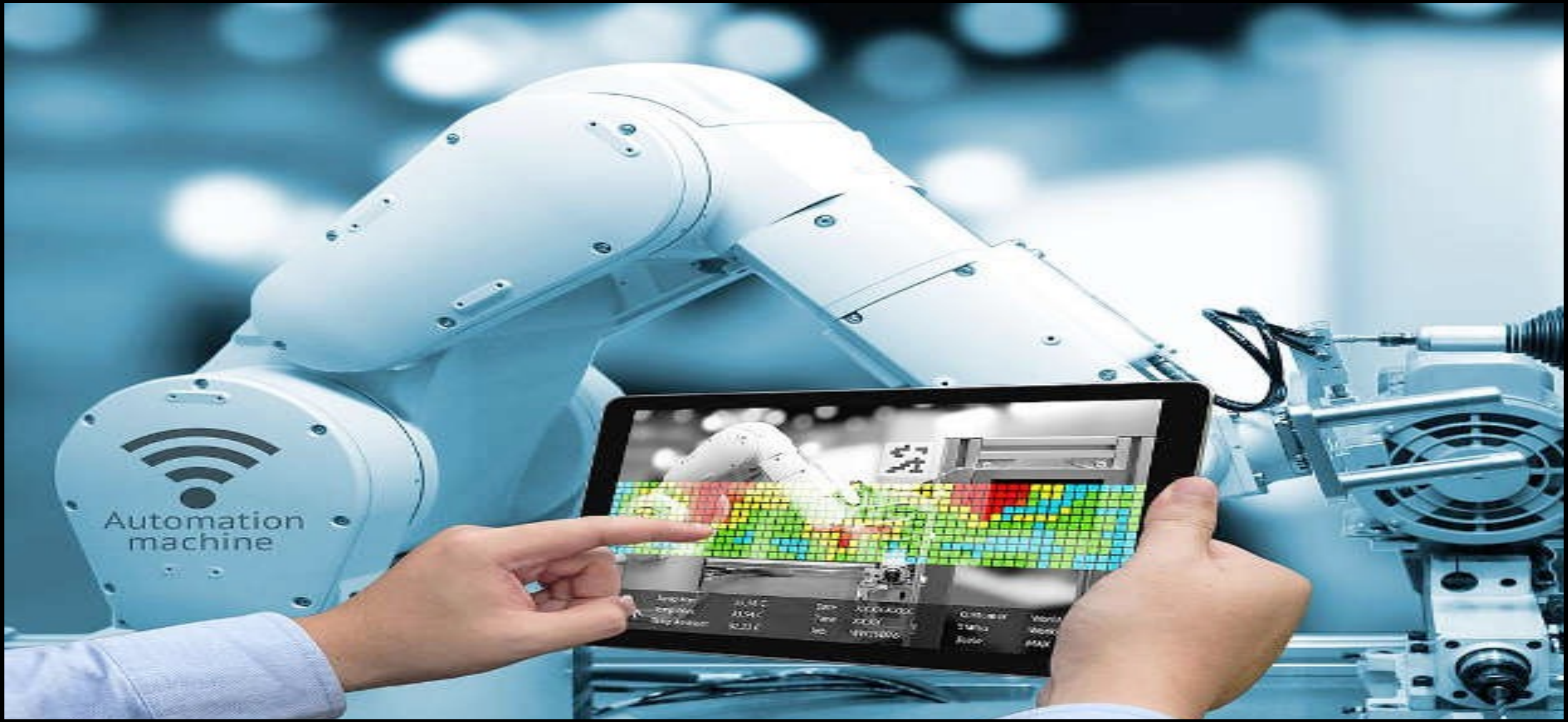
YOLO

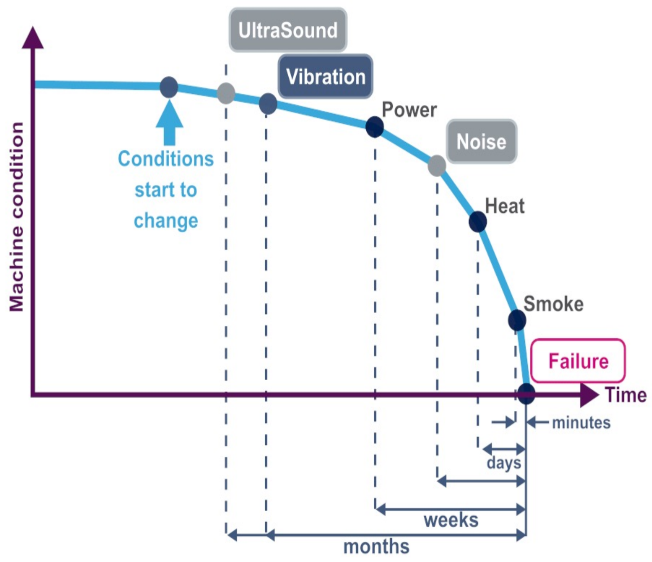
Younger for longer

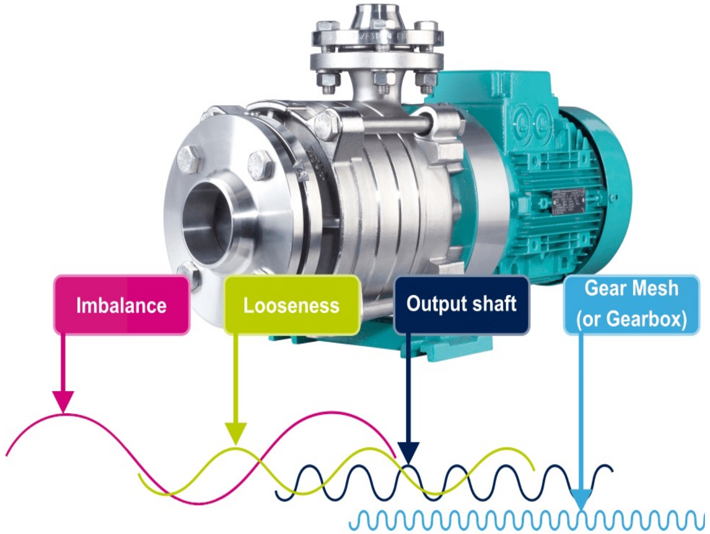


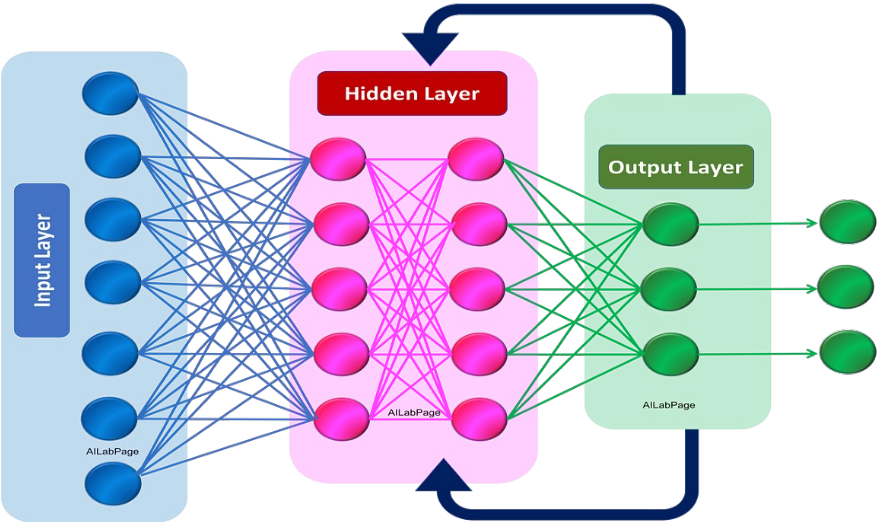
Marielle Stoelinga

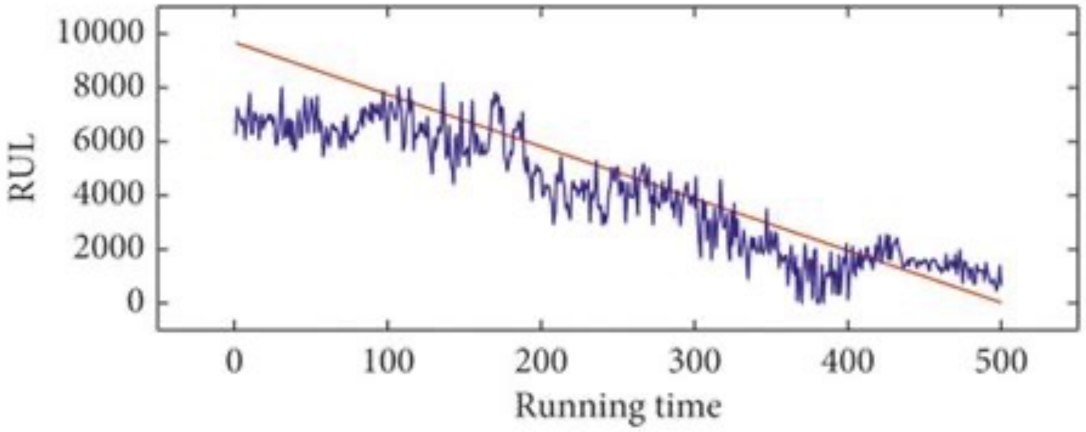
University of Twente & Radboud University, NL


PrimaVera

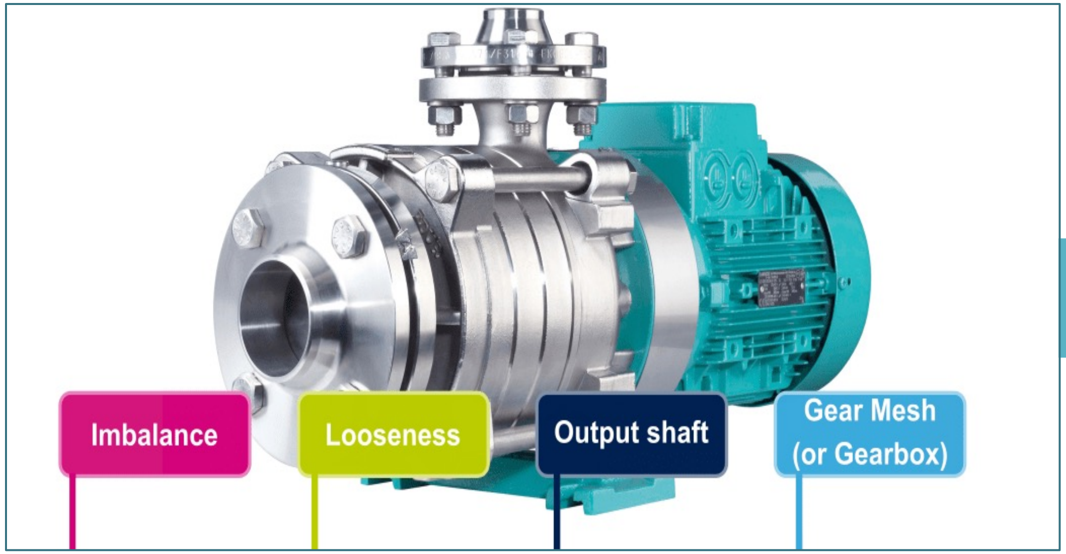


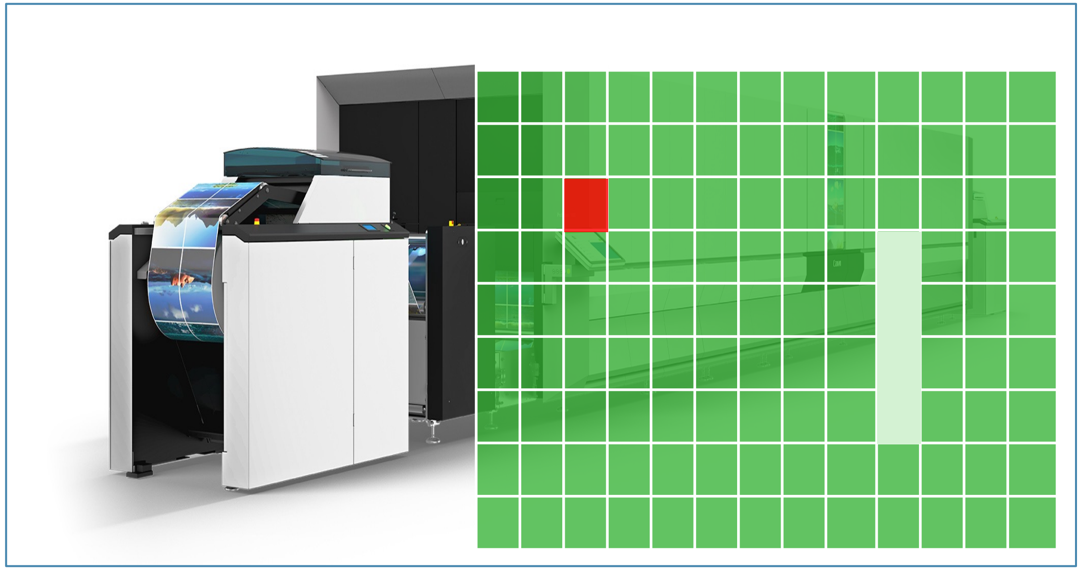






Remaining Useful Life = time before system needs maintenance or repair





Component RUL

System RUL

System-level predictions

- More than the sum of its parts
- The components role in a system is crucial
- Failures cascade, interact, amplify

Not a scaling issue — but a paradigm shift

Integrated Systems Health Management for Intelligent Systems

Fernando Figueroa [1]
NASA Stennis Space Center, MS, 3952, USA

CSG
DIaK
DIaKA
FCL
FET
FMEA
GN
IMBT
IPA
IS
ISHM
ISHM-DM
KSC
LC-20
LOX
NASA
NCAP
OSA-CBM
RCA
RETS
S4
SS

sensors
MDPI

Review
Challenges and Opportunities of System-Level Prognostics

Seokgoo Kim [1,2], Jo

Dependent failure behavior modeling for risk and reliability: A systematic and critical literature review ☆

Zhiguo Zeng
[a] *Chair on Risk and I*
[b] *Department of Indus*

A R T I C L E

Keywords:
Dependent failure be
Risk
Reliability

System-level failure prognostics: Literature review and main challenges

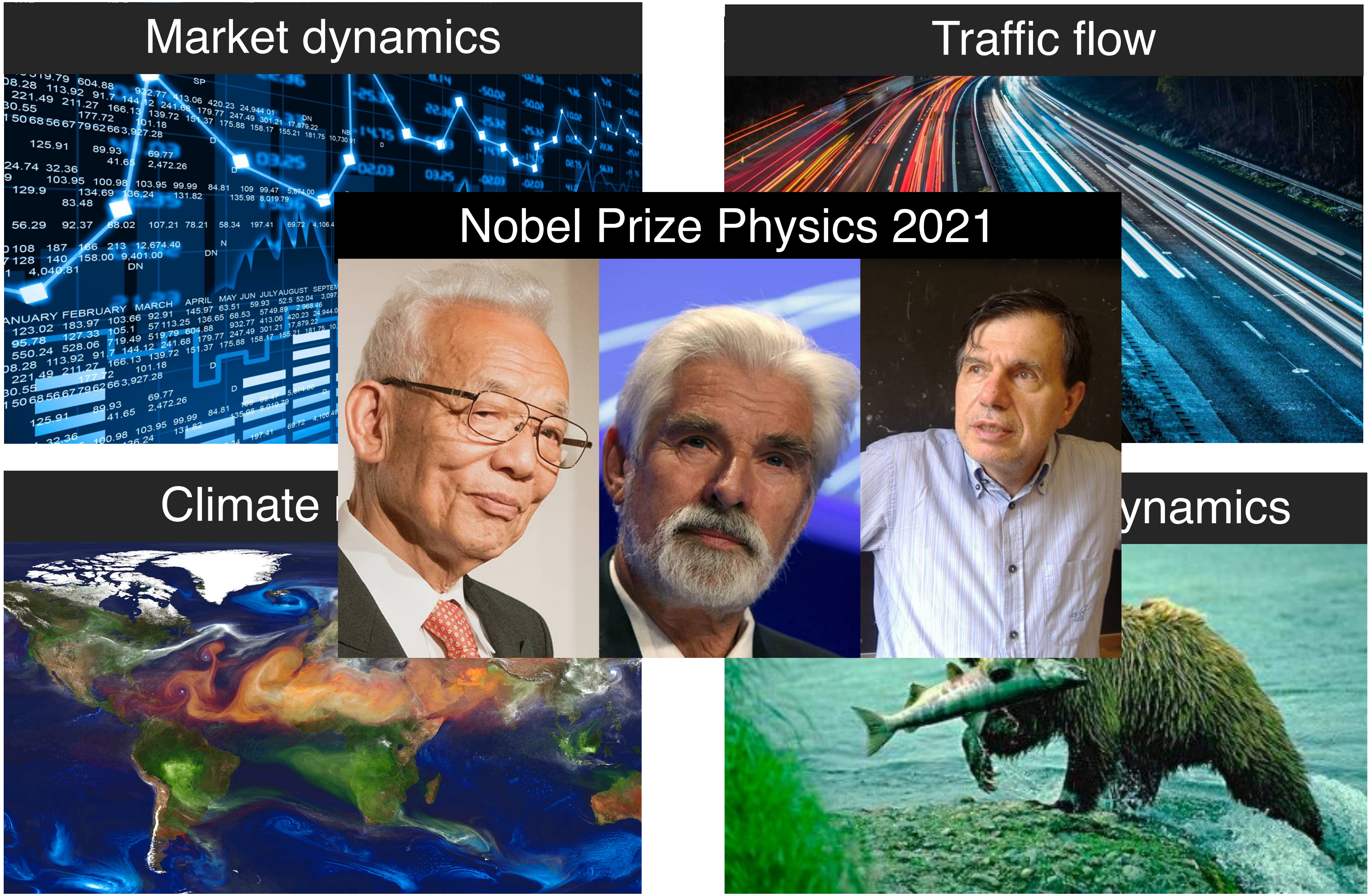
Journal of Risk and Reliability

DOI: 10.1177/1748006X221118448
www.sagepub.com/

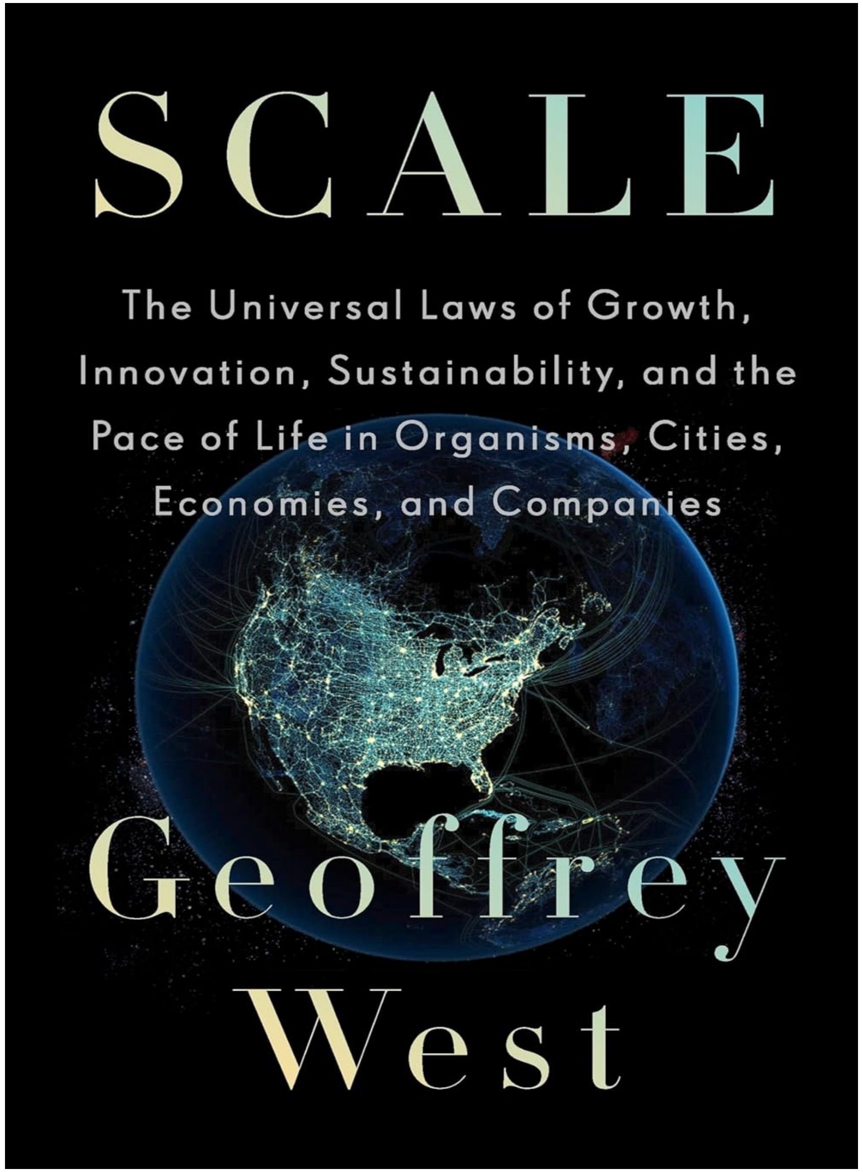
Ferhat Tamssaouet[1]

Abstract
This paper reviews met
system remaining useful
provided, emphasizing th
comprehensive review of

Complexity science



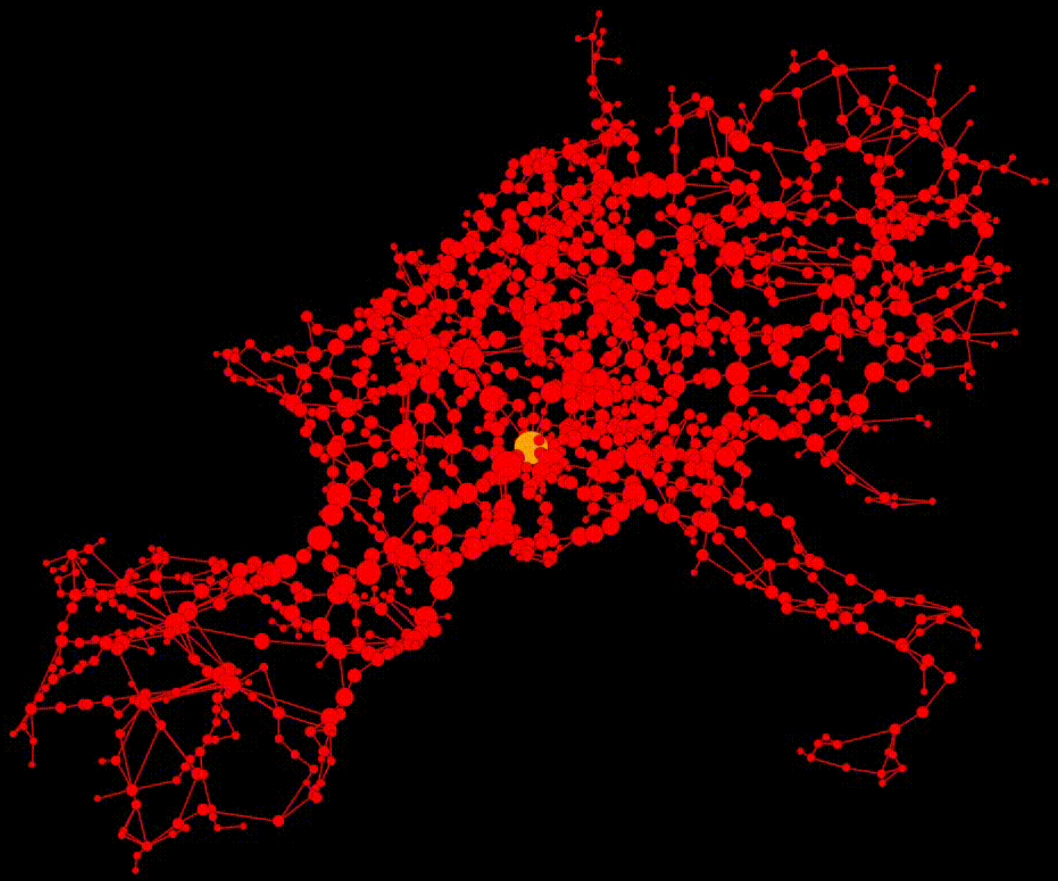
Complex adaptive systems



Emerging behaviour

- Ants follow simple rules
- **Global** behavior (bridge building) emerges from **local** interactions

Emergent failure behavior



Power transmission network

Overloaded nodes

Complex adaptive systems

Complex adaptive systems

- Many interacting agents
- **…** e.g. people, firms, neurons
- that evolve and learn over time
- Cities, ecosystems, ant colonies, economies, internet, brains

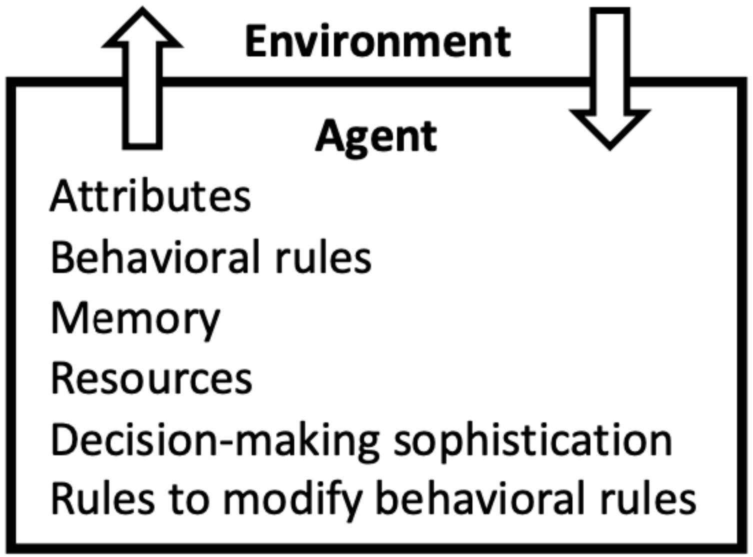
Emergent behavior

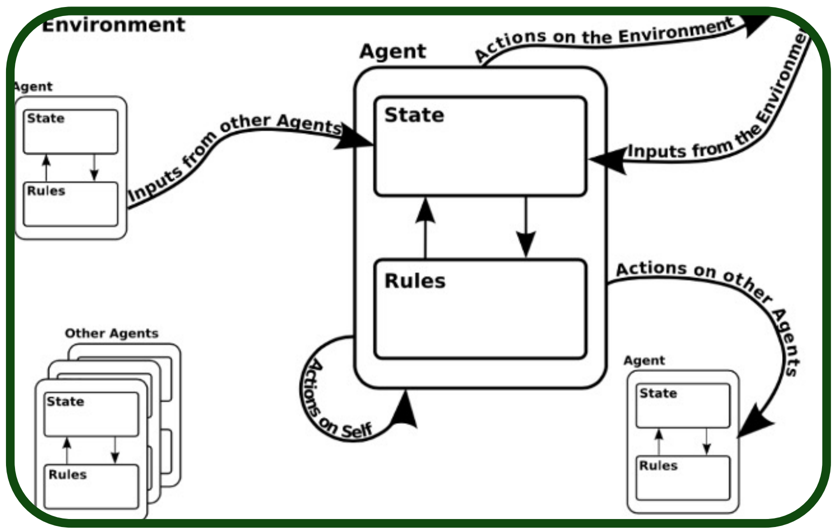
- Whole is more than sum of its parts
- Nonlinear dynamics:
  - Small changes have big effects
  - Tipping points

Emergent failures

- Whole is more than sum of parts
- Nonlinear dynamics:
- Small changes have big effects
- Do not treat CPSs as **artifacts**, but as **organisms**

Agent-based models: large scale simulation models





Agent-based models

Complex systems as interacting agents

- Local state
- Decision rules / update
- Interaction with environment

Agent-based maintenance

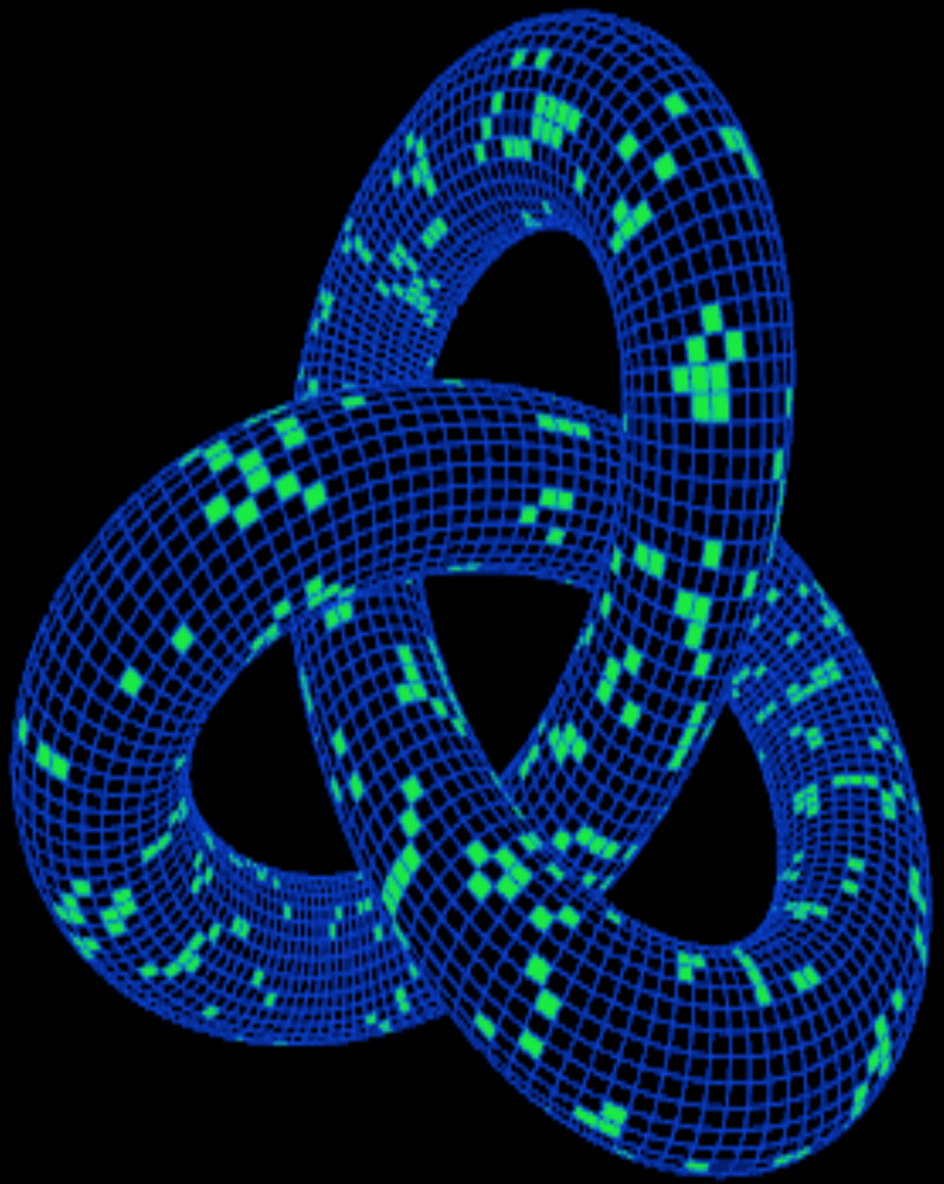
- Components with degradation states
- .. Depending on environment (load)

…. and other components

- Maintenance & repair units

Lee, J., Mitici, M., Blom, H. A. P., Bieber, P., & Freeman, F. (2023). *Analyzing Emerging Challenges for* Data-Driven Predictive Aircraft Maintenance Using Agent-Based Modeling and Hazard Identification. Aerospace.

Agent example: Conway's Game of life



Formation of life

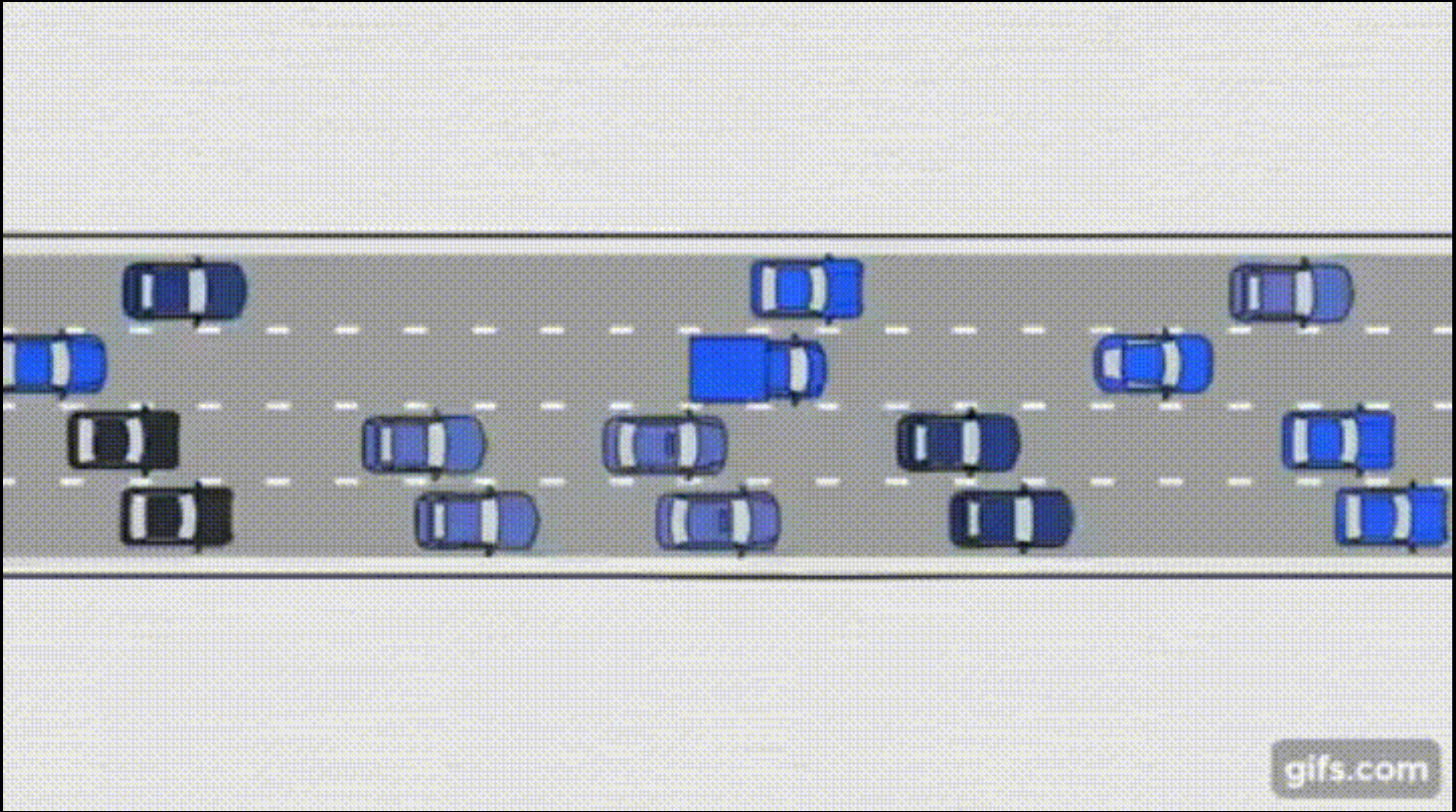
- Agents = cells

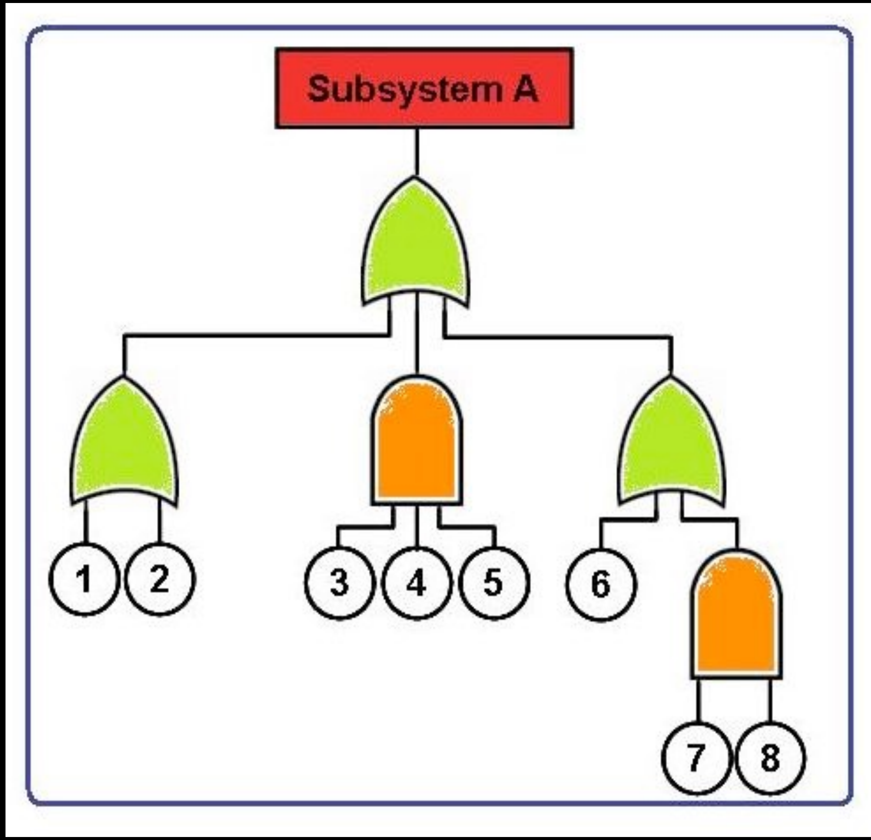
Live cell

- 0-1 live neighbour → die
- 2-3 live neighbours → live
- 4 live neighbours → die

Dead cell

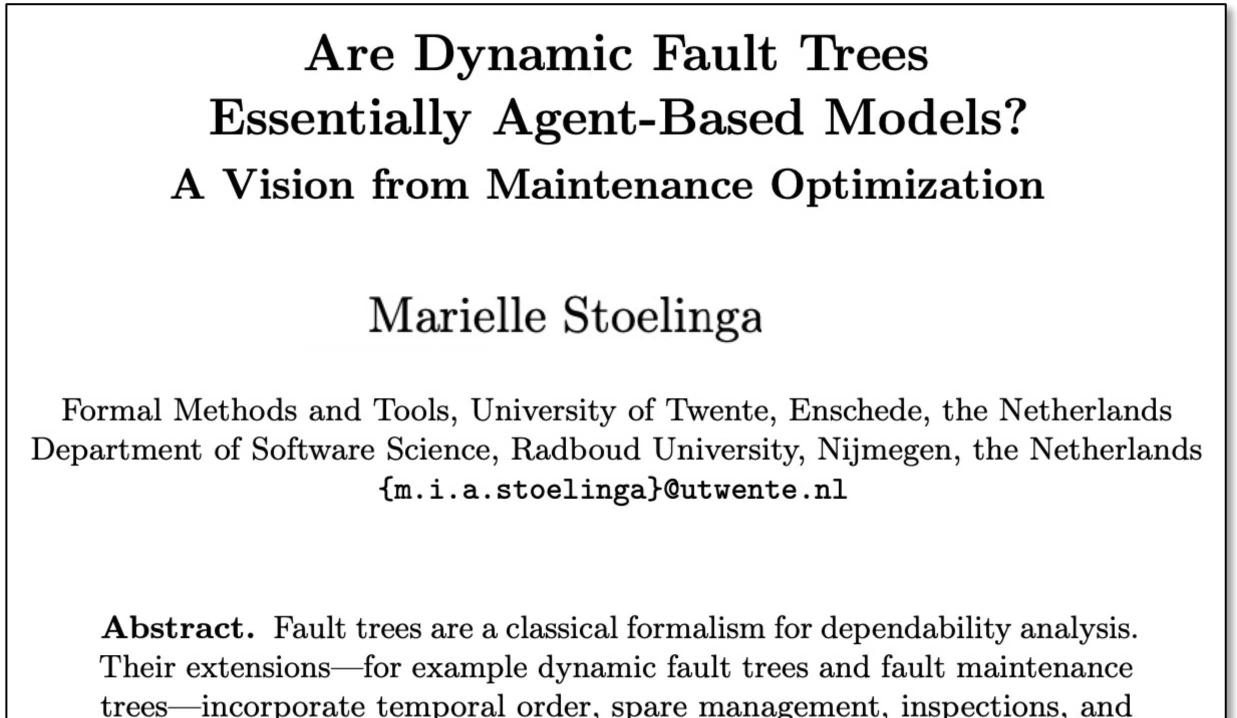
- 3 live neighbours → live





PART 2

Are fault trees actually agent-based models?



Are Dynamic Fault Trees Essentially Agent-Based Models?

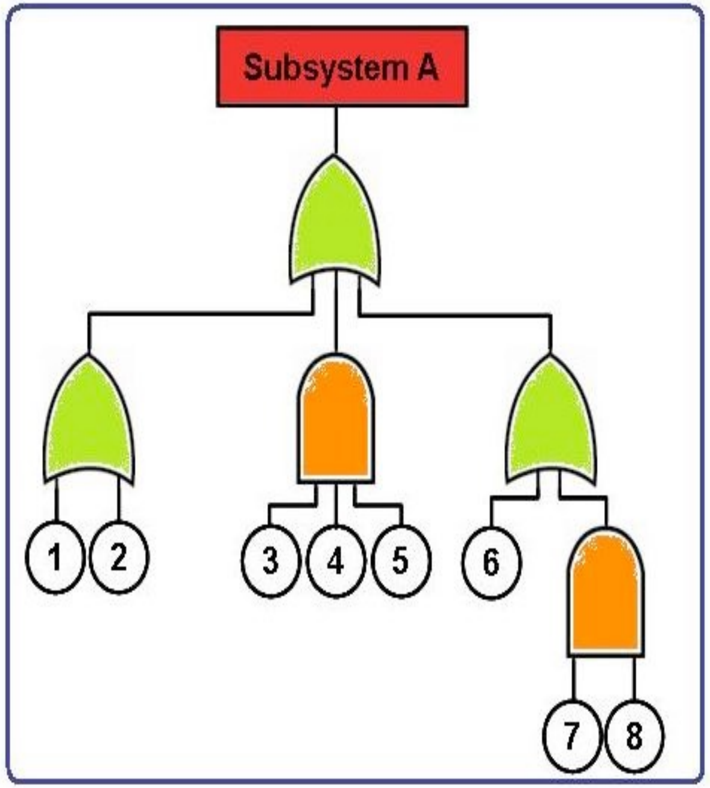
A Vision from Maintenance Optimization

Marielle Stoelinga

Formal Methods and Tools, University of Twente, Enschede, the Netherlands
Department of Software Science, Radboud University, Nijmegen, the Netherlands
{m.i.a.stoelinga}@utwente.nl

Abstract. Fault trees are a classical formalism for dependability analysis. Their extensions—for example dynamic fault trees and fault maintenance trees—incorporate temporal order, spare management, inspections, and

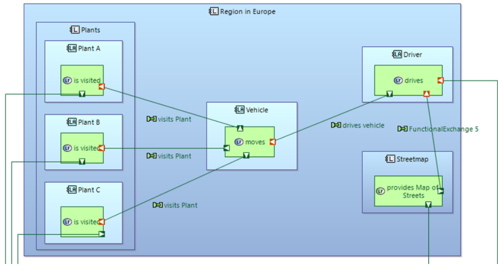
Fault trees: what are they?

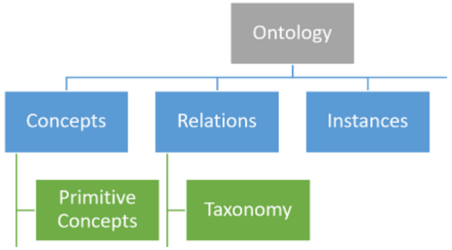


Graphical Model
- Tell how systems fail
- How do component failures lead to system failures?

Qualitative Analysis
- Pinpoint to root causes & critical parts

Quantitative Analysis: metrics / KPIs
- Reliability: **P**[no failure during mission time]
- Availability: **E**[up-time]
- …





Rijkswaterstaat

Fault trees

Nuclear power plants

> 50.000 BEs

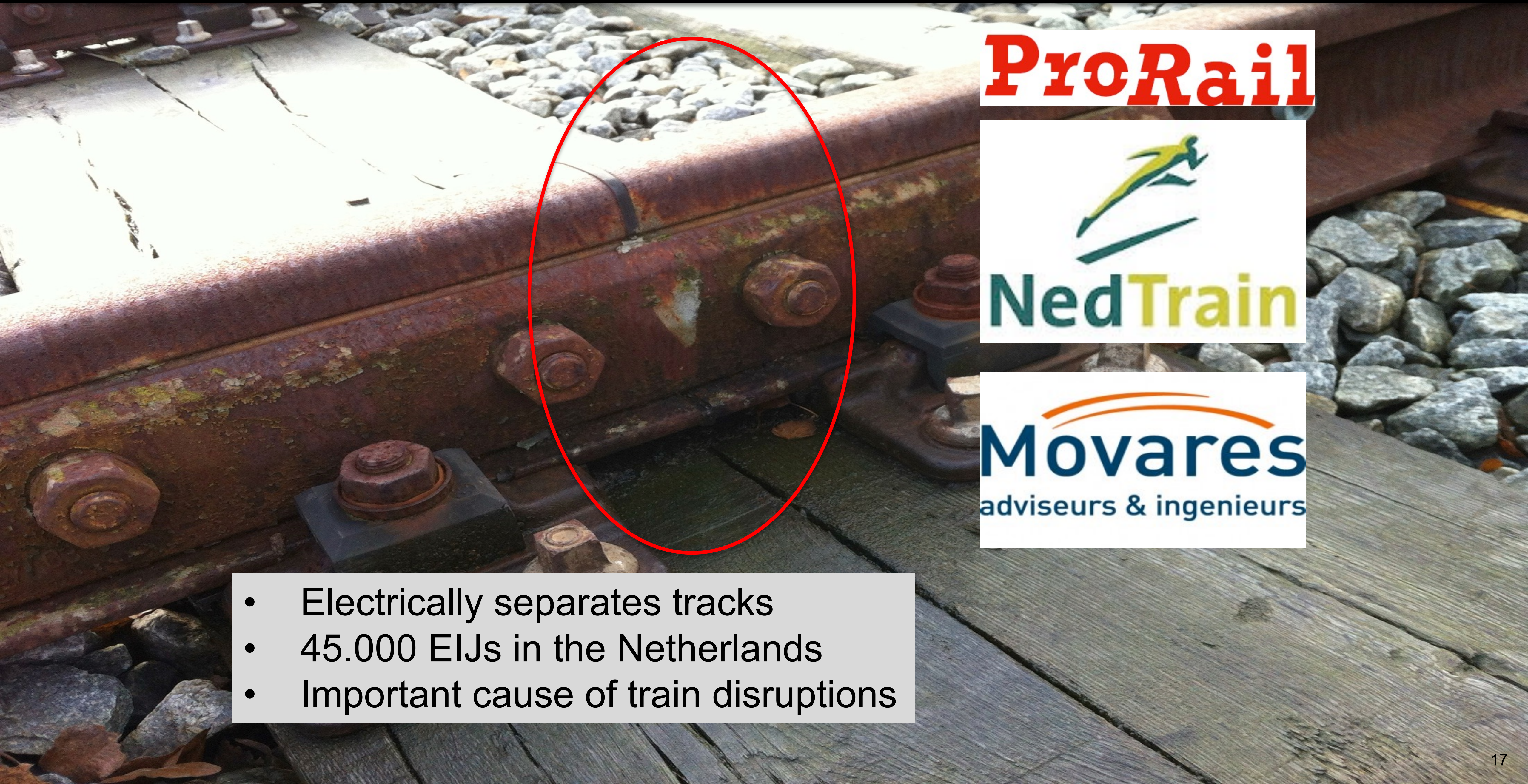
Storm surge barriers

> 100 layers

Railways

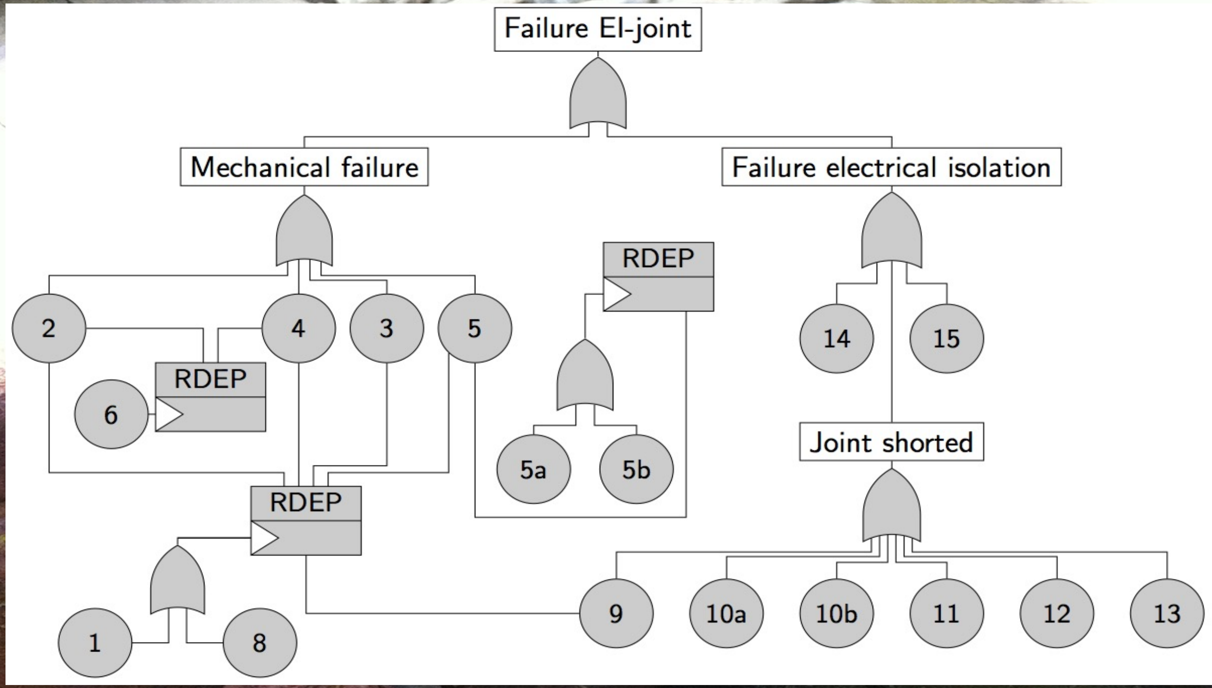
Complex

Case study: Electrically Insulated Joint

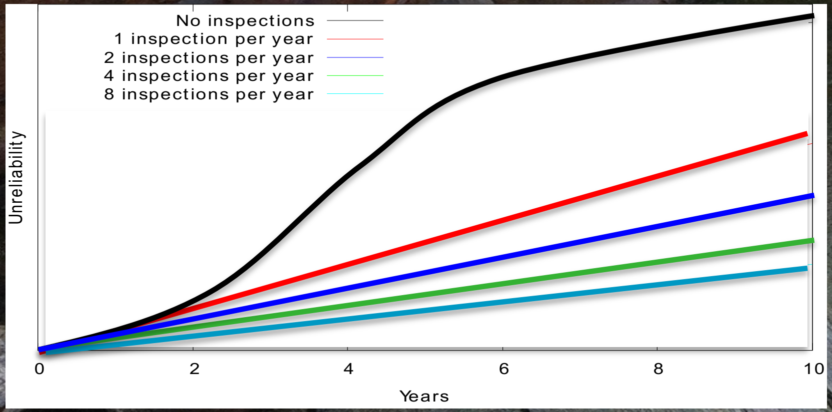


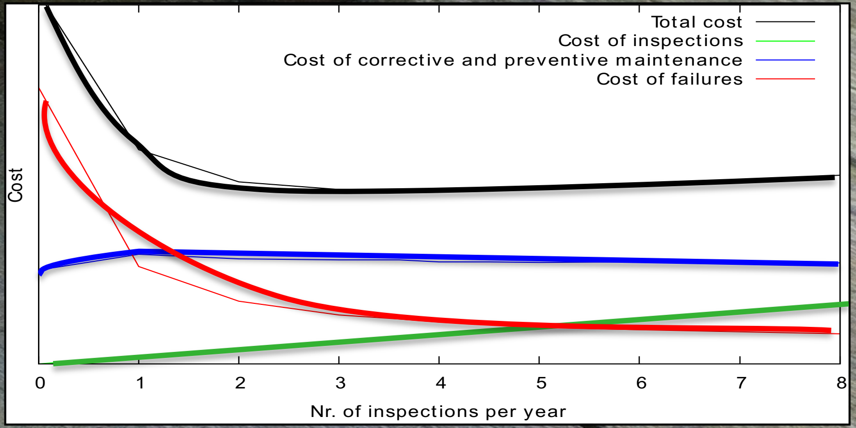
- Electrically separates tracks
- 45.000 EIJs in the Netherlands
- Important cause of train disruptions

Railroad joint: analysis results

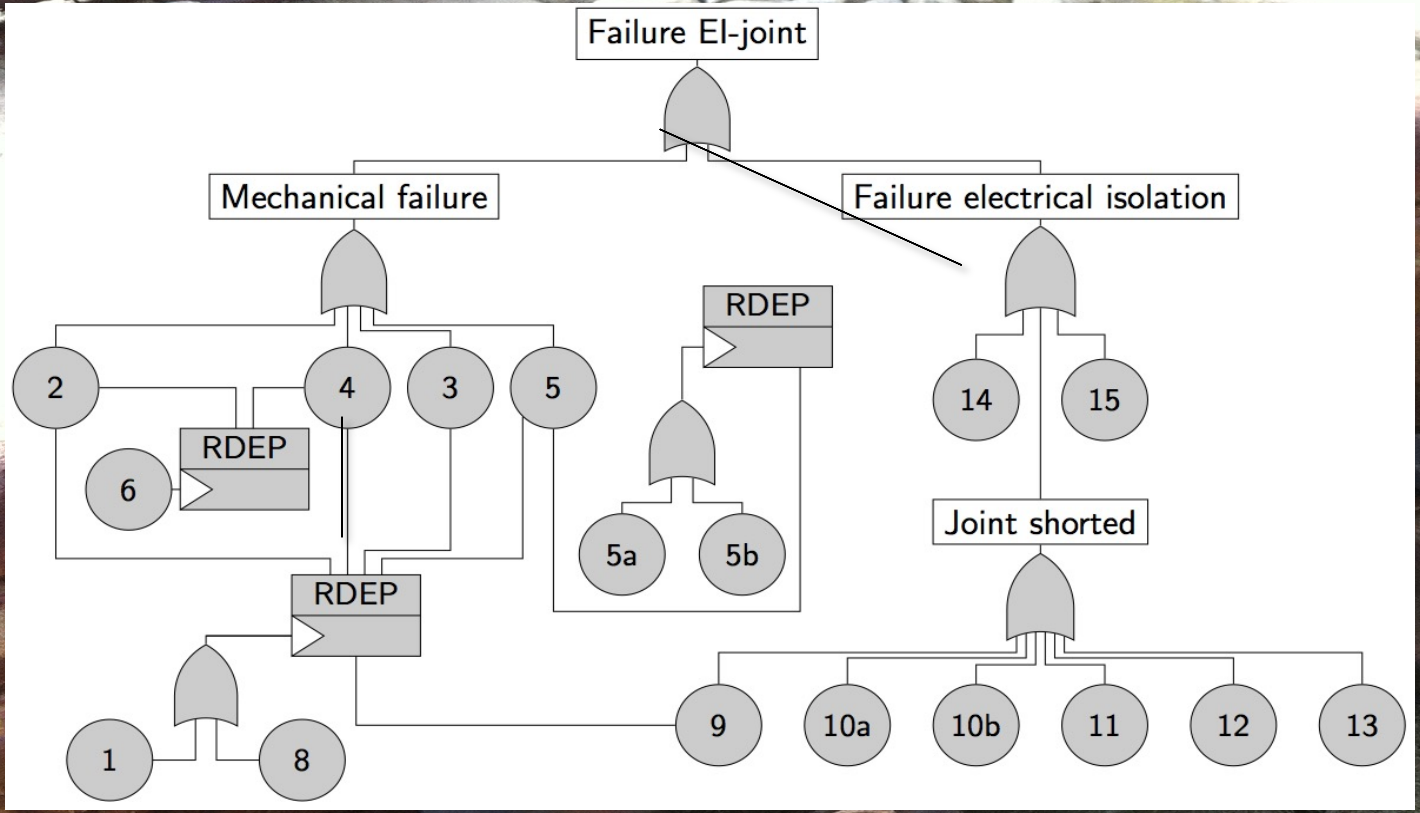


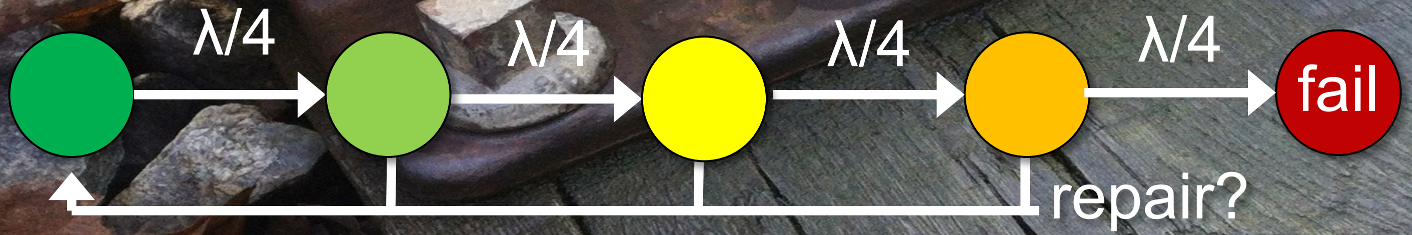
1. Bad geometry
2. Broken fishplate
3. Broken bold
4. Broken rail head
5. Glue broken
6. Battered head
7. Arc damage
8. Broken end plate
9. Overhang
10. a,b: Shavings (normal/ coated)
11. Splinters
12. Object
13. Grinding
14. Maintenance
15. Low resistance





Fault trees as agents





Agents

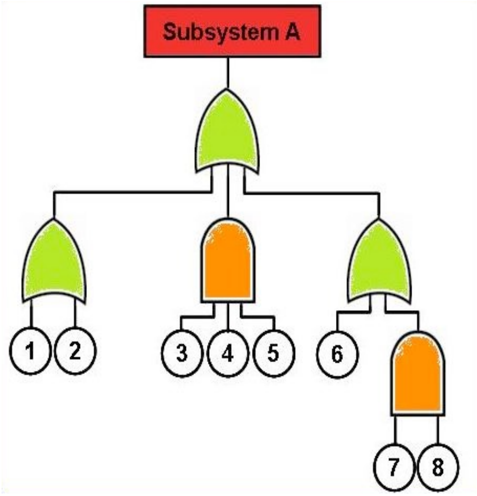
Degradation behavior
- Multi-state, not boolean
- Repairs yield better state

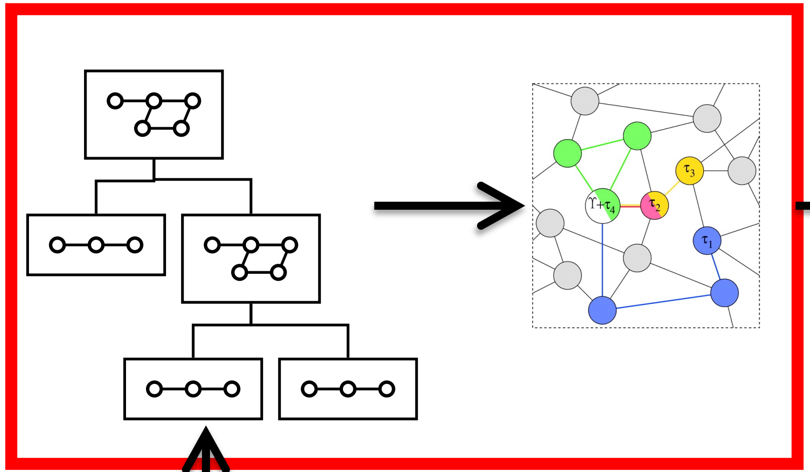
Repair units
- Interacts with components
- Repair one compnent at the time
- Repair times

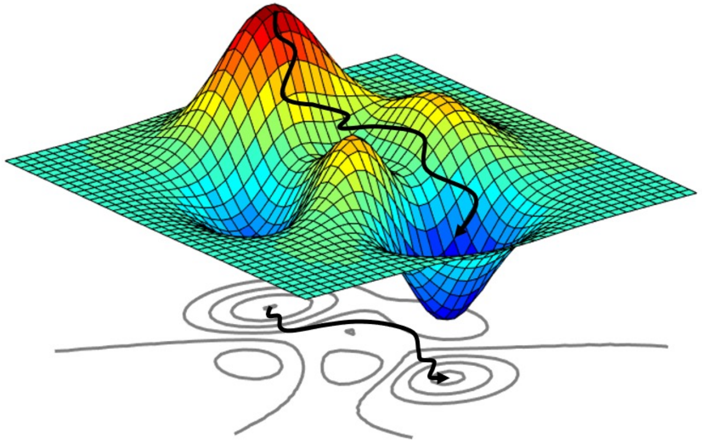
Spare parts
- Interacts with components
- Repair one compnent at the time
- Repair times

Planning / optimization
- How many repairs/spares needed?
- Cost-optimility?

Are fault trees agent-based models?







Interactive agents
- Individual states
- Interaction rules

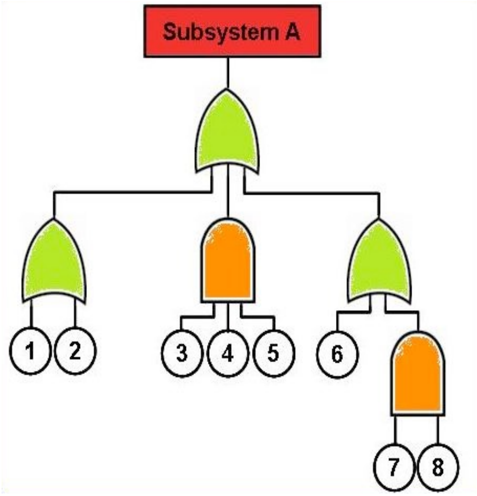
Different types
- Component failure behaviour
- Repair unit
- Spare management unit

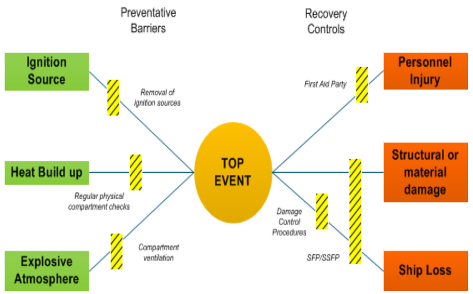
Complex systems

Interactive agents
- Not autonomous
- Not heterogeneous
- Not adaptive / learning

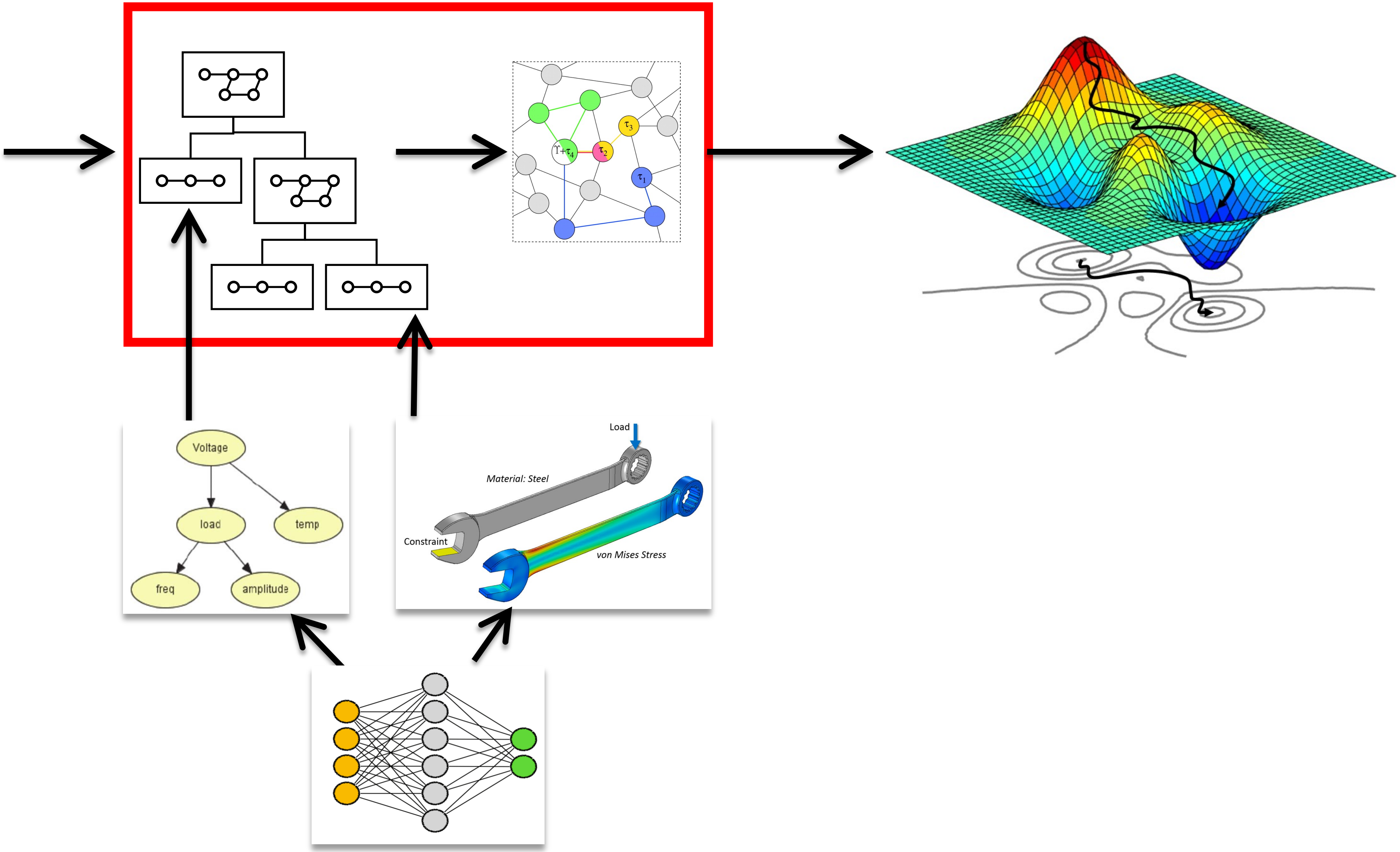
Interaction types
still limited

Are fault trees agent-based models?

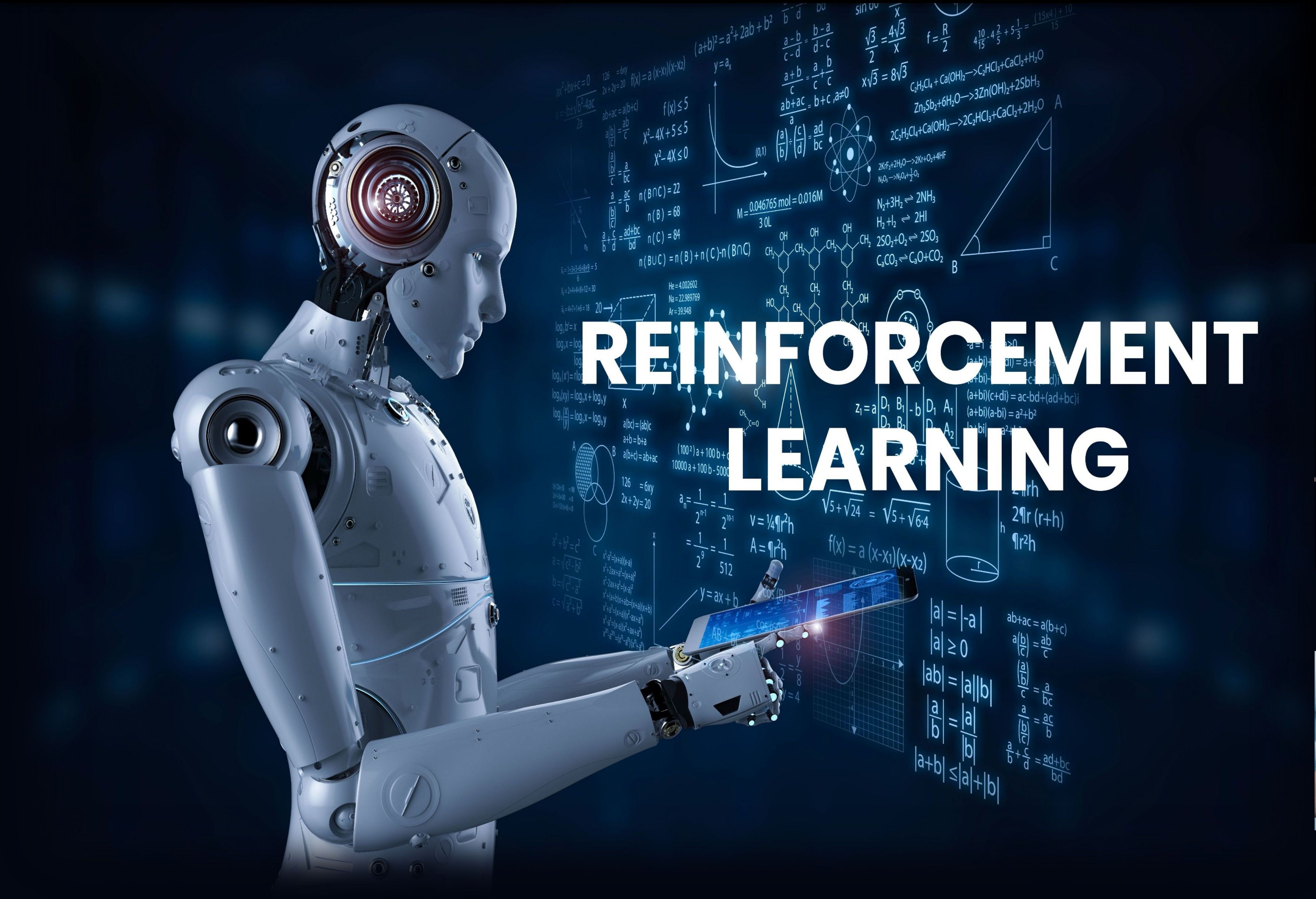




SysML



From analysis to planning & optimization

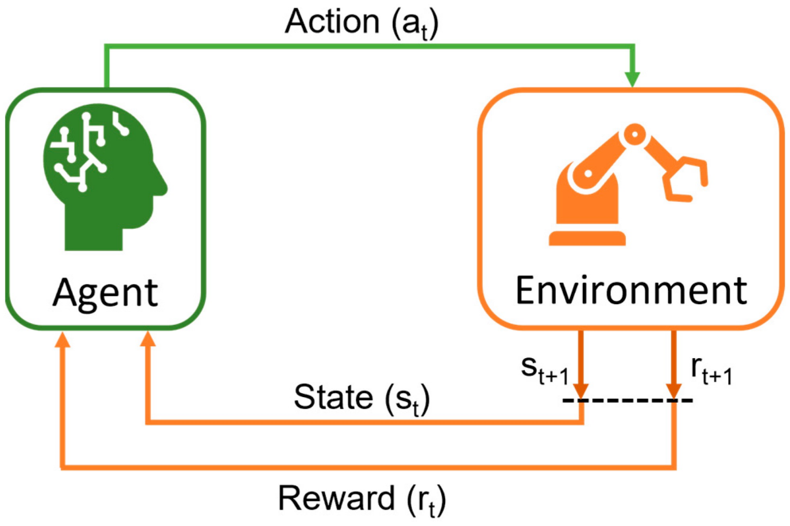


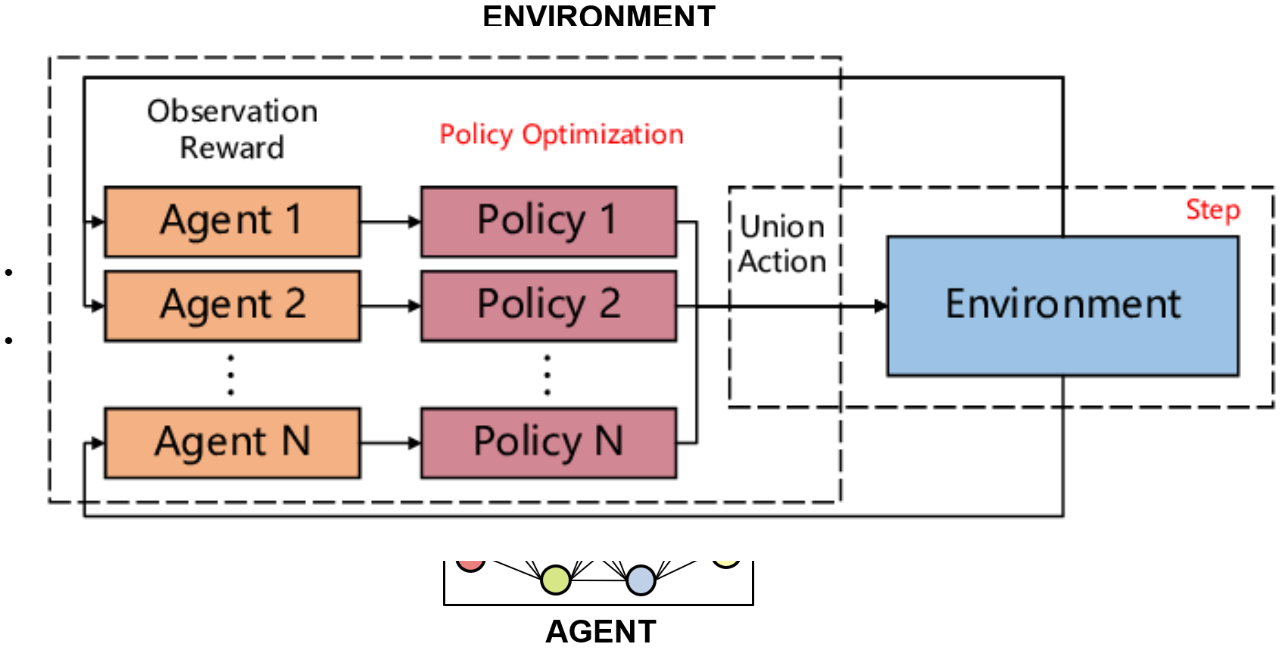
Q- learning =

Reinforcement learning method

https://www.youtube.com/shorts/IOF6ItD6RpA

Reinforcement learning

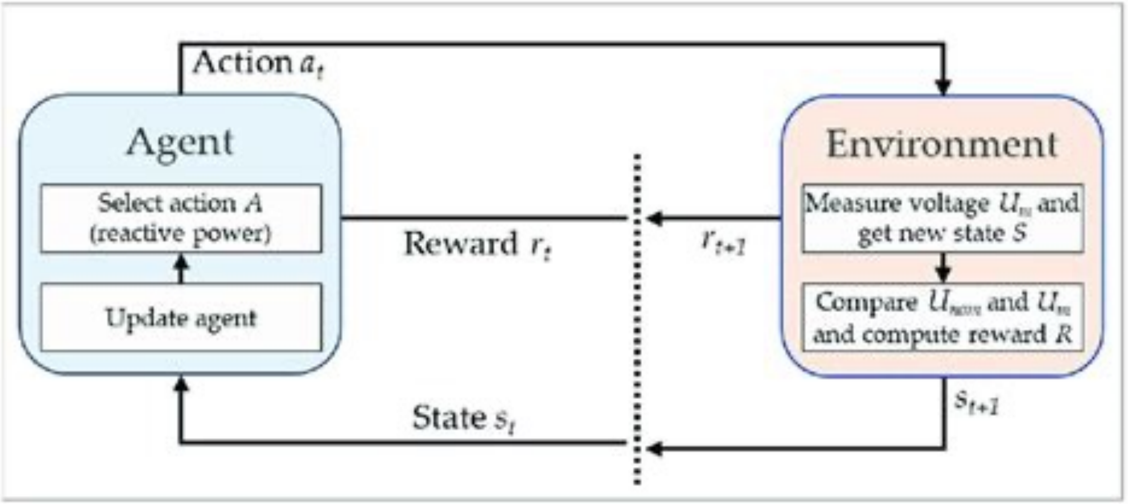


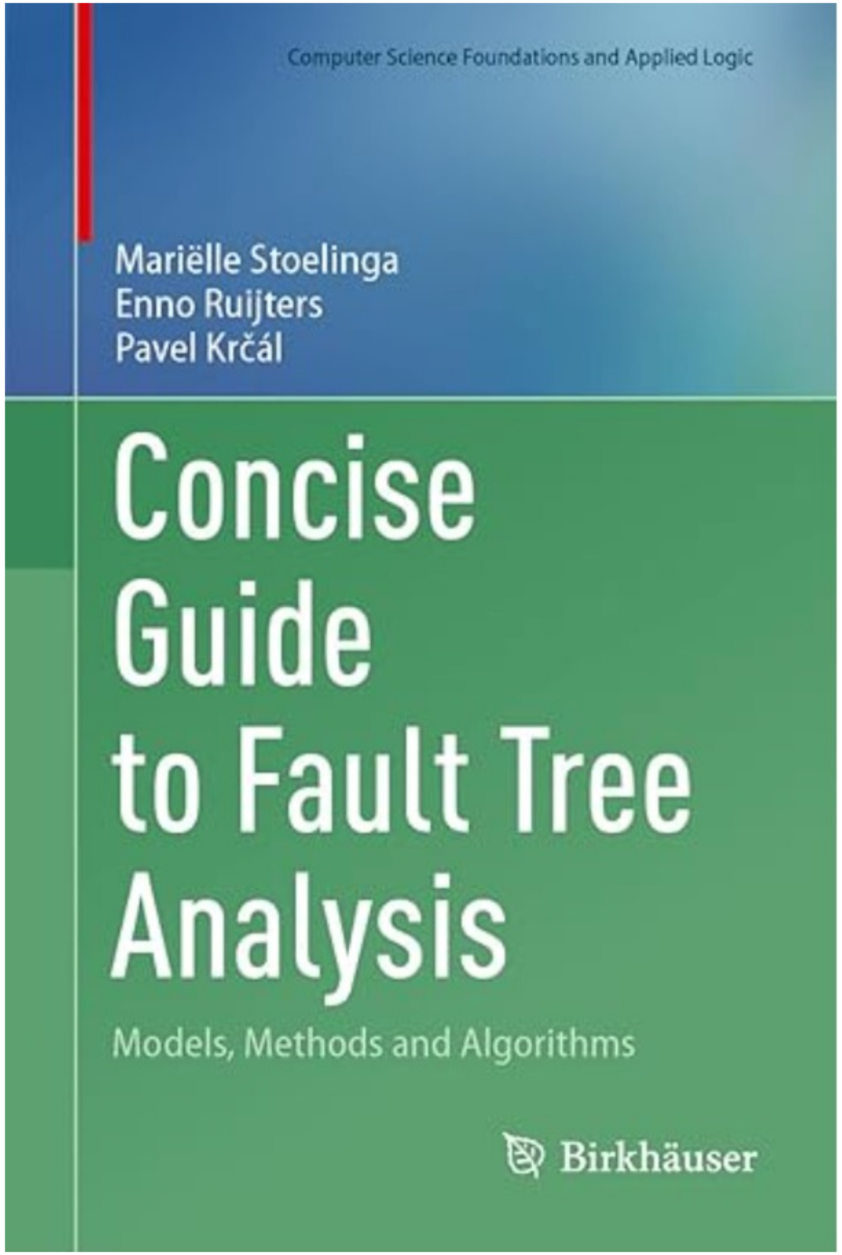


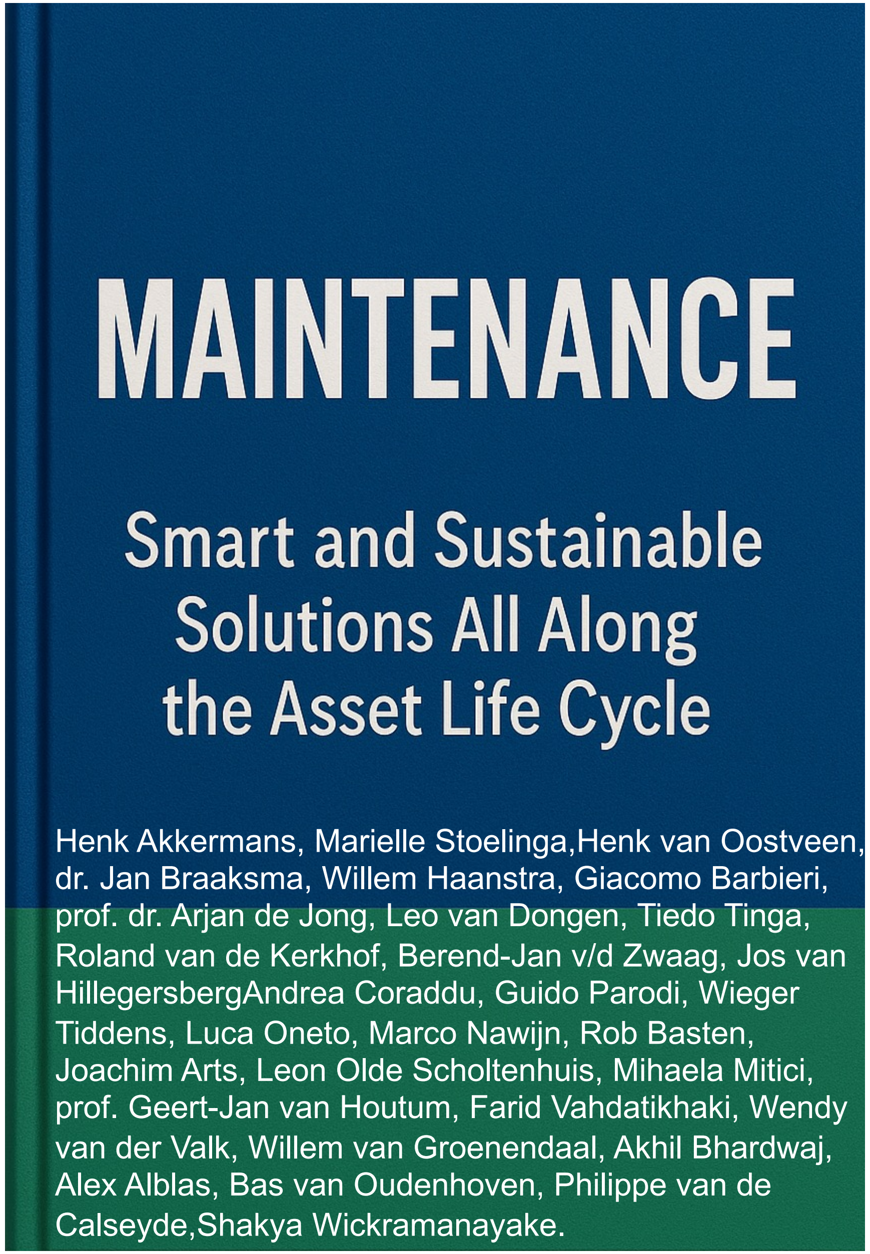
Reinforcement learning

Learn an optimal decisions by trial and error

- Good actions –> high total reward
- Agents builds knowledge over time
  - Build neural network (deep learning)
- Two tasks
  - Exploration (learn more)
  - Explotation (earn rewards)




Computer Science Foundations and Applied Logic
Mariëlle Stoelinga
Enno Ruijters
Pavel Krčál
Concise Guide to Fault Tree Analysis
Models, Methods and Algorithms
Birkhäuser


MAINTENANCE
Smart and Sustainable Solutions All Along the Asset Life Cycle
Henk Akkermans, Marielle Stoelinga,Henk van Oostveen, dr. Jan Braaksma, Willem Haanstra, Giacomo Barbieri, prof. dr. Arjan de Jong, Leo van Dongen, Tiedo Tinga, Roland van de Kerkhof, Berend-Jan v/d Zwaag, Jos van HillegersbergAndrea Coraddu, Guido Parodi, Wieger Tiddens, Luca Oneto, Marco Nawijn, Rob Basten, Joachim Arts, Leon Olde Scholtenhuis, Mihaela Mitici, prof. Geert-Jan van Houtum, Farid Vahdatikhaki, Wendy van der Valk, Willem van Groenendaal, Akhil Bhardwaj, Alex Alblas, Bas van Oudenhoven, Philippe van de Calseyde,Shakya Wickramanayake.

SUMMARY

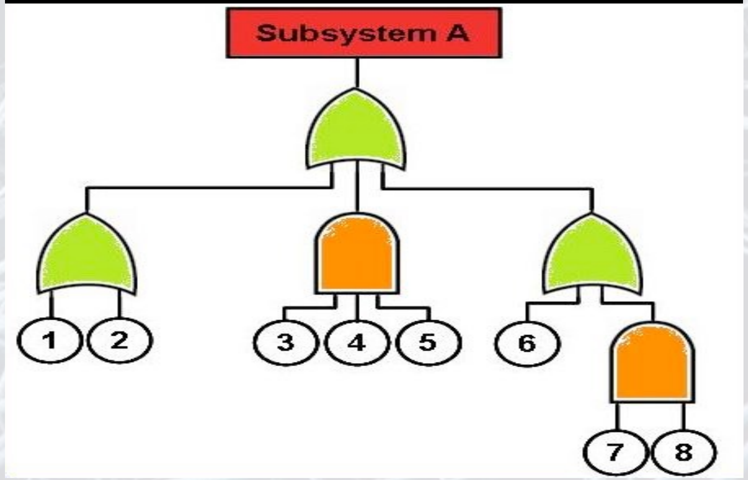
Complexity science

Organisms, no artefacts

Emergent behavior

Agent-based models

Towards agents



Planning & optimization