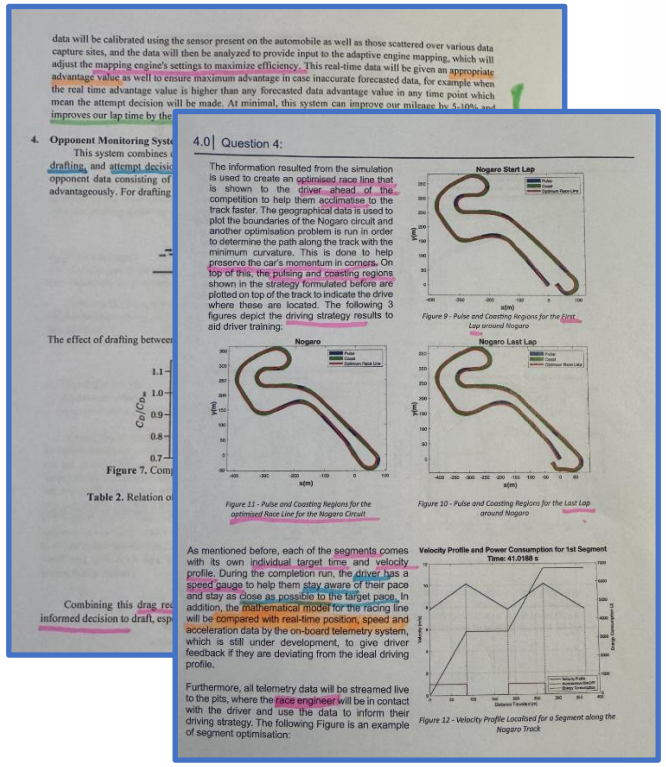
Reading Web-Articles

Classic Reading

New Style Reading



Talking to huge documents



data will be calibrated using the sensor present on the automobile as well as those scattered over various data capture sites, and the data will then be analyzed to provide input to the adaptive engine mapping, which will adjust the mapping engine's settings to maximize efficiency. This real-time data will be given an appropriate advantage value as well to ensure maximum advantage in case inaccurate forecasted data, for example when the real time advantage value is higher than any forecasted data advantage value in any time point which mean the attempt decision will be made. At minimal, this system can improve our mileage by 5-10% and improves our lap time by the

4. **Opponent Monitoring Syste**

This system combines
drafting, and attempt decisi
opponent data consisting of
advantageously. For drafting

The effect of drafting betwee

Figure 7. Com

Table 2. Relation o

Combining this drag re
informed decision to draft, esp

4.0 Question 4:

The information resulted from the simulation is used to create an optimised race line that is shown to the driver ahead of the competition to help them acclimatise to the track faster. The geographical data is used to plot the boundaries of the Nogaro circuit and another optimisation problem is run in order to determine the path along the track with the minimum curvature. This is done to help preserve the car's momentum in corners. On top of this, the pulsing and coasting regions shown in the strategy formulated before are plotted on top of the track to indicate the drive where these are located. The following 3 figures depict the driving strategy results to aid driver training:

Nogaro Start Lap

Figure 9 - Pulse and Coasting Regions for the First Lap around Nogaro

Nogaro

Figure 11 - Pulse and Coasting Regions for the optimised Race Line for the Nogaro Circuit

Nogaro Last Lap

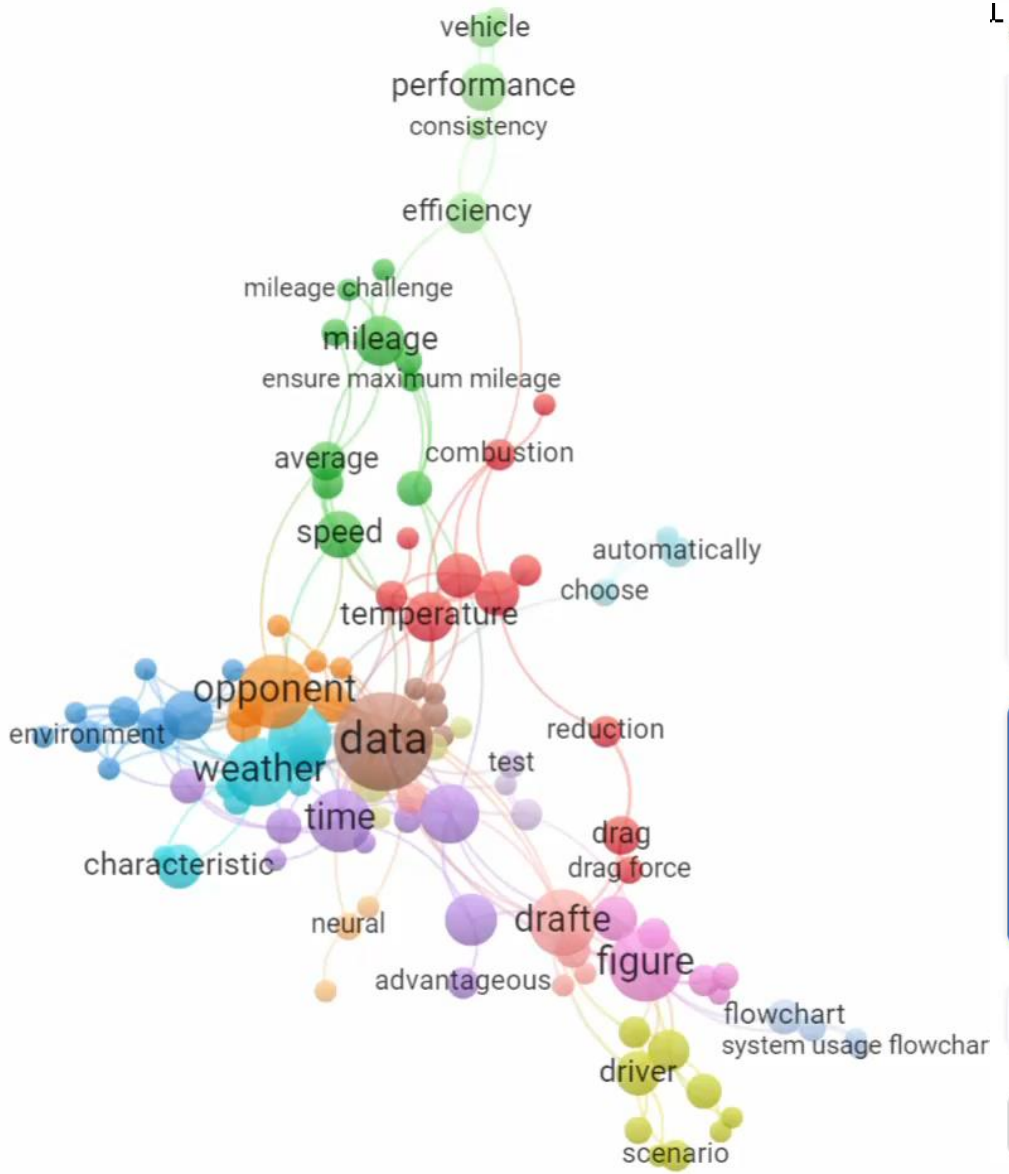
Figure 10 - Pulse and Coasting Regions for the Last Lap around Nogaro

As mentioned before, each of the segments comes with its own individual target time and velocity profile. During the completion run, the driver has a speed gauge to help them stay aware of their pace and stay as close as possible to the target pace. In addition, the mathematical model for the racing line will be compared with real-time position, speed and acceleration data by the on-board telemetry system, which is still under development, to give driver feedback if they are deviating from the ideal driving profile.

Velocity Profile and Power Consumption for 1st Segment
Time: 41.0188 s

Furthermore, all telemetry data will be streamed live to the pits, where the race engineer will be in contact with the driver and use the data to inform their driving strategy. The following Figure is an example of segment optimisation:

Figure 12 - Velocity Profile Localised for a Segment along the Nogaro Track



Chat

and drivers, including advantage values for various parameters that influence performance.

- **Informed Decisions**: The visual representation of data helps the team make quick, informed decisions during races.

5. **Expected Outcomes**:

- The strategy aims for a 5-15% increase in overall efficiency and improved consistency in performance, positioning the car competitively for the Driver's World Championship.

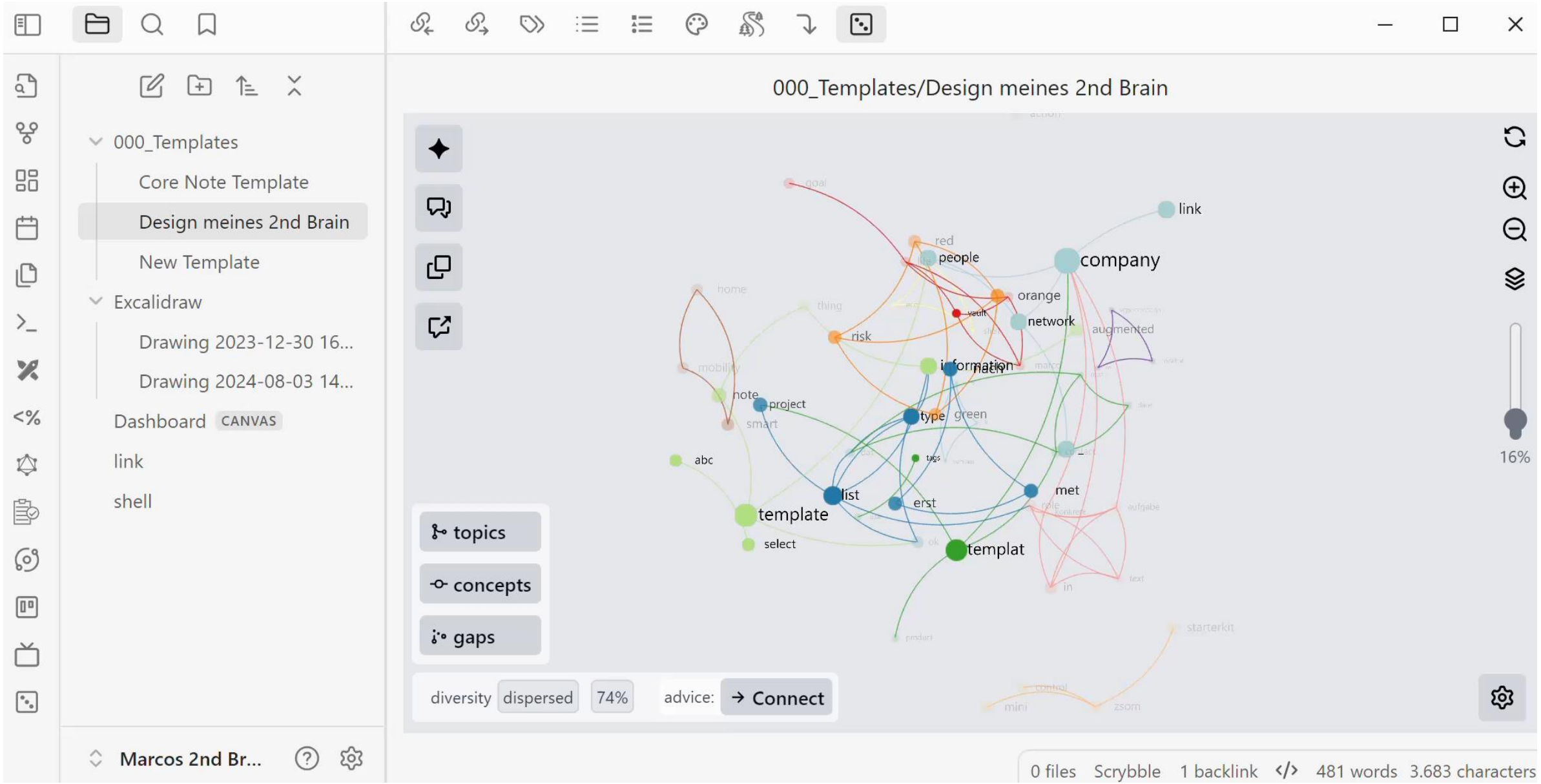
This comprehensive data strategy integrates environmental analysis, opponent behavior, and engine performance to enhance the team's racing capabilities.

I will ask you five more technical questions on the content of the PDF. You will only focus on the data of this PDF and not use any other data from the internet. When you give your answers, please do so short an concsise and in maximum 7 bullet points. The answers must not exceed 100 words.

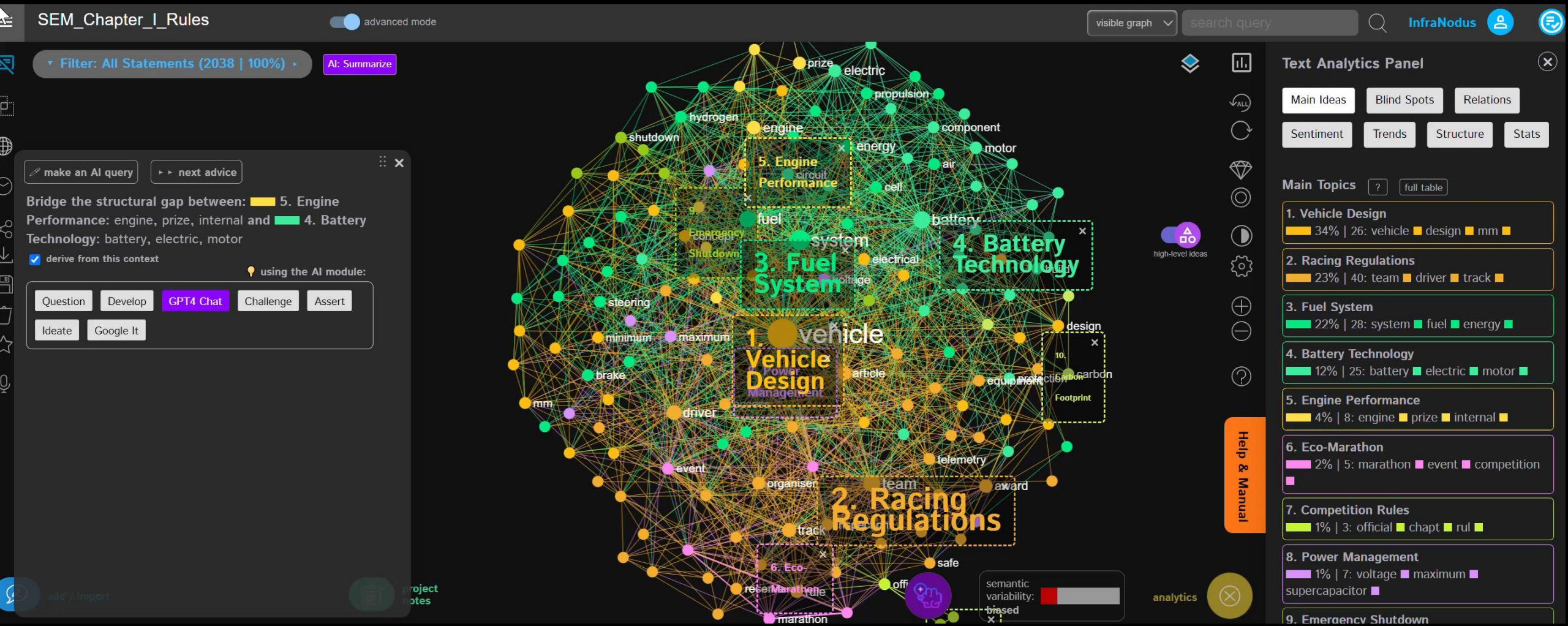
Understood! Please go ahead with your questions.

Ask any question...

Curate your 2nd Brain



Exploring a collective Brain where you store and retrieve Data Driven Racing Knowledge



schmid-elektronik.ch/**sandbox2_en/**

schmid-elektronik.ch/**sandbox1_en/**

About us

Schmid Elektronik is a family-run, Swiss technology SME for embedded systems and industrial electronics. Customers are supplied with feasibility studies, prototypes, pilot series, minimum viable products (MVP), batch size 1 as well as small and medium series. Market services include hardware and software engineering, products for LabVIEW on customer-specific hardware and production services (EMS). One of Schmid Elektronik's specialties is Internet-of-Things things.

Since 2007, Schmid Elektronik has been one of the NI Partners, specialized for LabVIEW on Embedded-Hardware.

Z-BRAIN®

The ZBrain product family from Schmid Elektronik consists of hardware platforms for embedded systems that are graphically programmable with NI LabVIEW (RT, FPGA). With this Schmid Elektronik completes the NI platform (sbRIO, cRIO, PXI, SLSC) and enables its customers to run LabVIEW on their own hardware. Be it in prototypes, MVPs or products.

Schmid Elektronik is an official partner of the Shell Eco-marathon and part of its Data & Technology Team. Schmid Elektronik has been providing development and production services as well as products and on-site services for the telemetry system since 2015.

Services include webinars, jury in the Data & Telemetry Off-Track-Award, Bootcamps and Technical Vehicle Inspection. The Swiss family-owned SME thus joined the ranks of global players, which are also partners in the program.

About me

The systems engineer in me has a passion for embedded systems, LabVIEW, Python, IoT, MVPs, complexity, networks, dimensions, augmented intelligence and amazing innovation (AI).

As an entrepreneur, I enjoy the privilege of coaching the smart leadership and development team of a 40-person, 50+ year old family business.

I orientate myself on the Swiss style of modesty, quality and reliability, the courageous pioneering spirit of Silicon Valley and the unity of opposites from Asian philosophy.

Three times a year, I leave my desk and become a technician again at Shell Eco-marathon, inspecting vehicles and teaching students data-driven racing technology in the form of boot camps. Because a sustainable energy and mobility future is close to my heart.

Contact

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