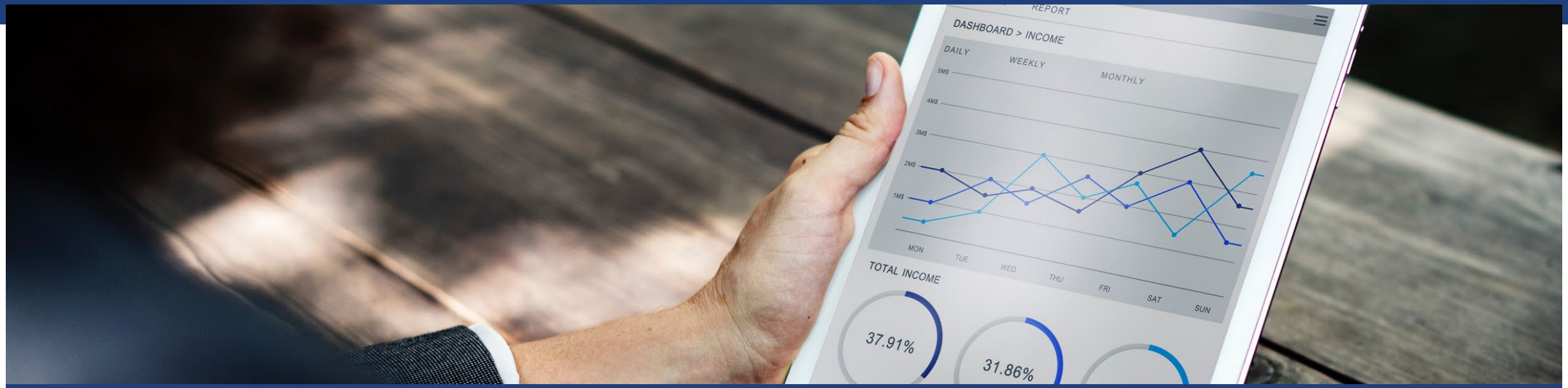
ETH zürich



Managing IT & AI

Prof. Dr. Stefan Feuerriegel

Chair of Management Information Systems

http://mis.ethz.ch

ABOUT ME

Solving management problems with artificial intelligence (AI)

Research examples

1 Nationwide **health management system** (specifically diabetes & Ebola)

Key partner: World Health Organization

2 Data-driven analysis of **patient journey** for chronic conditions

Key partner: University Hospital Basel

3 Data-driven **detection** of acute diabetes (hypoglycemia)

Key partner: INSELSPITAL

Examples of AI for better management

1 Effective police patrolling

2 Effective disease management

3 Early warnings for fake news in social media

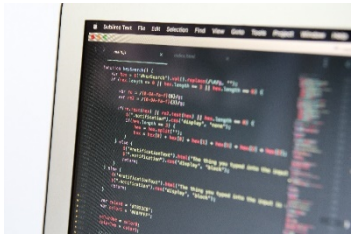
Mastering predictive analytics promises value creation

Understand business

Obtain business understanding in order to define goals and derive KPIs

Prepare data

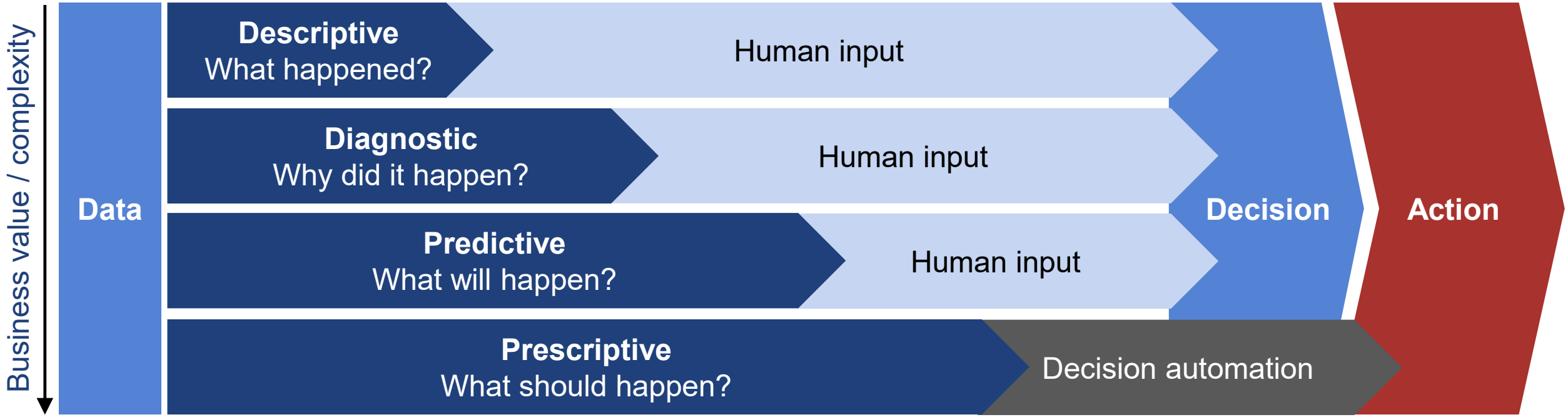
Identify and collect internal and external data sources that potentially contain interesting information



Apply analytics

Develop customized model from predictive analytics and evaluate performance for decision-making

Replacing “Excel” with AI for management



- Predictive analytics learns by “demonstration” and thus replicates past decisions (and errors)
- Prescriptive analytics promises to identify optimal decisions

Learning objectives

Being able to …

1. Identify the **need for IT management** in real-world applications

2. Extract **management challenges** of real-world IT/AI implementations along the dimensions of (1) technology, (2) organizations, and (3) people

3. Contrast to benefits of **iterative approach to management** over traditional "top-down" project management

AGENDA

Expanding your IT skills from the “single” programmer to managing a team

What you have done (mostly) in you studies …

… what you will do at work

Agenda

1. **Motivation**
   - Why should I bother about IT management?
2. **Managing IT**
   - Framework
   - Case: IT system for health crisis management
3. **Managing AI**
   - Framework
   - Examples from research

Agenda

1 **Motivation**
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Most job profiles of ETH graduates nowadays not involve IT skills but building new IT-based systems

Relevance for IT management

- **93%** of EU workplaces interact with IT systems
  → these IT system needs to be continuously adapted according to the work's needs (e.g., new products)
- **90%** of manager in the EU work on projects with a digital component
- **38%** of workplaces report that the lack of digital skills has an impact on their performance

If IT fails, this has immediate consequences:

- e.g., manufacturing processes pause, e-commerce stops

QUESTION
Can you give examples where managing IT is linked to the job of a STEM graduate?

Where does an engineer need to manage IT?

...

Why do medical professionals need IT literacy?

Study of the European Commission "ICT for Work: Digital Skills in the Workplace"
https://ec.europa.eu/digital-single-market/en/news/new-report-shows-digital-skills-are-required-all-types-jobs

Definition of information technology, and examples of IT systems

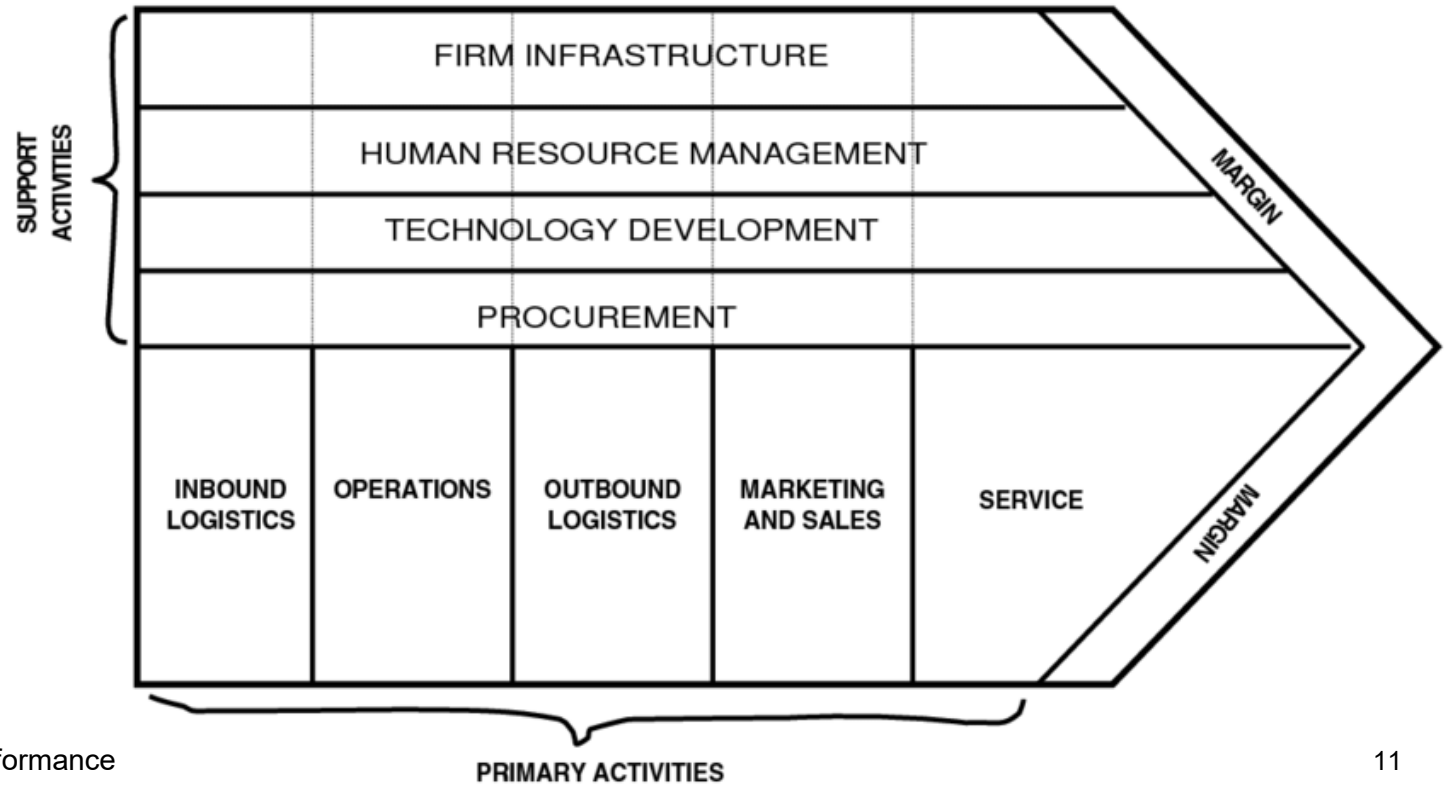
Definition

Information technology (IT)

… is the use of computers to store, retrieve, transmit, and manipulate data or information

Examples

QUESTION
Can you give examples where business and organization use systems for specific activities?



Porter (1985): Competitive Advantage: Creating and Sustaining Superior Performance

… but the development of most IT systems fails

70% of all IT projects are considered **failures** or, at least, flawed

Even if projects don't fail outright

- 31% don't meet their **goals**
- 43% exceed the initial **budget**
- 49% are **late**

QUESTION
What is the common denominator for failure?

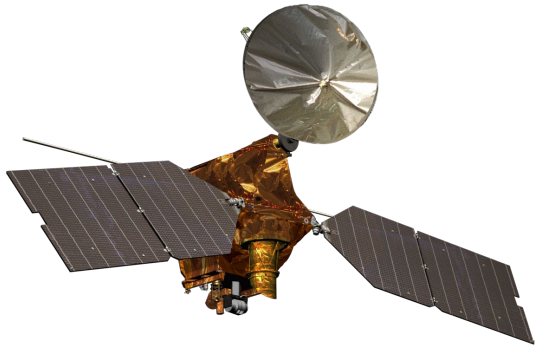
Examples

Windows Vista™

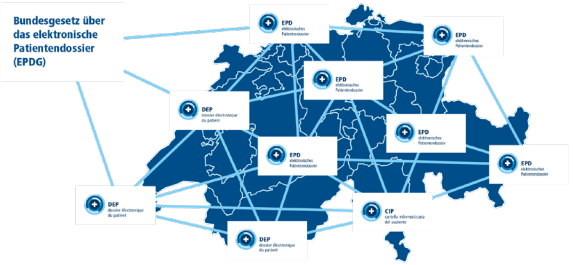
Heathrow baggage system failure

Ariane 5

Mars Climate Orbiter



E-Patientendossier



Doherty, Ashurst, & Peppard (2012). Factors aecting the successful realization of benets from systems development projects: Findings from three case studies. Journal of Information Technology, 27 ,
Kim & Kishore (2018). Do we fully understand information systems failure? An exploratory study of the cognitive schema of IS professionals. Information Systems Frontiers, 32, 39
2017 Report of the Project Management Institute https://www.pmi.org/-/media/pmi/documents/public/pdf/learning/thought-leadership/pulse/pulse-of-the-profession-2017.pdf?sc_lang_temp=en

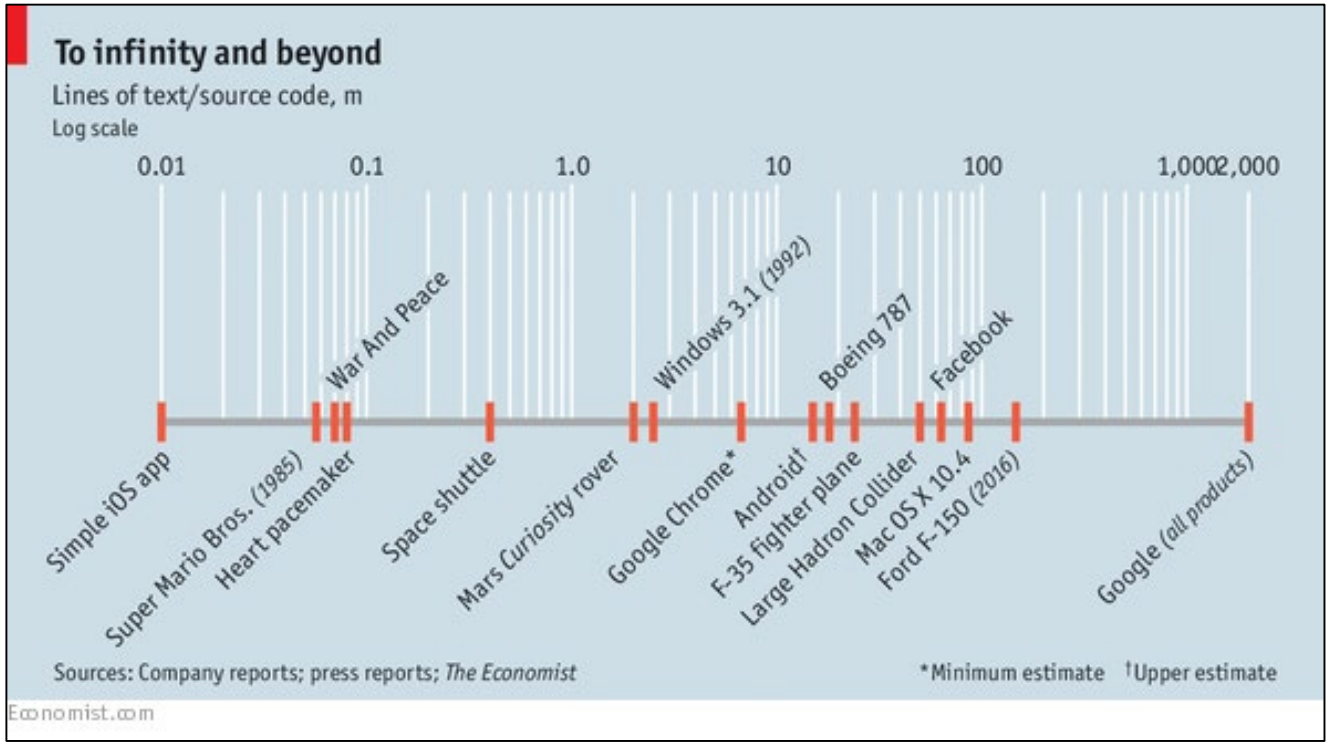
Some IT defects happen by law of large numbers …

Estimated **15–50 errors per 1000 lines** of delivered code (industry average)

Example: Microsoft applications:

- Approx. 10 - 20 defects per 1000 lines of code during in-house testing
- 0.5 defects per 1000 lines of code in released products

Variations due to programing language, management style, etc.



… but other IT defects are a result of **bad planning**

AGENDA

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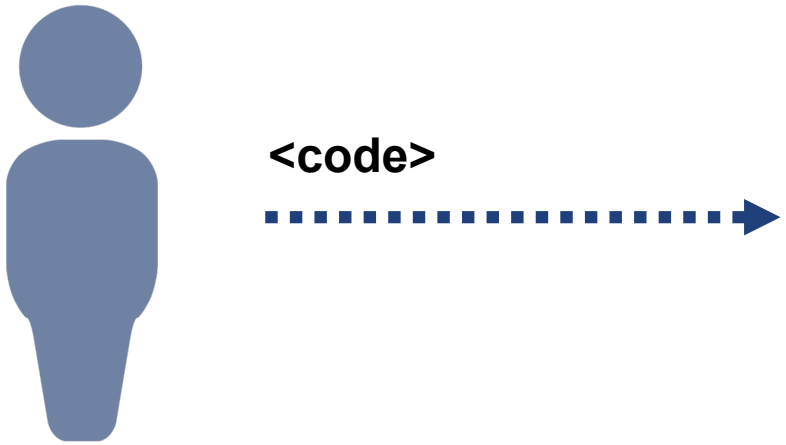
What you have done (mostly) in you studies …

… what you will do at work

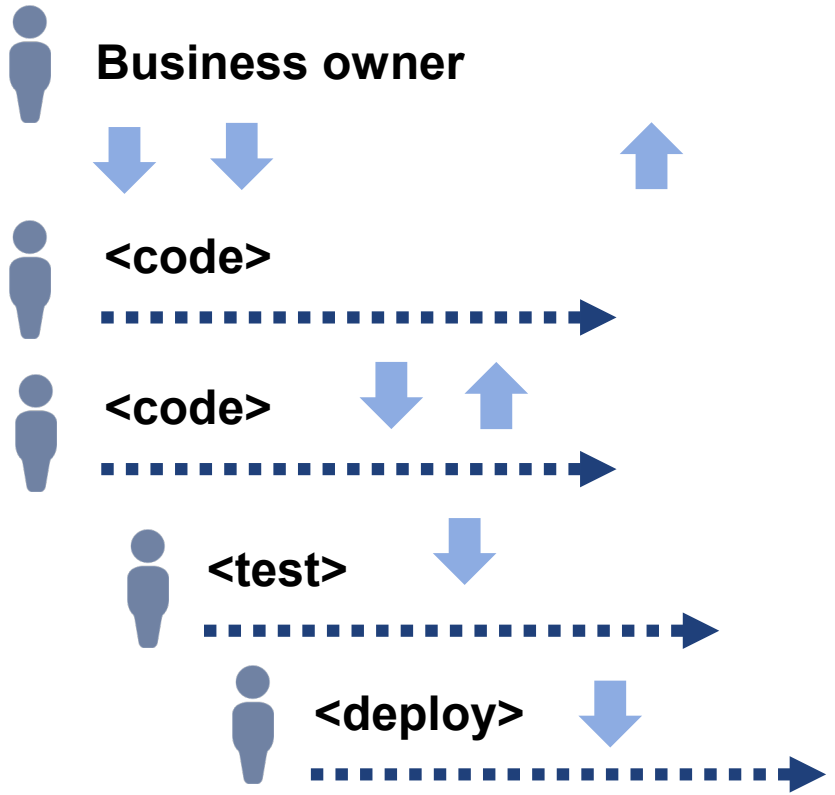
AGENDA

IT management must deal with interdependencies, interactions and interfaces to business owners

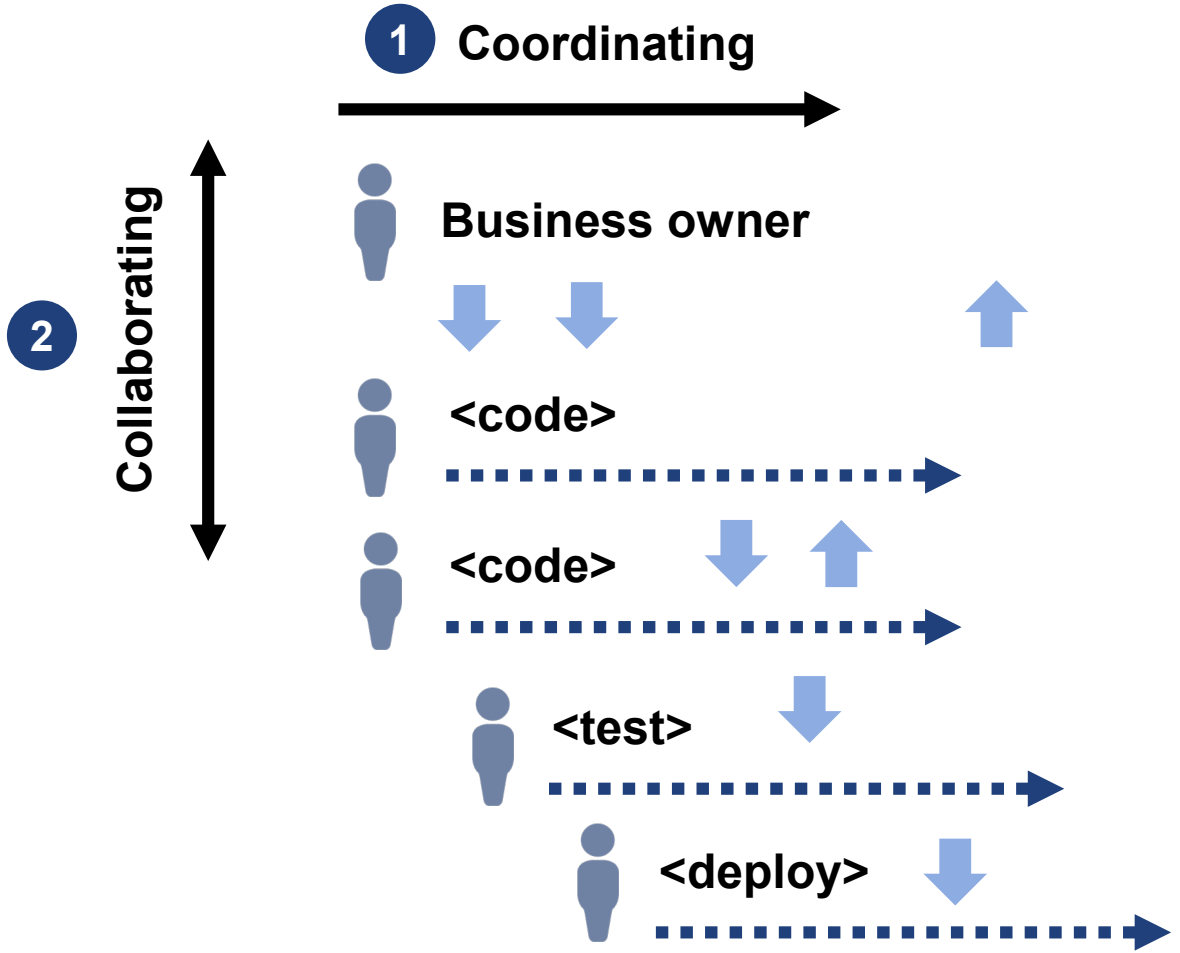
Single programmer



Managing a team of programmers



Challenges in IT management can bee loosely grouped into (1) a time dimension (coordinating) and (2) a stakeholder dimension (collaborating)



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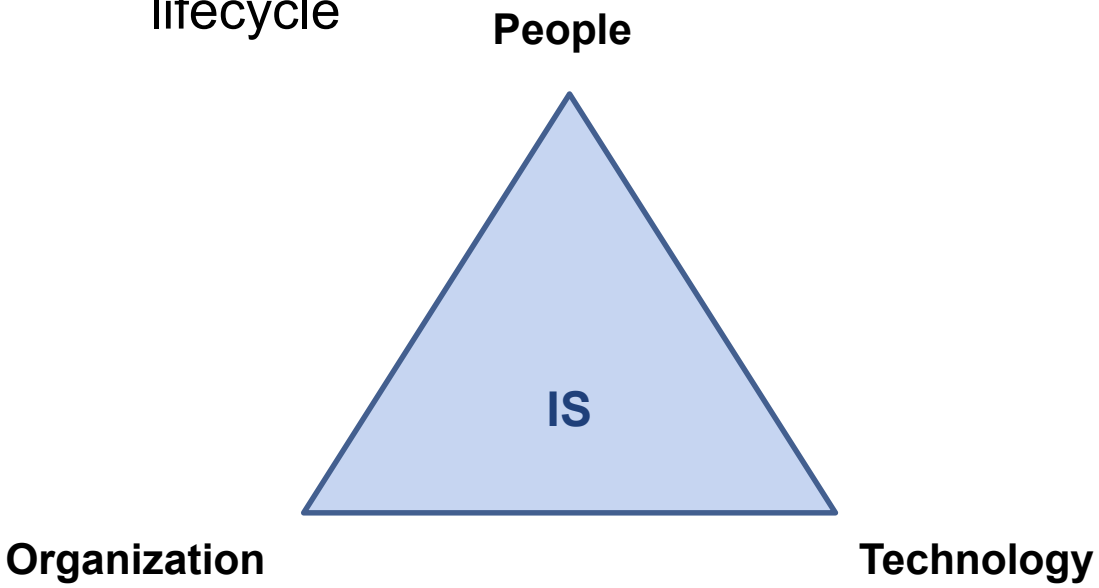
Successful IT management must span both the macro and the micro view

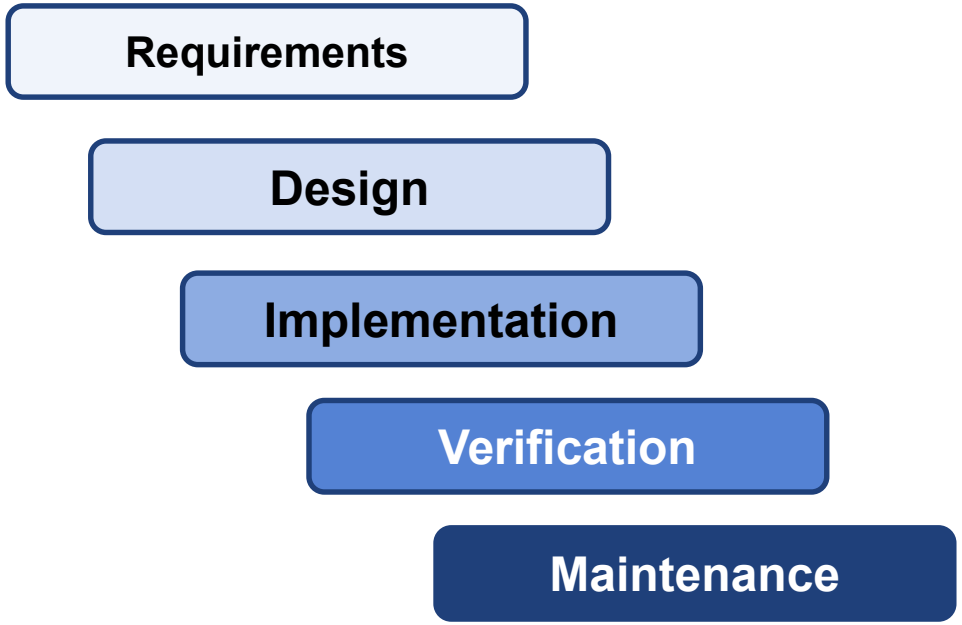
1 Macro view: Collaborating

- Integrates IT with **organization** (business processes) and **people** (technology acceptance)
- Must manage both across complete lifecycle



2 Micro view: Coordinating

- Provides guidelines how the programming process itself can be organized



1 Management must integrate IT with both people and organization

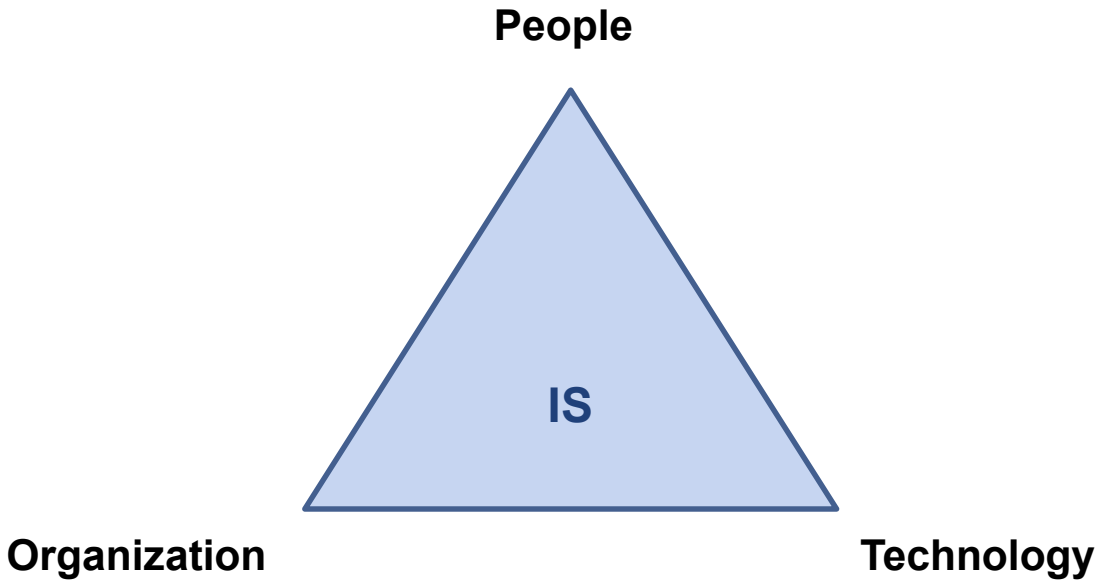
Information technology (IT)

… is the use of computers to store, retrieve, transmit, and manipulate data or information

Information system (IS)

… is a set of coordinated components, which act together towards producing, distributing and or processing information

- IT is a subset of information systems
- systems consist of people, processes, the organization, machines and information technology.



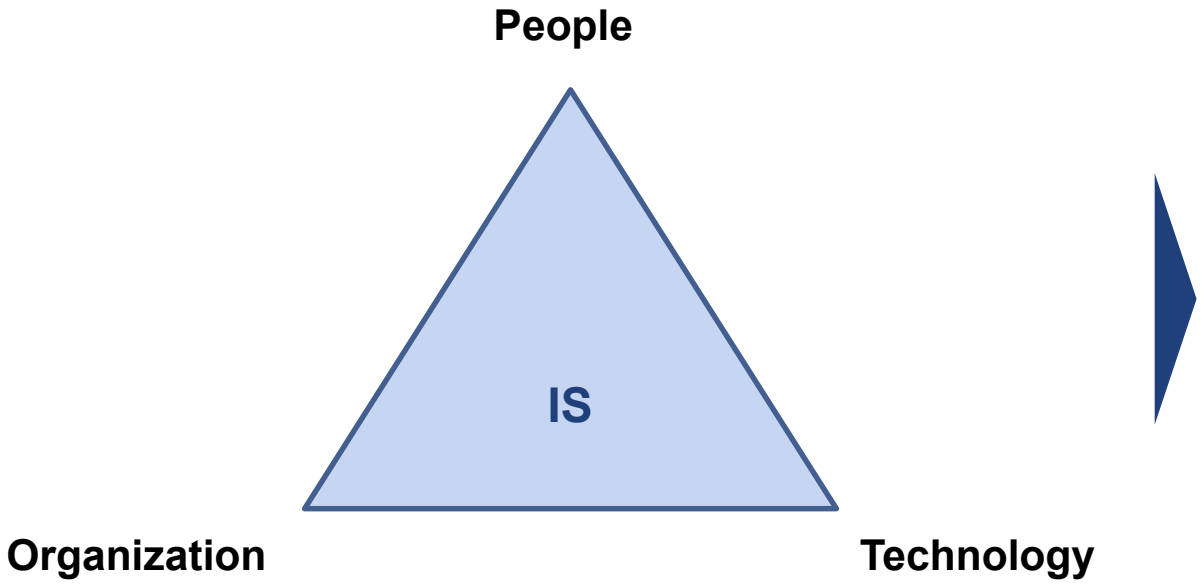
Orlikowski, 1992. The Duality of Technology: Rethinking the Concept of Technology in Organizations. Organization Science, 3(3):398
Orlikowski, 2010. The sociomateriality of organisational life: considering technology in management research. Administrative Science Quarterly, 34(1):125

CASE

1 Applying the technology-people-oganization framework in practice

Group work (15 min, 3-5 persons)

- Table with challenges
- Familiarize yourself with the case (stakeholders!)
- Sort objective / requirements (primary/secondary) / anticipated challenges / potential actions for case



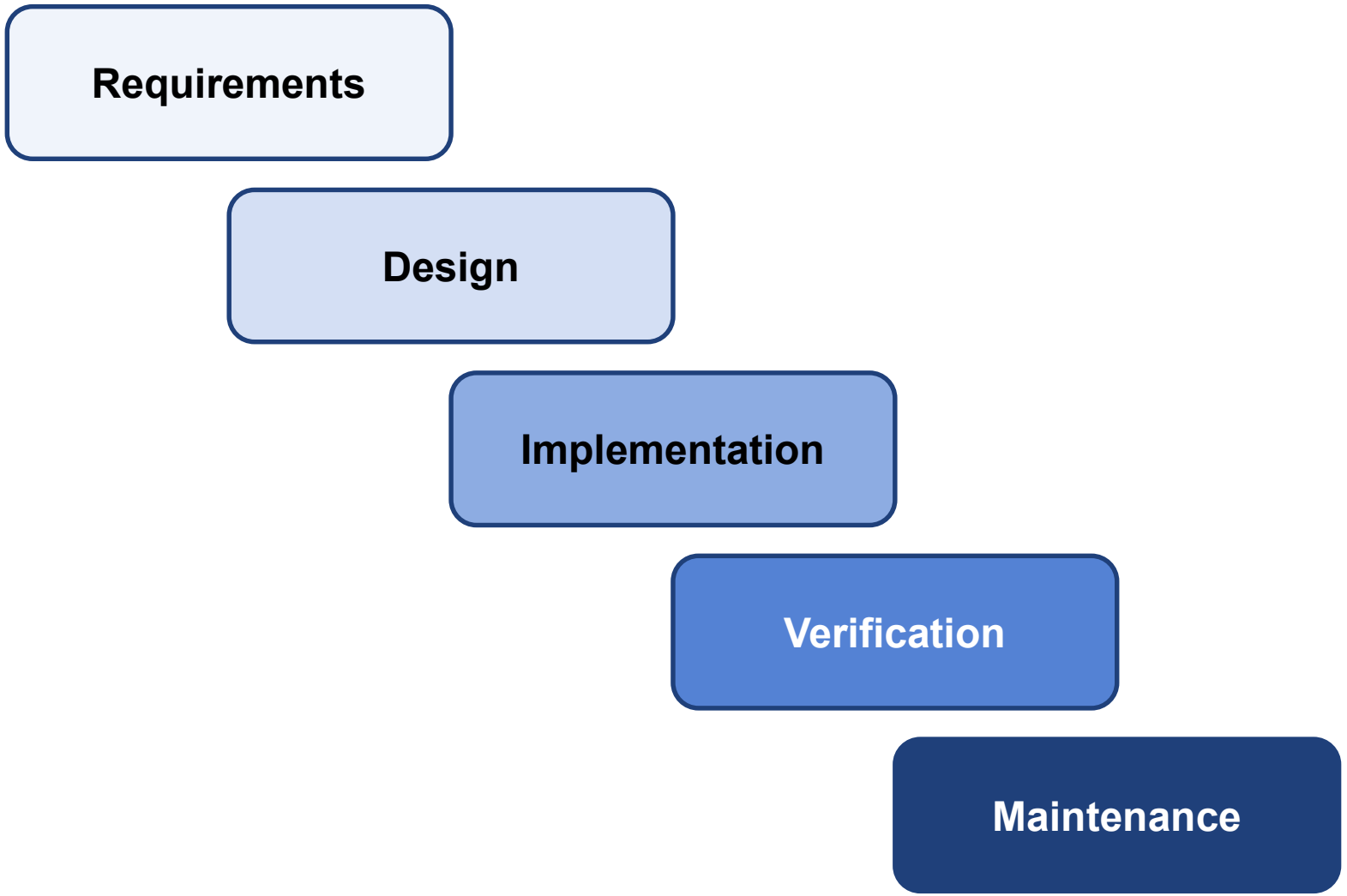
CASE

1 Sort objective / requirements (primary/secondary) / anticipated challenges for case

Group work (5, 3-5 persons)
- Deliverable 1 slide
- Familiarize yourself with the case (stakeholders!)
- Sort objective / requirements (primary/secondary) / anticipated challenges / potential actions for case

Stakeholder	Objective	Requirements	Anticipated Challenges	Potential Actions
Ministry of Health	Monitor spread of disease	Primary: get current figures within 2 hours Secondary: …	Dynamic visualization	Create a dashboard
Local Hospitals	…	…	…	…
…				

2 Developing IT systems usually involves 5 steps



2 Deep-dive requirements: Requirements for new IT is nowadays formalized as user stores

- **User stories** are short, simple descriptions of a feature told from the perspective of the person who desires the new capability (user/customer)

- User stories contain:
  - Who?
  - Does what?
  - What's the goal?

- They help:
  - Deliver a product the client really needs
  - Time/budget estimation

Example for a backup tool:

- As a power user, I can specify files or folders to backup based on file size, date created and date modified.
- As a user, I can indicate folders not to backup so that my backup drive isn't filled up with things I don't need saved.

Further information:
https://www.mountaingoatsoftware.com/agile/user-stories

CASE

2 User stories

Group work (5 min, 3-5 persons)
- Deliverable 1 slide
- Think of stakeholders + 1 user story

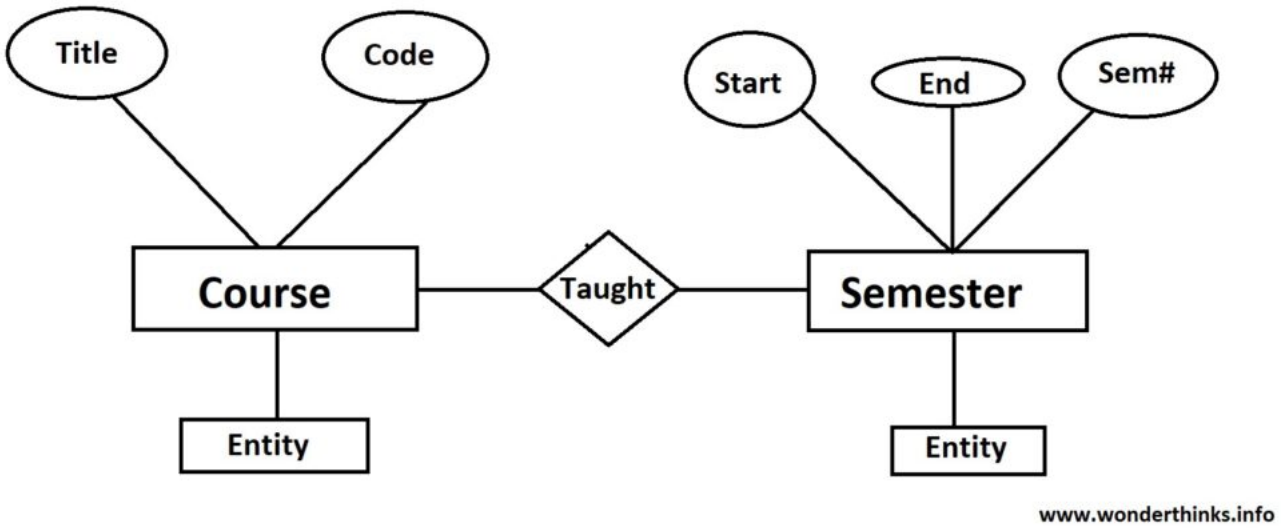
Stakeholder				
Ministry of Health				
Local Hospitals	…	…	…	…
…				

2 Deep-dive design: Entity relationship diagram for data structure

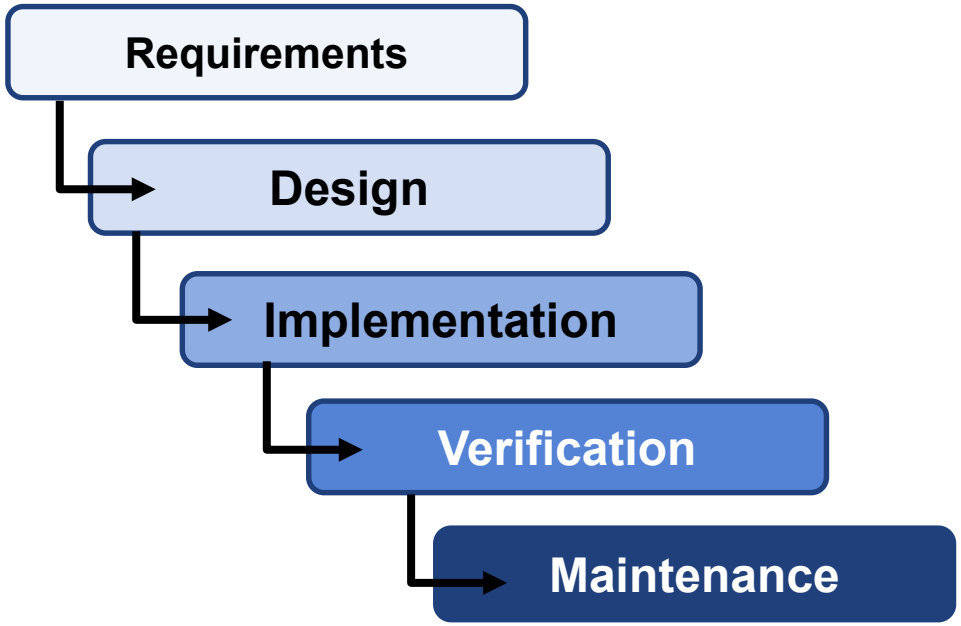
Group work (10 min, 3-5 persons)
- ER diagram

An entity–relationship (ER) diagram describes interrelated things of interest in a specific domain of knowledge.

- A basic ER model is composed of:
  - entity types that classify the things of interest
  - specifies relationships that can exist between entities



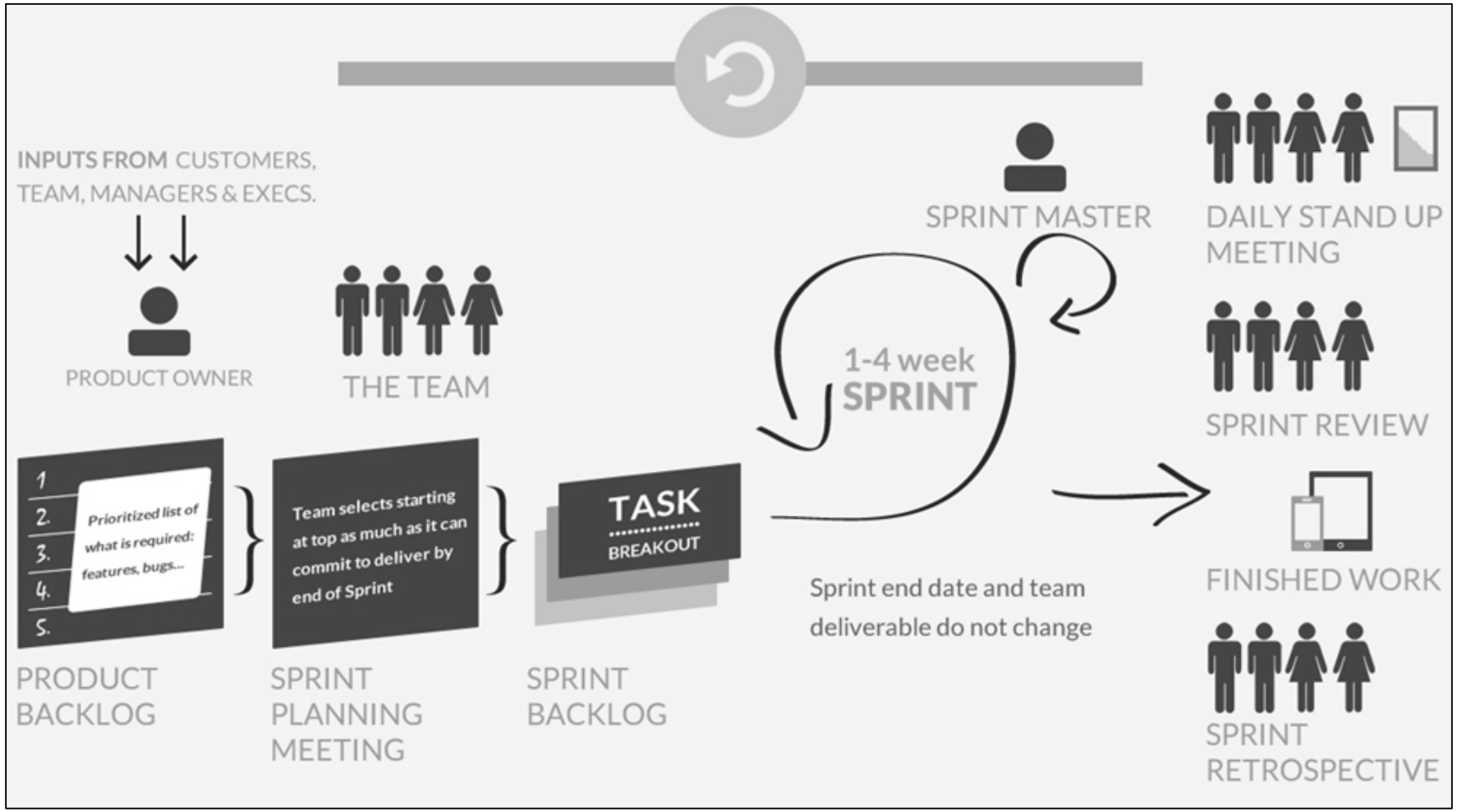
2 Becoming agile: Moving from waterfallmodel to an iterative approach



Group discussion (3 min)
What are potential drawbacks here?

https://www.ted.com/talks/tom_wujec_build_a_tower_build_a_team?language=en

2 Putting things together: SCRUM for agile development



https://www.ics.ie/news/view/1653

Personal takeaways

1. **Prioritize** (you can never master all tasks)
2. Adapt to dynamics in the environment by choosing a **flexible design**
3. Choose an **agile management** approach
4. Don‘t underestimate the effort to **manage organizations and people**

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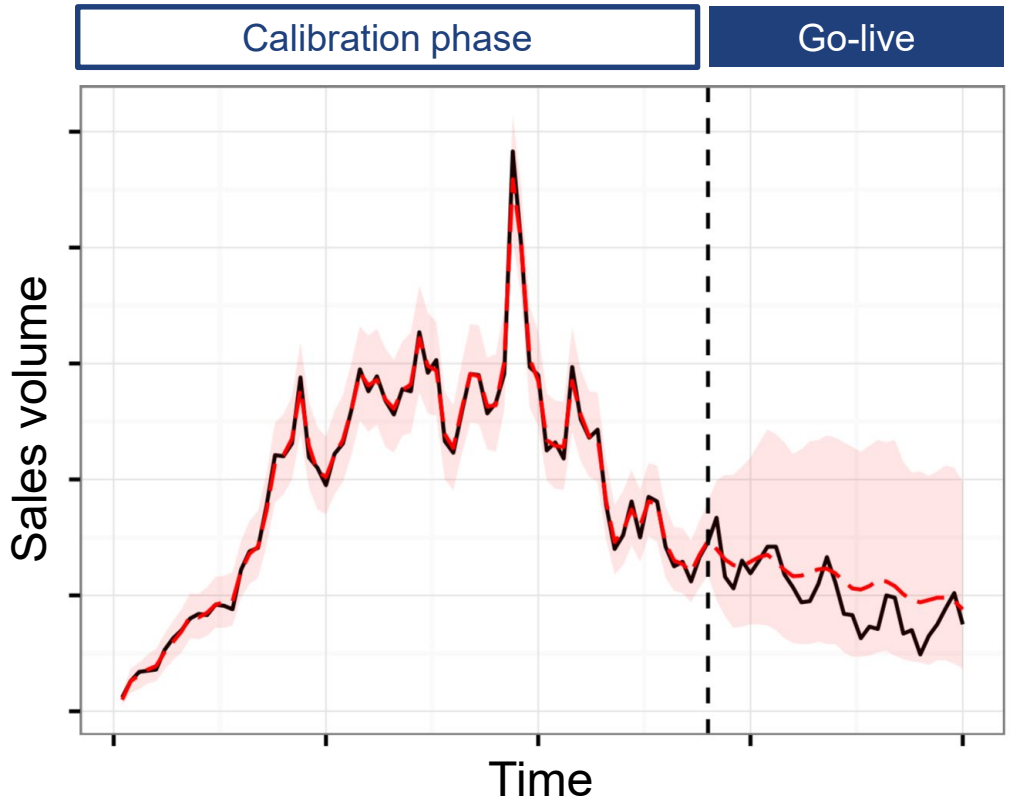
Managerial decision support for effective police management

1 Kadar, Feuerriegel, Noulas, Mascolo (2019): Leveraging mobility flows from location-based services to test crime pattern theory. RR at ICWSM
2 Zöchbauer, Feuerriegel (2019): Cost-effectiveness of predictive policing under repeat crime victimization. MSOM Conference

Naïve predictions can fuel decision-making – but only sometimes

Example: Forecasted sales volume

→ input to production quota



- Replicates observed patterns from past data

$$Y = f(x_1, \ldots, x_n)$$

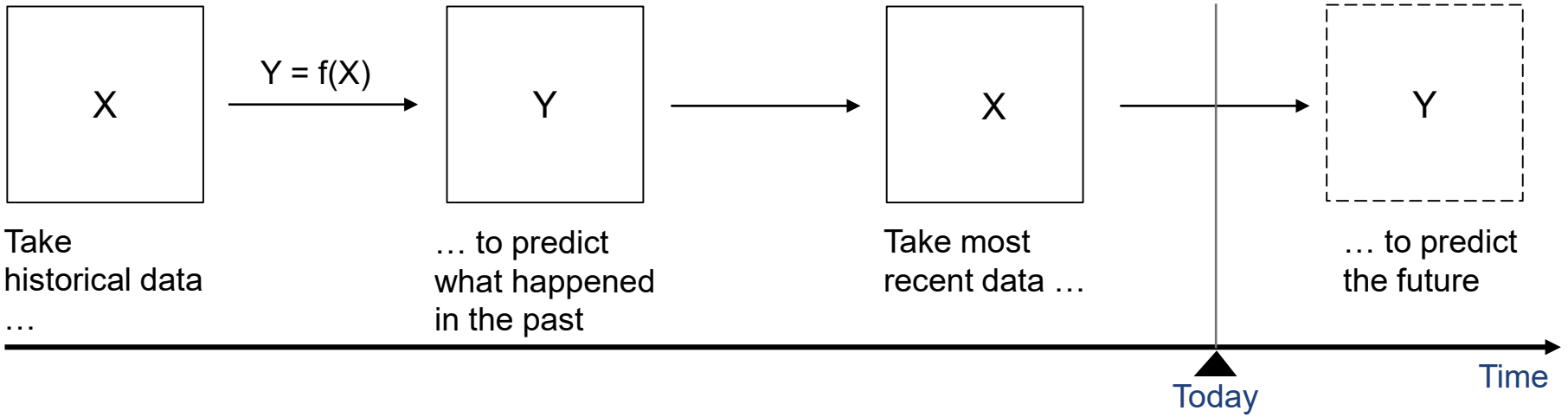
with e.g. neural networks

- Leverages external predictors

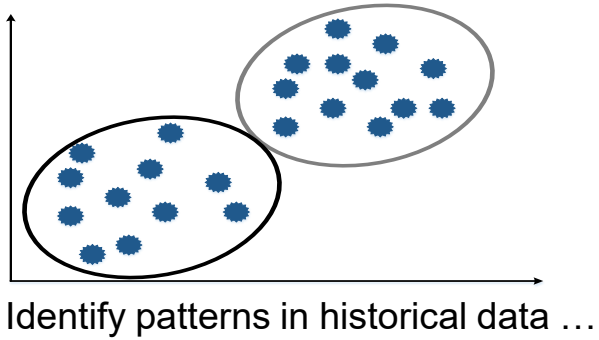
MODELING BASICS

There are 2 approaches to modeling – supervised and unsupervised learning, but only the former uses historical data to predict the future

Supervised learning



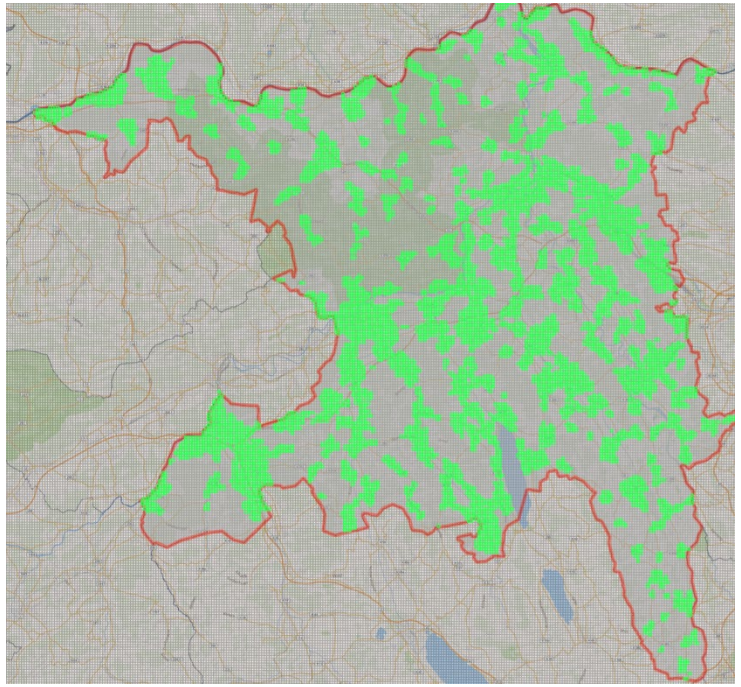
Unsupervised learning

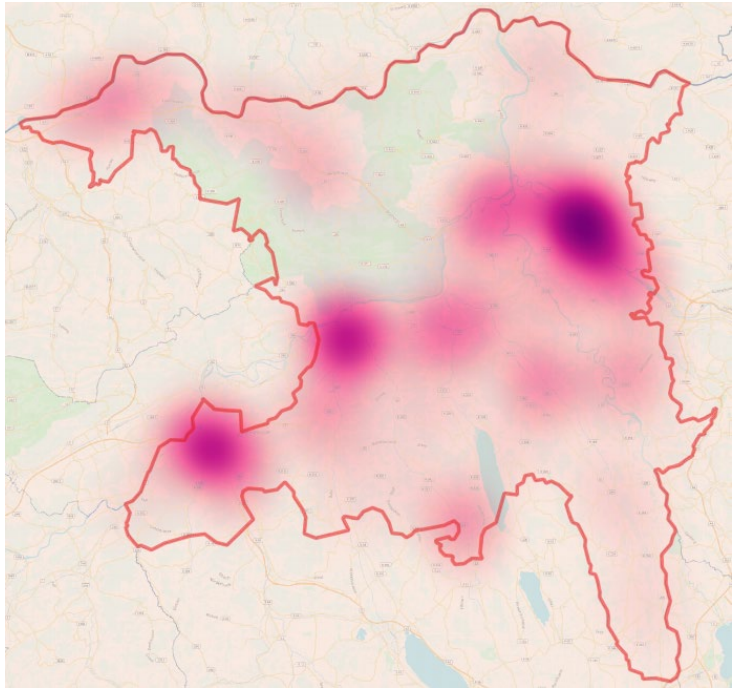


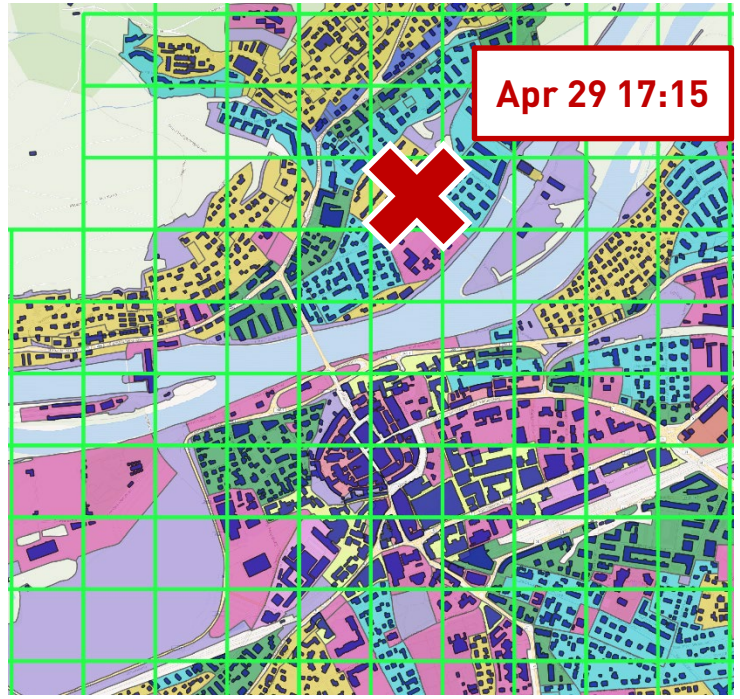
- Unclear management implications of clusters
- No ground truth labels what a „true“ labels are
- Not designed to generalize to unseen instances
- Single-time analysis rather than continuous decision support

Dynamic estimations of crime risk

Historic crime	Current practice: hotspot map	Dynamic risk map

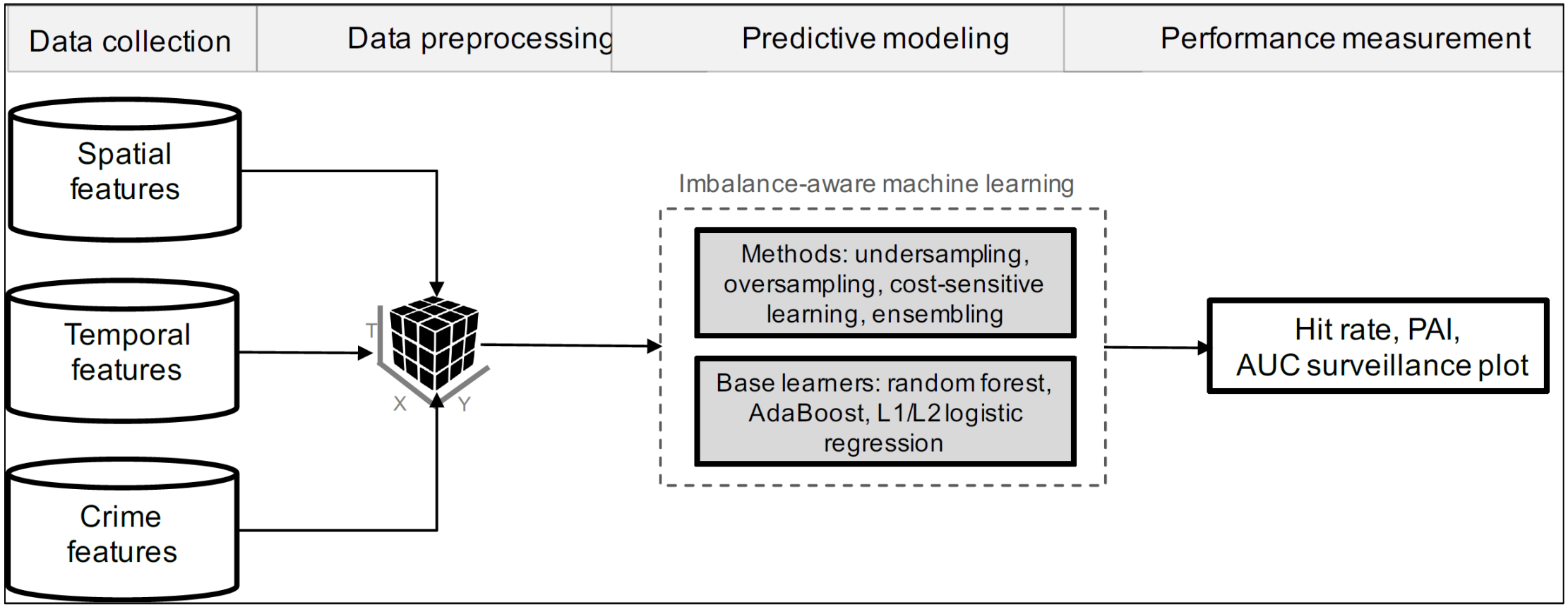






Kadar, Maculan & Feuerriegel (2019): Public decision support for low population density areas. Decision Support Systems

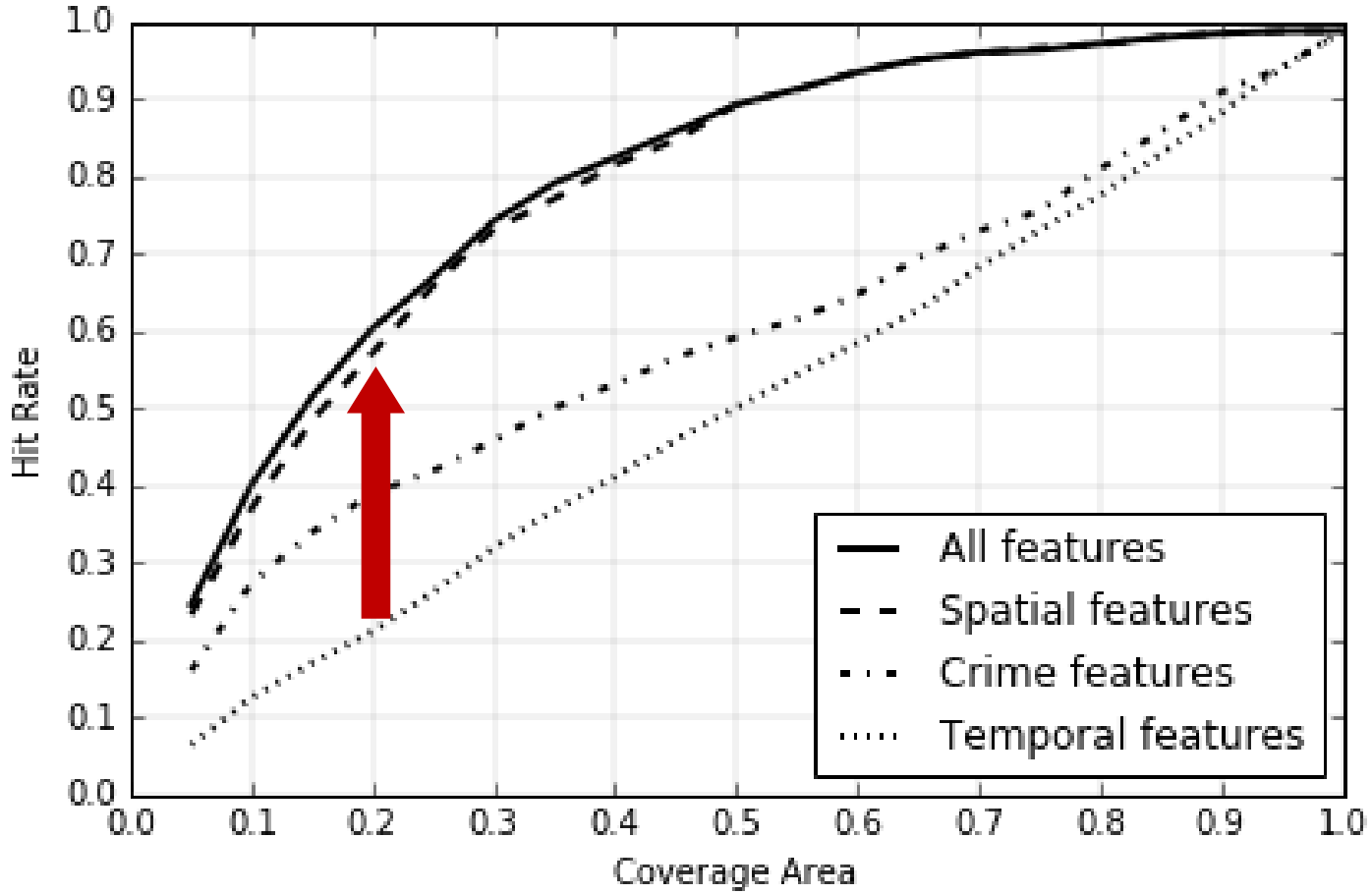
Data-driven risk model



$$\mathbb{P}(\text{crime}_{it} = 1) = f(\text{spatial}_i, \text{temporal}_t, \text{crime}_{i,t-1}; \theta)$$

Kadar, Maculan & Feuerriegel (2019): Public decision support for low population density areas. Decision Support Systems

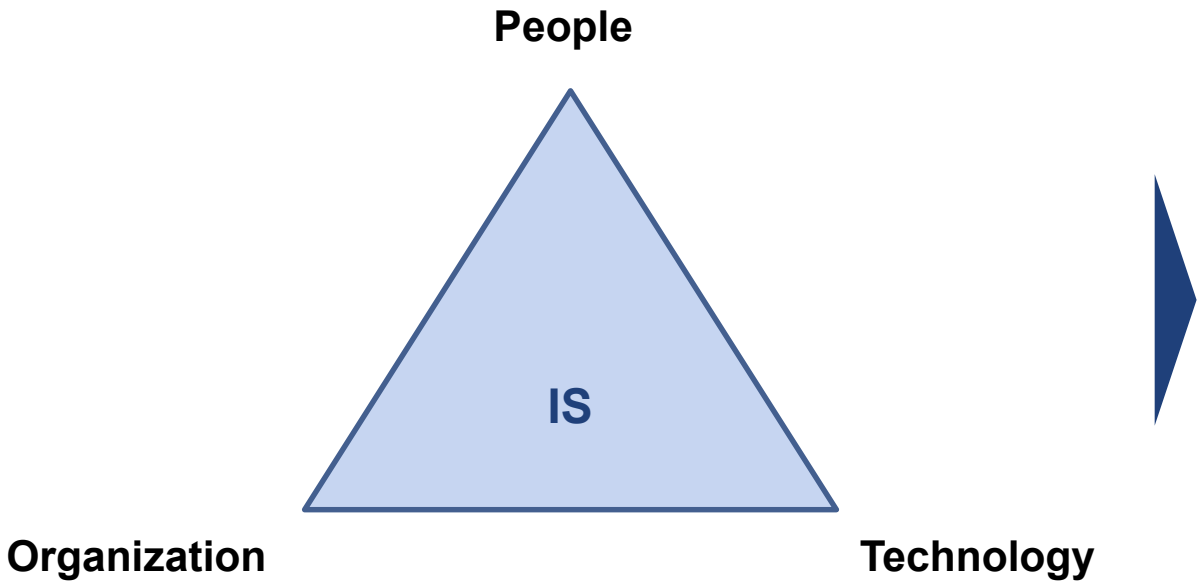
Effectiveness



1 Applying the technology-people-organization framework to AI

Peer discussion (5 min)

- What are challenges across these dimensions in the previous examle?



1 Deep-dive: Communicating the capabilities of AI with business experts

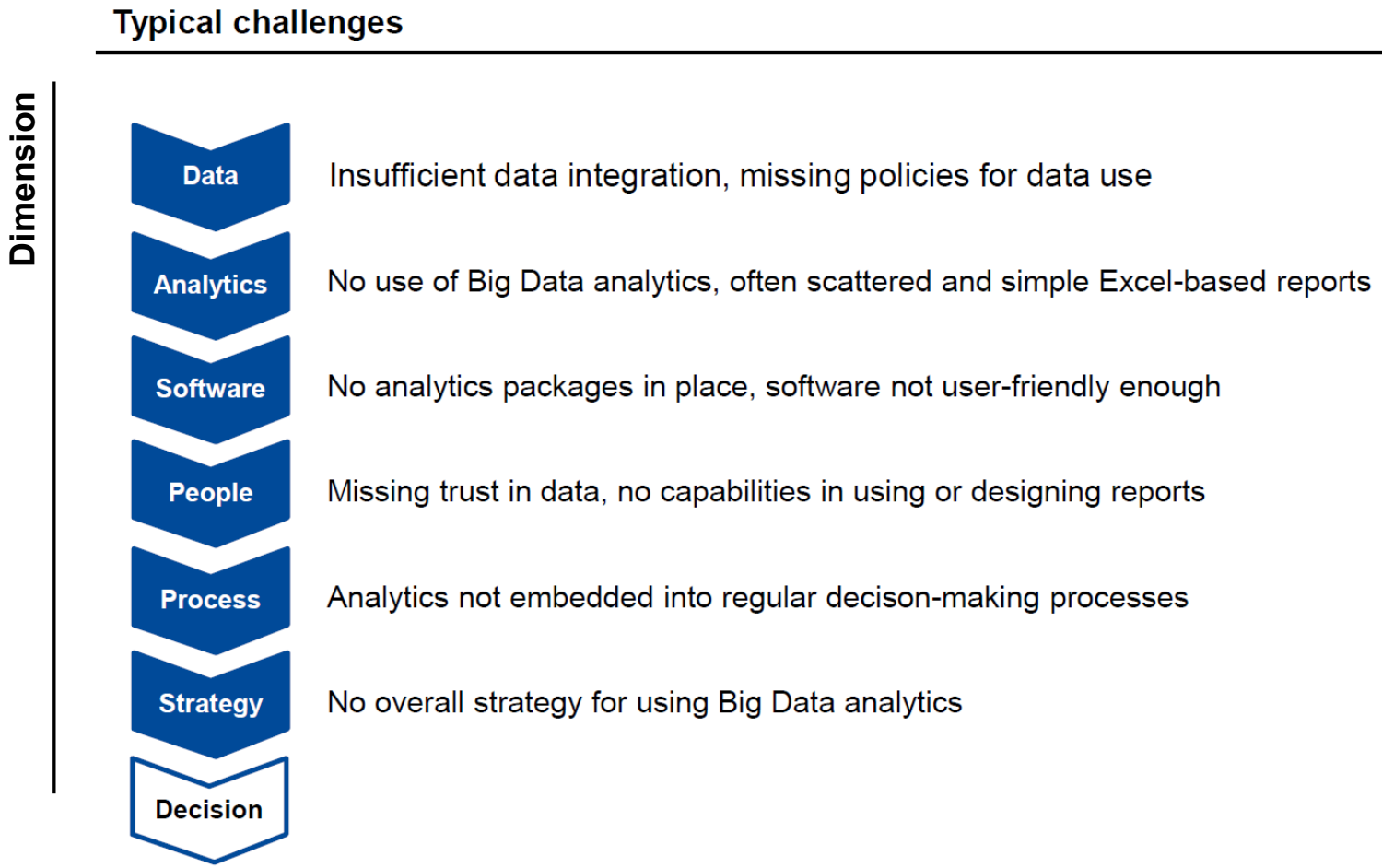
Learning a function that maps well-defined inputs to well-defined outputs

1. Large (digital) data sets exist or can be created containing input-output pairs
2. The task provides clear feedback with clearly definable goals and metrics
3. No long chains of logic or reasoning that depend on diverse background knowledge or common sense (**1 second rule**)
4. No need for detailed explanation of how the decision was made
5. A tolerance for error and no need for provably correct or optimal solutions
6. The phenomenon or function being learned should not change rapidly over time
7. No specialized dexterity, physical skills, or mobility required

What can machine learning do? Workforce implications. Science (2017) https://doi.org/10.1126/science.aap8062

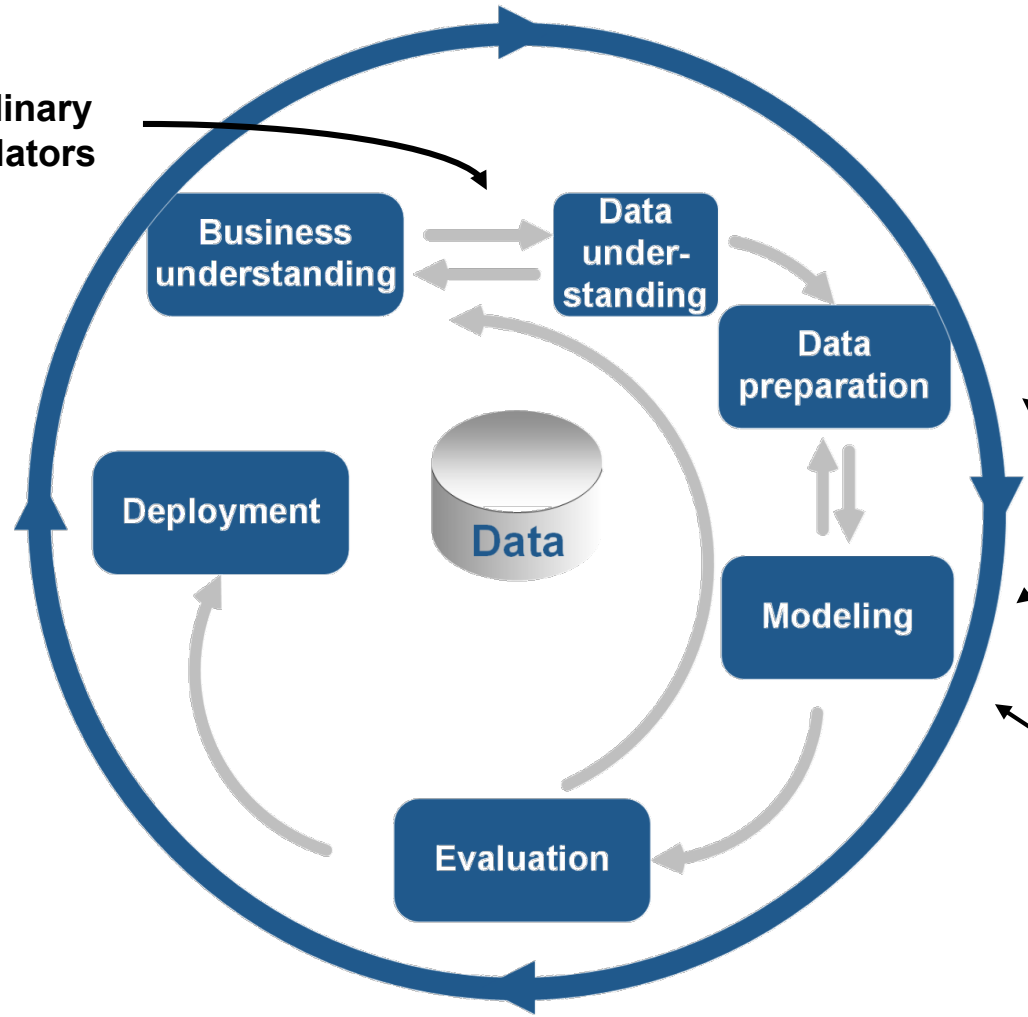
1 A holistic approach is required, yet facing various challenges

When applied in practice, you will likely face several challenges across the process



2 An iterative approach to managing AI

Cross Industry Standard Process for Data Mining (CRISP-DM)



Requires interdisciplinary team with data translators

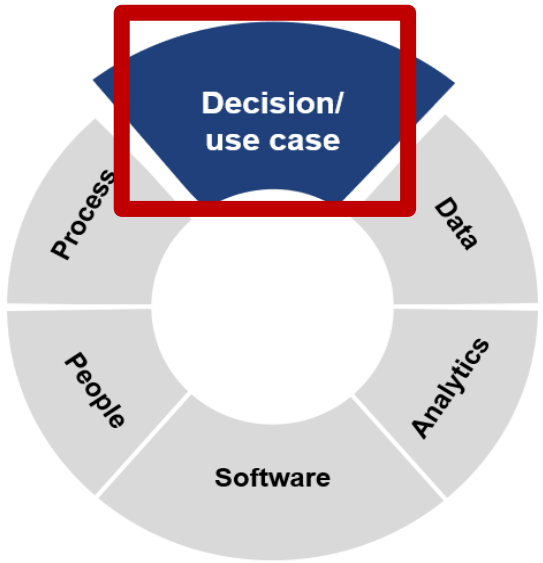
Consumes usually 80% of the time

Re-deployment beneficial if (A) substantially more data is available or (B) highly dynamic environments

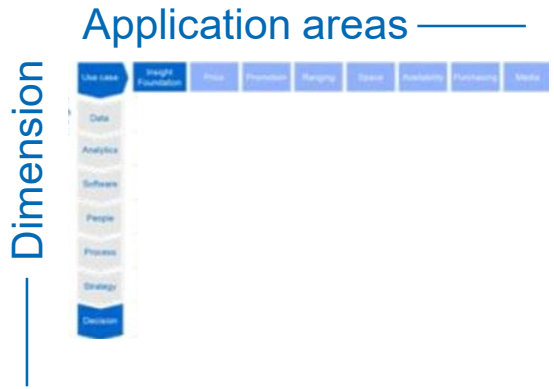
Consists of another iterative process

Personal experience on what makes successful AI implementations

AI value chain



Matrix of AI value chain dimensions and application areas



Key principles

Goal of the AI value chain is to identify and prioritize areas of improvement in analytics and big data along a structured framework

Decision backwards

Build the capability by **starting with the business decisions** you want to drive and working backwards

Step-by-step

Focus on specific topics and **set each element in place** - a chain is only as strong as its weakest link

Test and learn

Move from data to decision and from decision back to the data with which to measure the outcome

What we do in research (ask me for thesis opportunities!)

1 Effective police patrolling

2 Effective disease management

3 Early warnings for fake news in social media

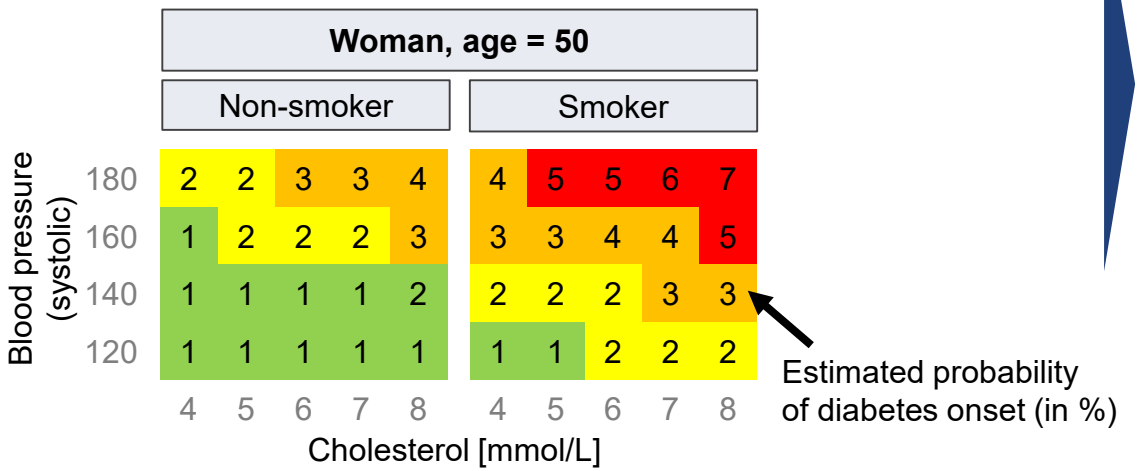
Leveraging the complete patient journey for personalized health management

Example | **Allocating preventive treatments to patients at risk of diabetes type II**

Current practice

- Chart-based risk scores
- Focuses on the **current** health condition (e.g. age, sex, …)

Example (SCORE-CVD chart [1])



Proposal: data-driven health management

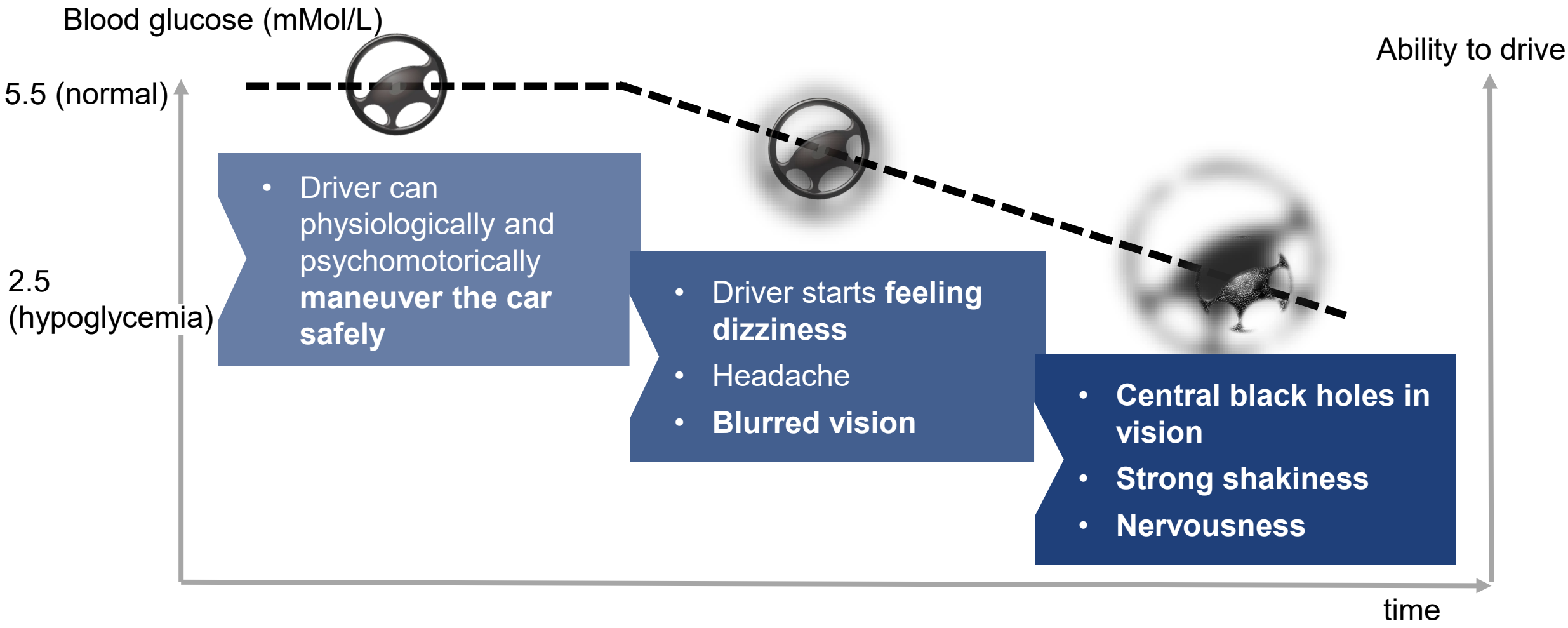
- Personalized recommendations tailored to **individual risk profiles**
- Leverages the **complete patient trajectory**

1. Baseline variables (age, weight, …)
2. Lab tests
3. Past medications
4. Co-occurring health conditions (i.e. co-morbidities)

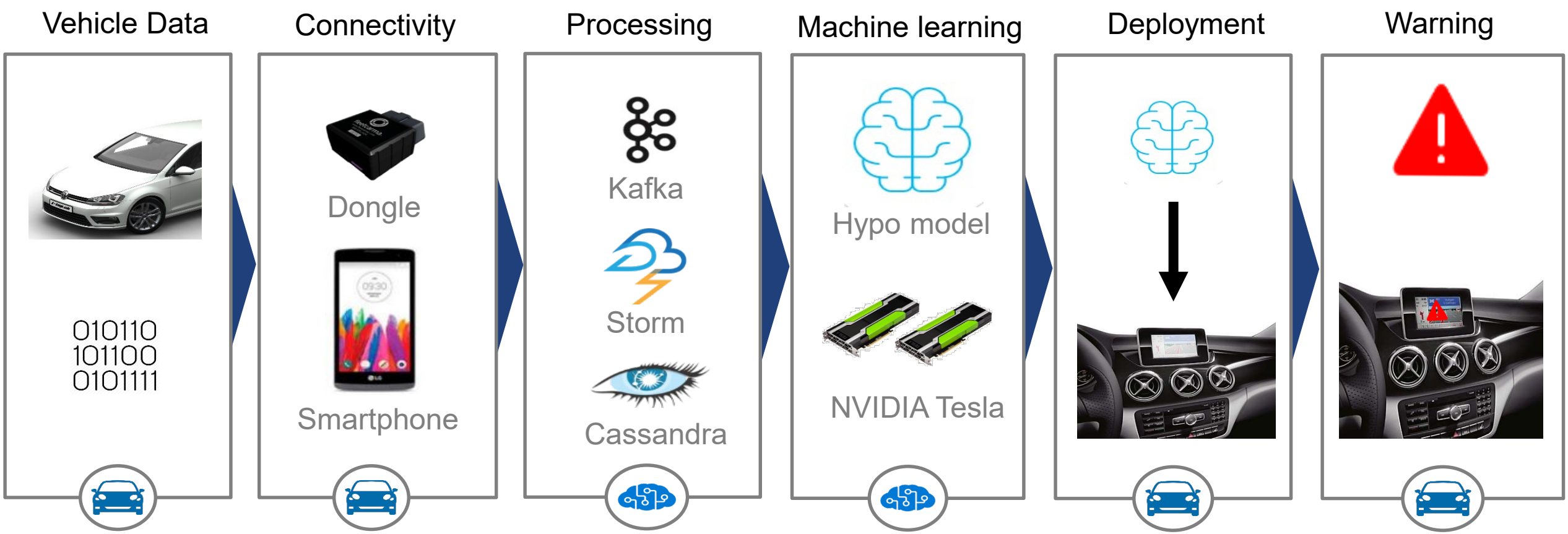
Leveraging the complete health trajectory requires **new AI-based models**

1) "SCORE chart" from the 2016 European Guidelines on cardiovascular disease prevention. European Heart Journal
Similar procedures are followed by Framingham Diabetes Risk Score and the NIDDK diabetes risk score

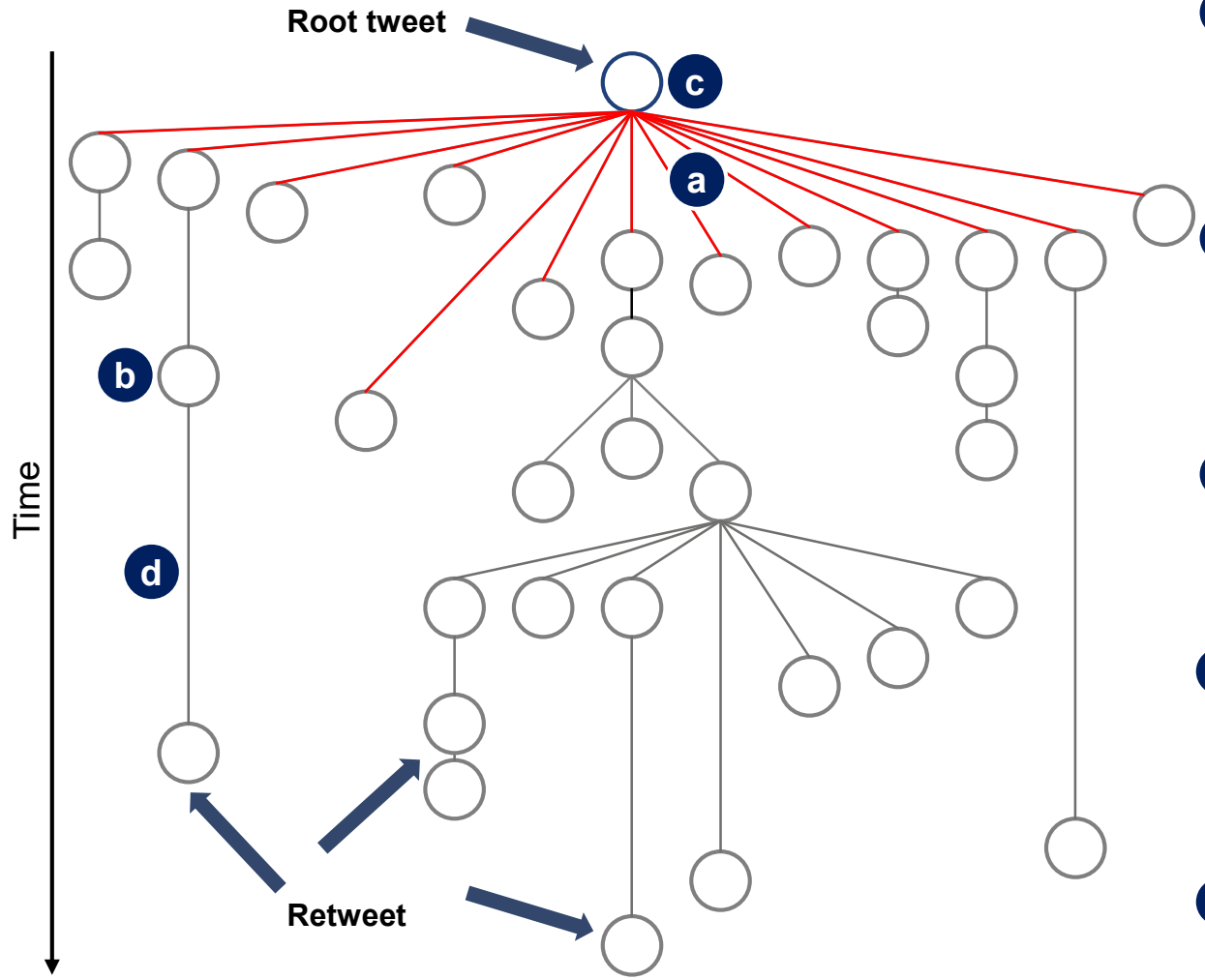
Hypoglycemia has consistently been shown to be associated with an increased risk of driving mishaps



We design, implement and evaluate a vehicle hypoglycemia warning system



Learning fake news from Twitter cascades



a #Retweets

- Both root tweets and retweets are subsequently retweeted
- Retweet count of central interest

b User information

- For each retweet, user-specific information such as #followers is observed

c Content information

- Emotional reaction and topic of the root tweet

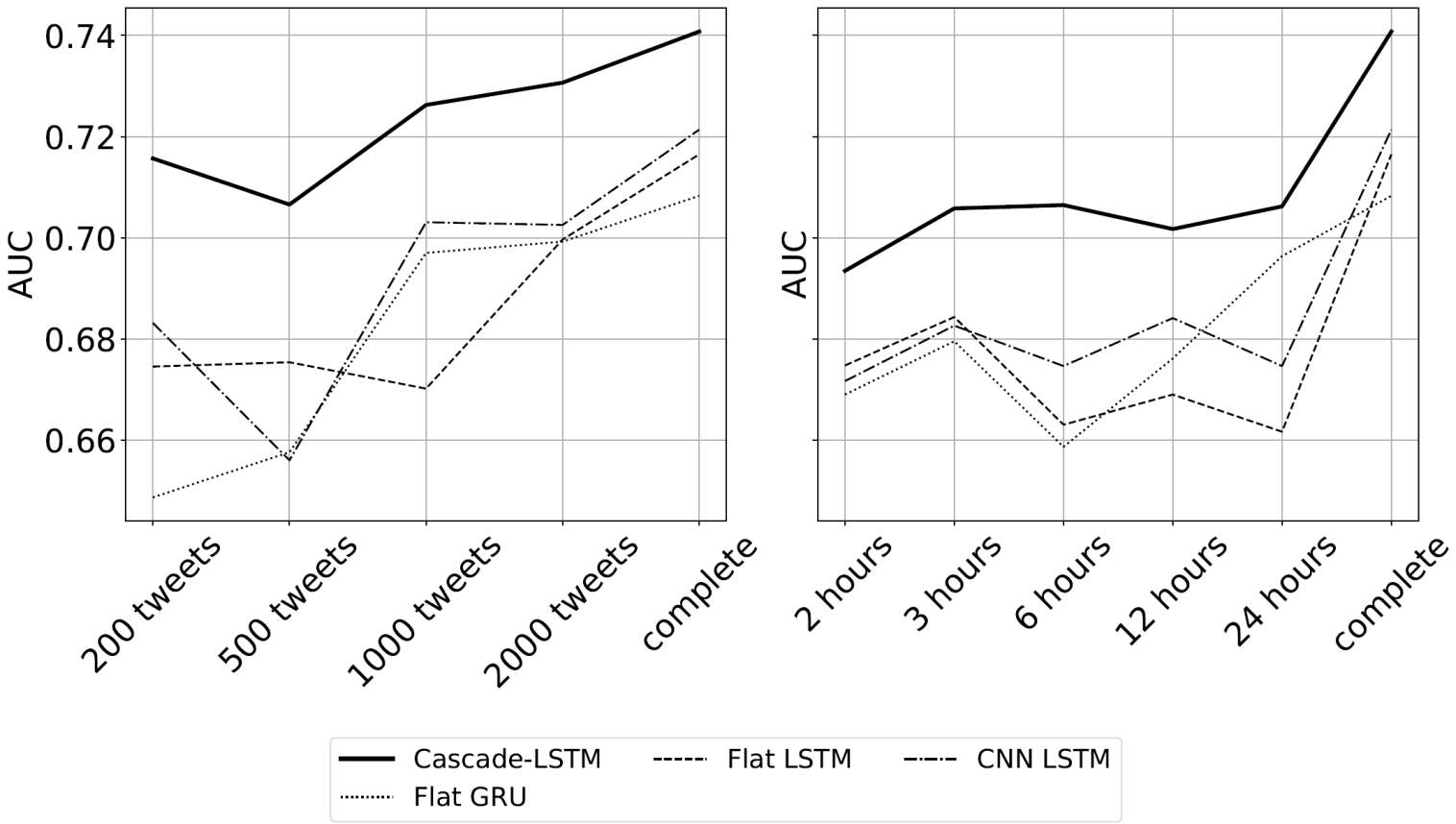
d Cascade information

- Statistics summarizing structure of the cascade, e.g., elapsed time, size

e Veracity

- Truthfulness of a rumor is detected after timer

Results


0.74
0.72
0.70
0.68
0.66
AUC
200 tweets
500 tweets
1000 tweets
2000 tweets
complete
AUC
2 hours
3 hours
6 hours
12 hours
24 hours
complete
Cascade-LSTM
Flat LSTM
CNN LSTM
Flat GRU

ETH zürich

Chair of Management Information Systems

Stefan Feuerriegel

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