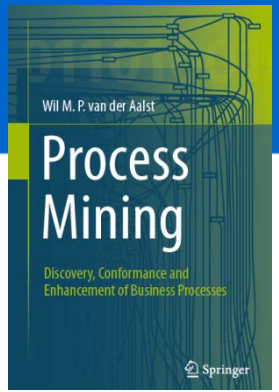
Process Mining: Data Science in Action

Workflow Nets and Soundness



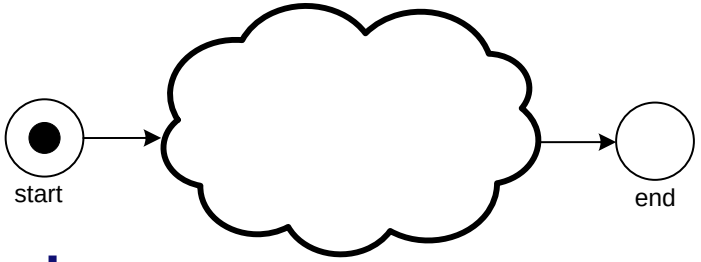
prof.dr.ir. Wil van der Aalst
www.processmining.org

TU/e Technische Universiteit Eindhoven University of Technology

Where innovation starts

Motivation

- For process mining we often use (or aim at) Workflow Nets (WF-nets).



- WF-nets:
  - have a well-defined start and end
  - should be free of obvious anomalies (soundness)
- WF-nets are a subclass of Petri nets often used in the context of workflow management and business process management (systems).

TU/e

"Business Process Management (BPM) is the discipline that combines knowledge from information technology and knowledge from management sciences and applies this to operational business processes"

Wil M. P. van der Aalst, “Business Process Management: A Comprehensive Survey,” ISRN Software Engineering, vol. 2013, Article ID 507984, 37 pages, 2013. doi:10.1155/2013/507984

Adam Smith (1723-1790)

sh **Frederick Taylor** (1856-

the 1915 **Henry Ford** (1863-194

princ int Since 19 ters and

man line dis munication

rastruct the most

do tor influencing

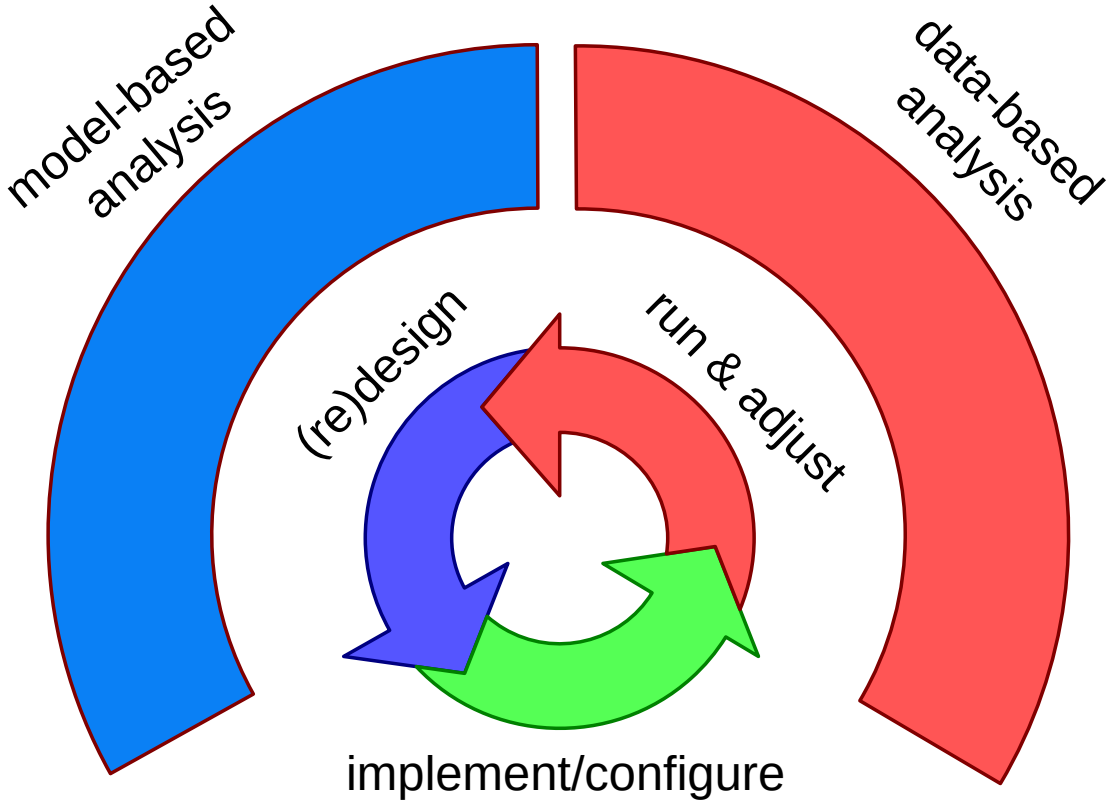
b ness processes and their

management.

Data science in Action: The next level!

Data = the new oil

BPM lifecycle

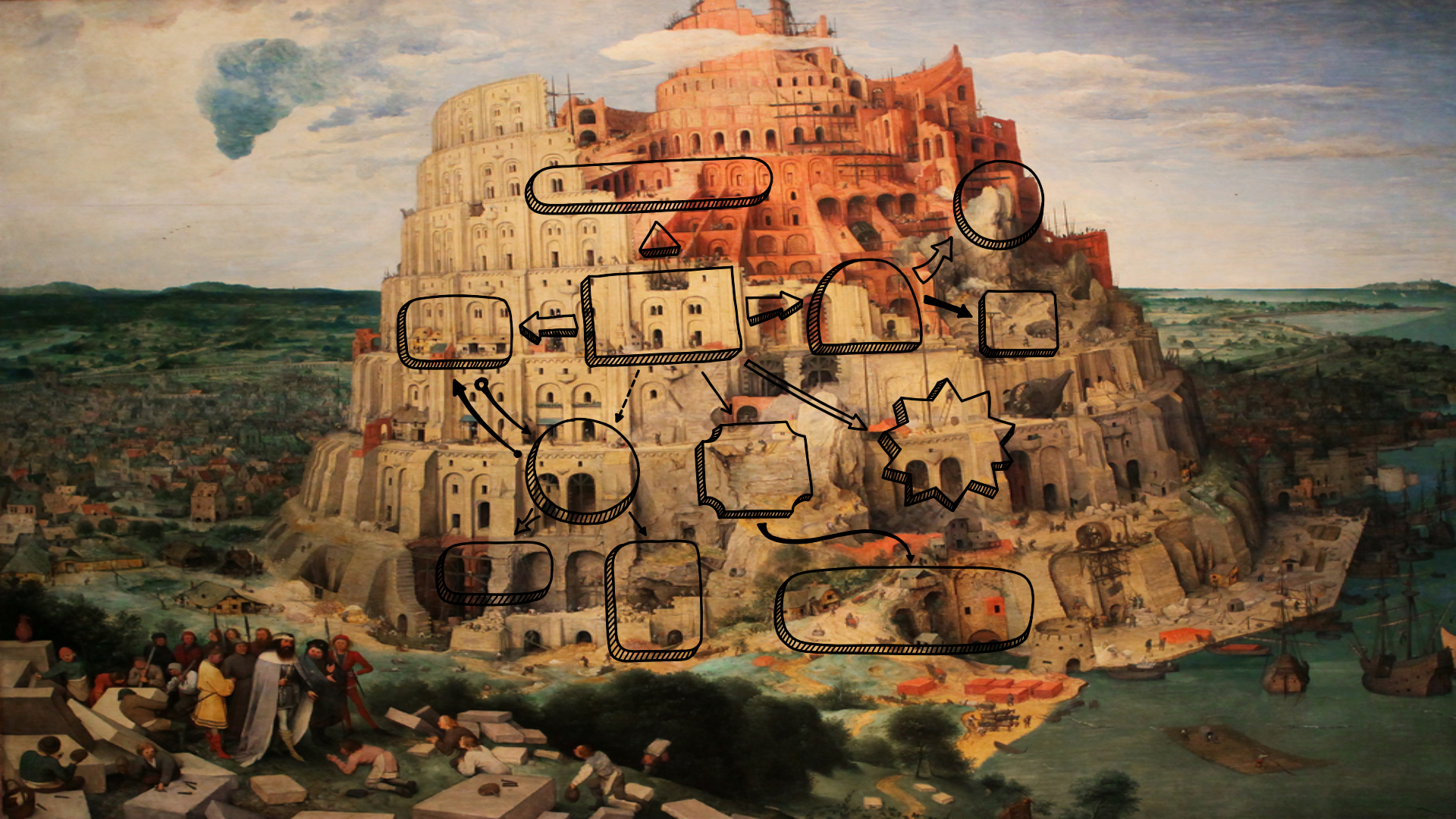


TU/e

What is the role of (process) models?

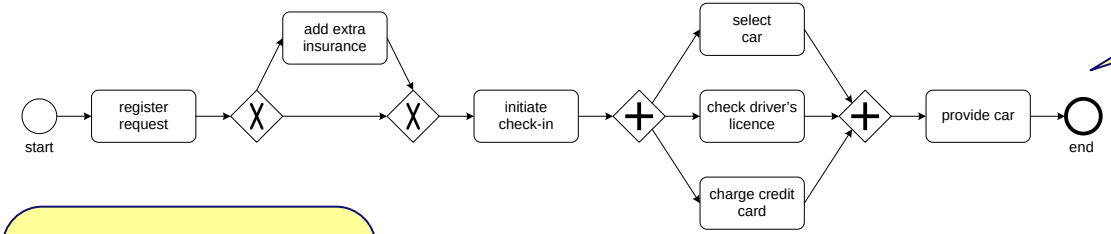
- **Role of models in BPM/WFM:**
  - **reason *about processes* (redesign) and**
  - **make decisions *inside processes* (planning and control).**
- **Process models may be used to:**
  - **discuss responsibilities,**
  - **analyze compliance,**
  - **predict performance using simulation, and**
  - **configure a WFM/BPM system.**

TU/e



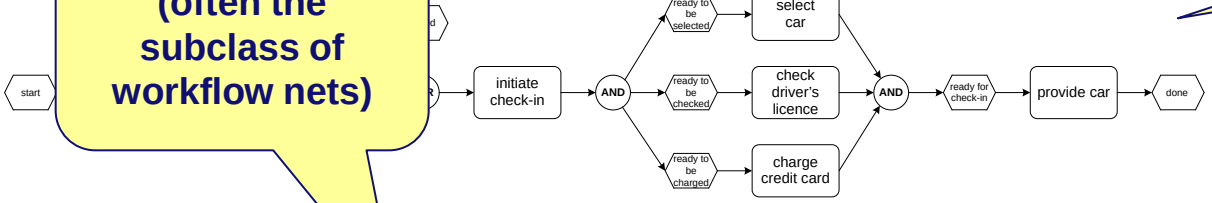
Many notations

Business Process Model and Notation (BPMN)

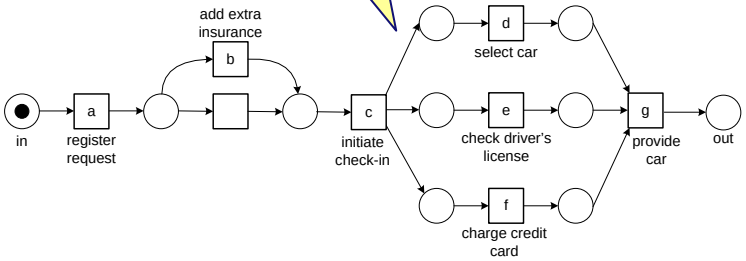


Event-Driven Process Chains (EPCs)

Petri nets (often the subclass of workflow nets)

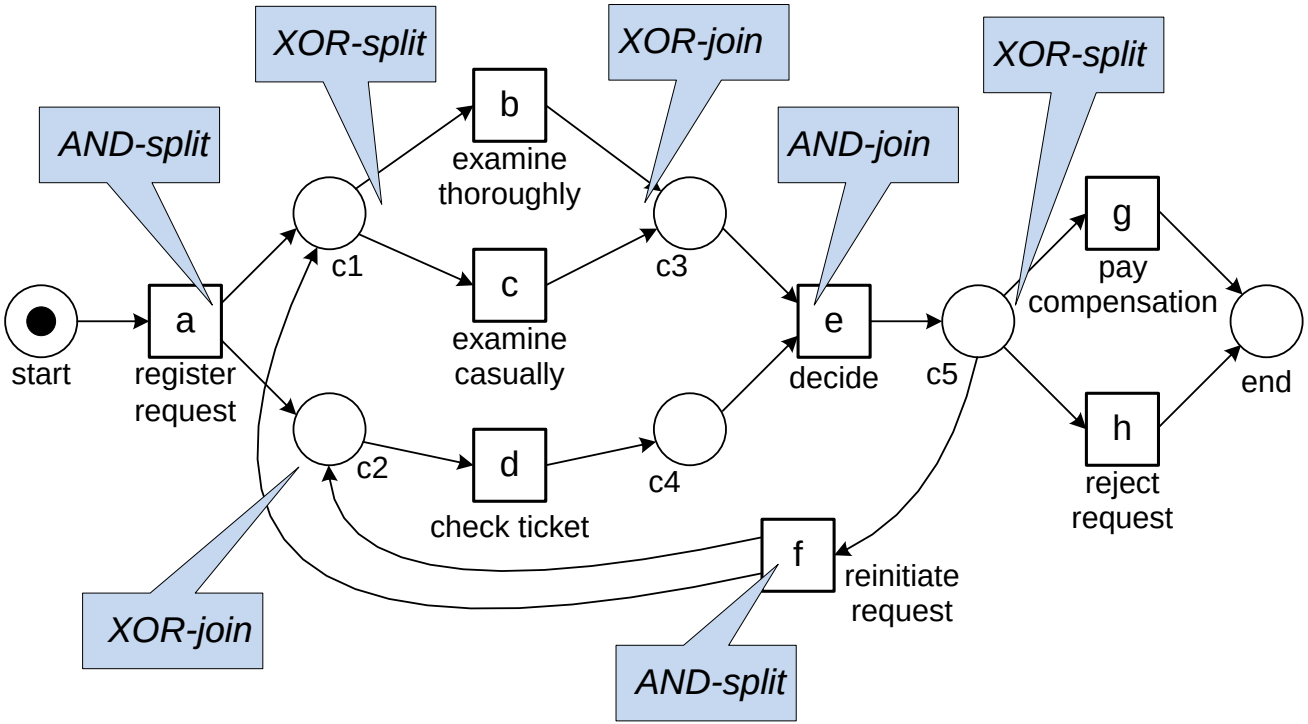


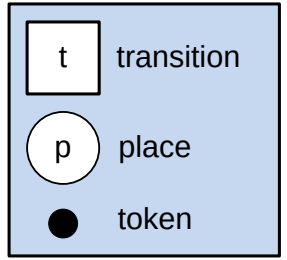
Event log (example/observed behavior)



TU/e

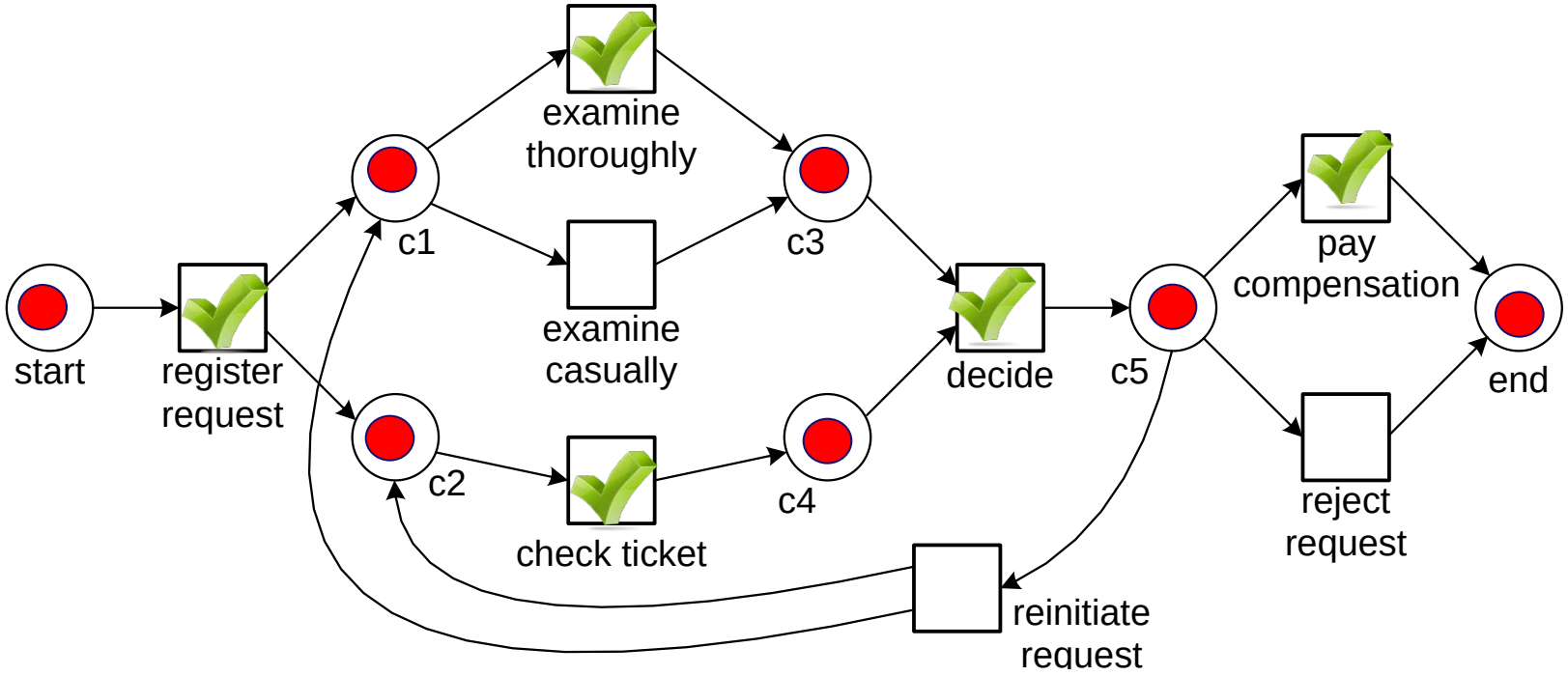
Petri nets (as seen before)





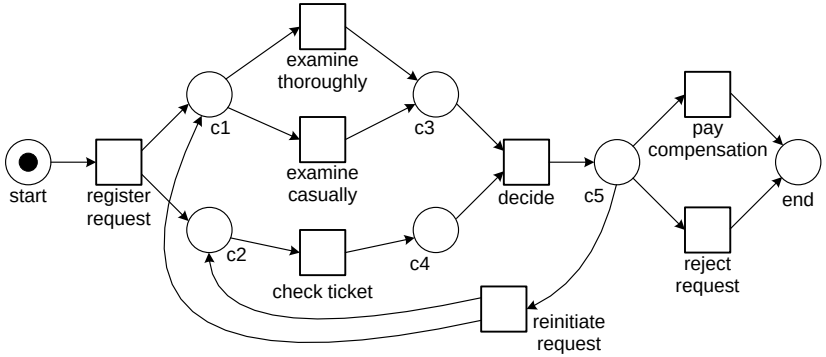
TU/e

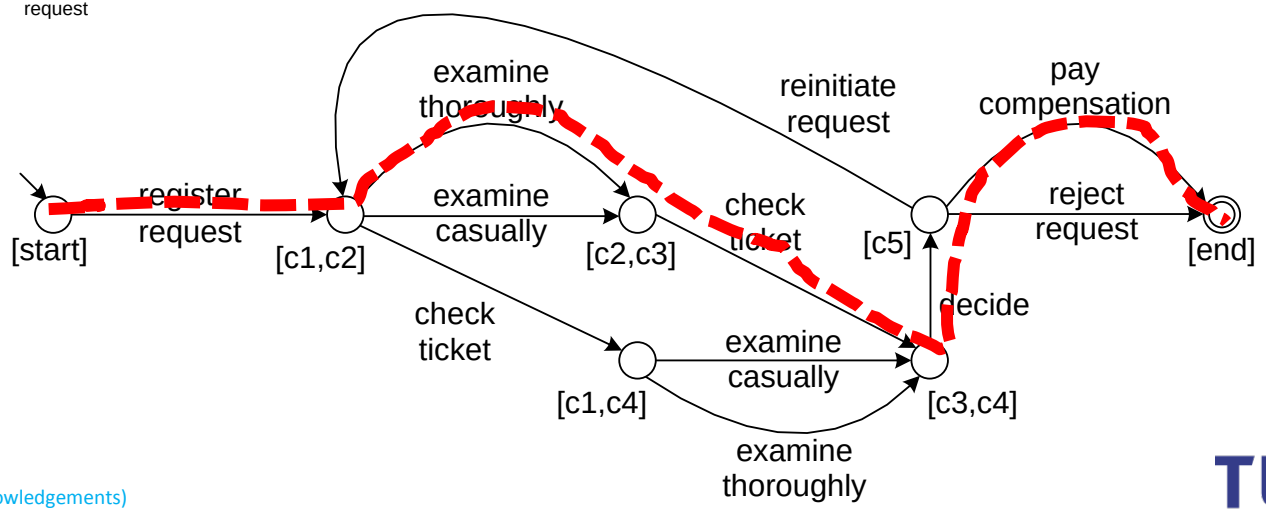
Example run of the model



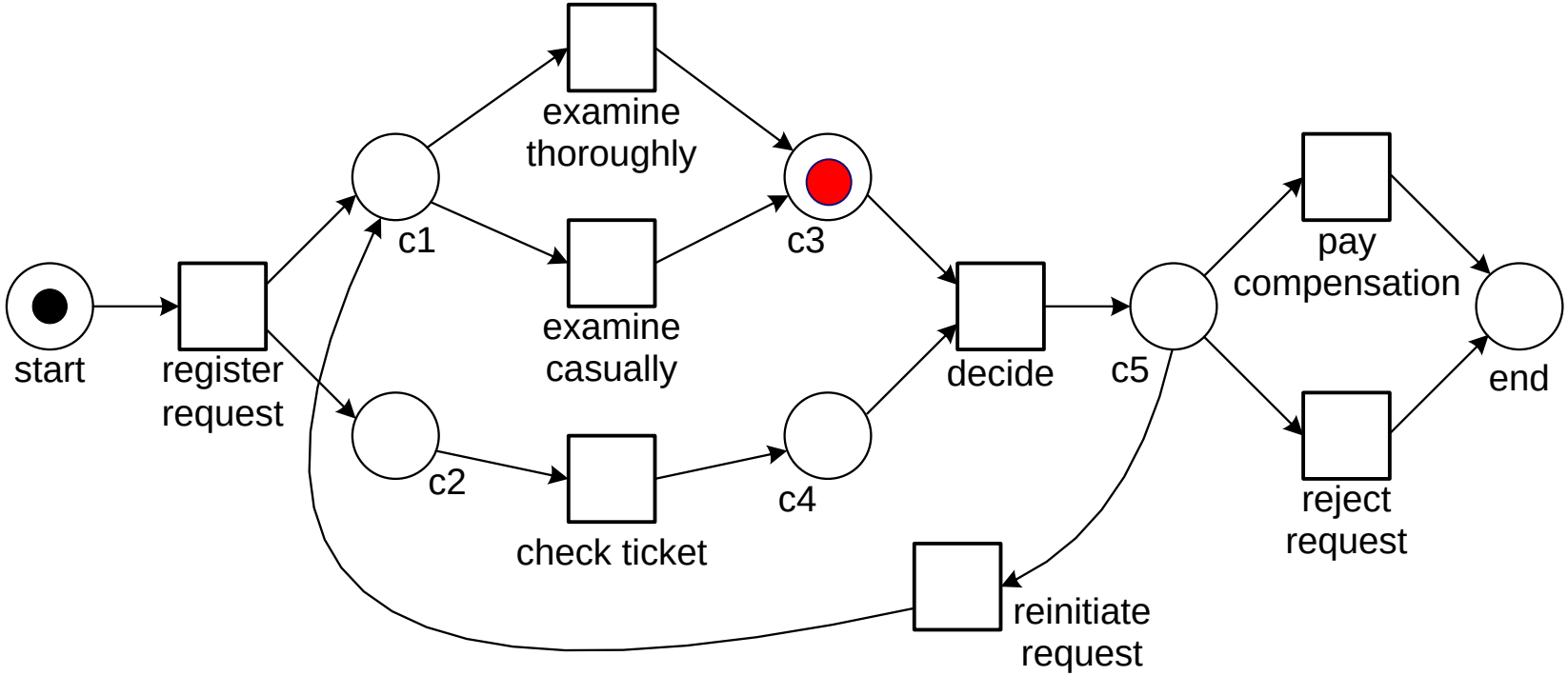
Only one of infinitely many possible firing sequences!

Reachability graph





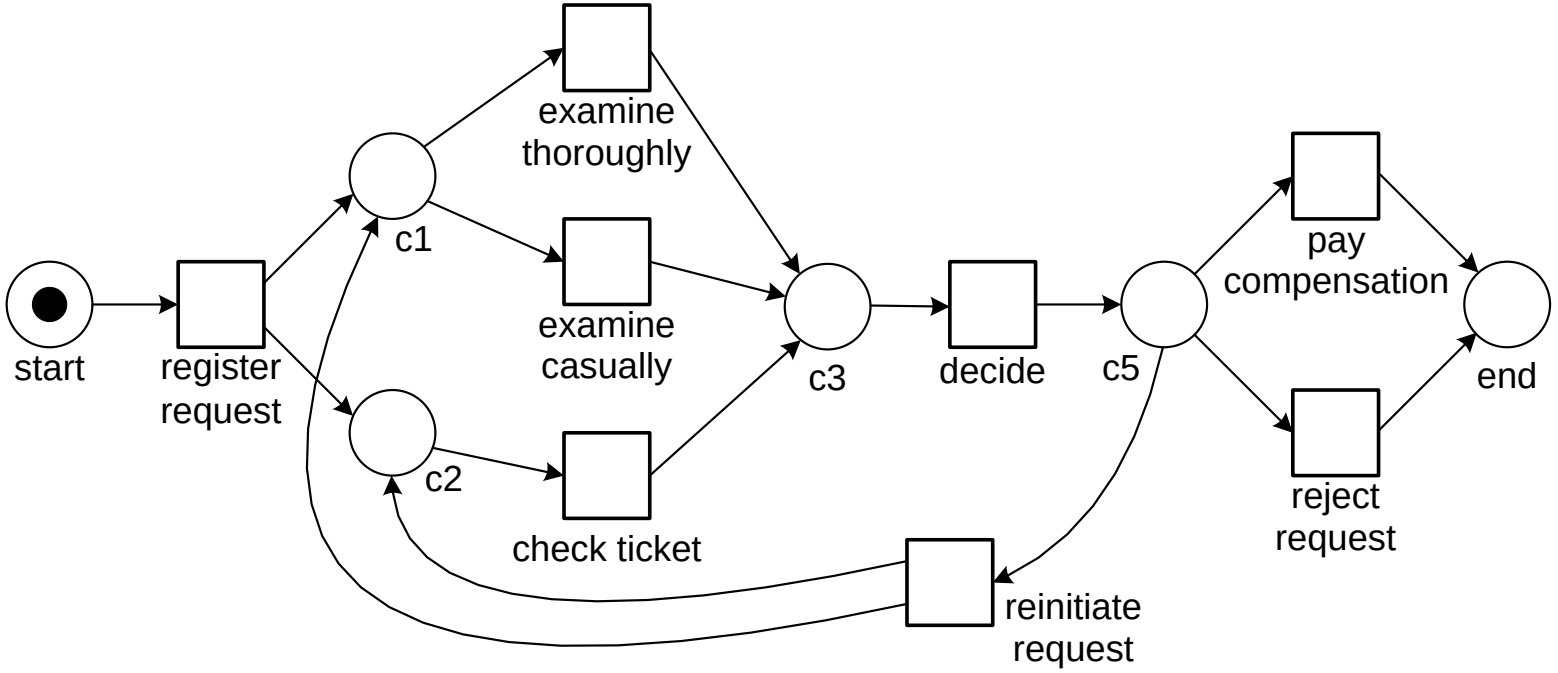
Good model?



No, deadlock possible: [c3].

TU/e

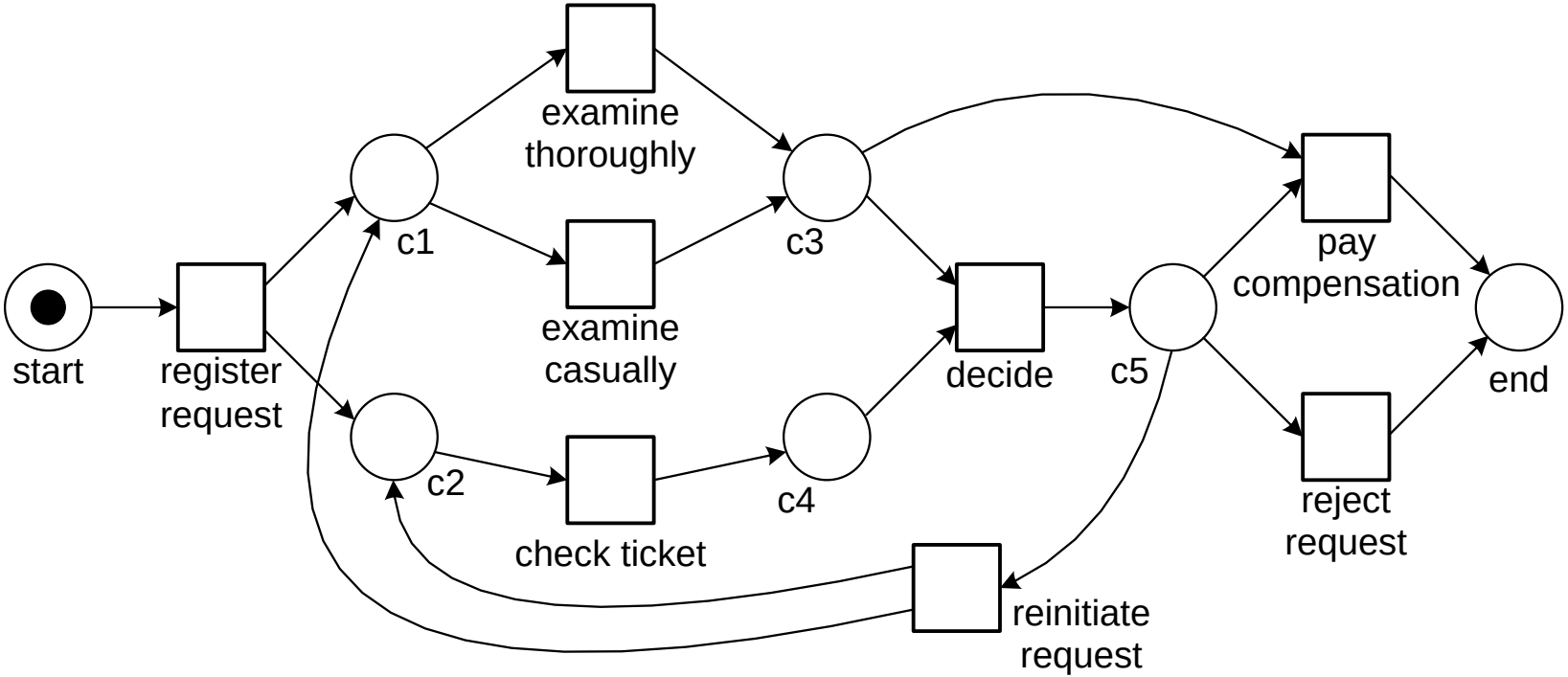
Good model?



No, AND-split does not have corresponding join!

TU/e

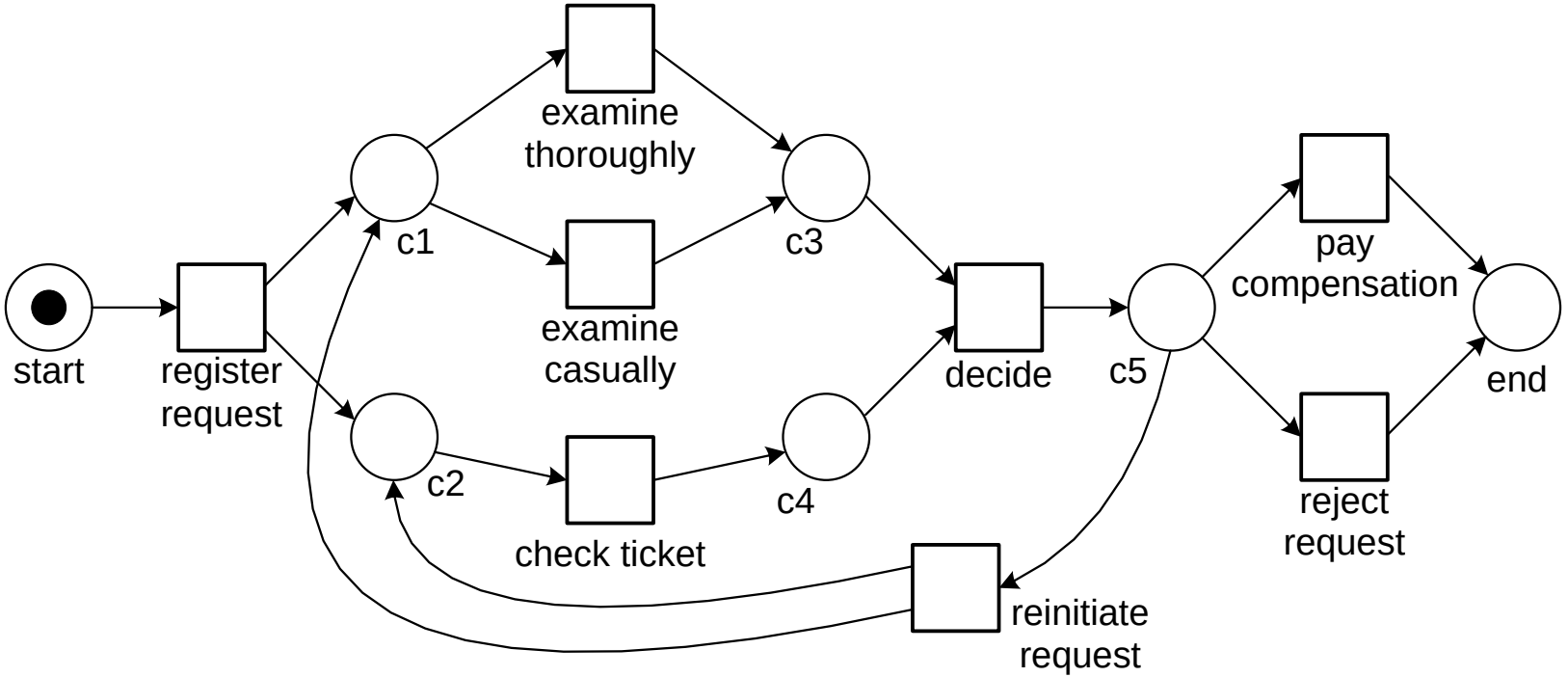
Good model?



No, "pay compensation" is dead!

TU/e

Good model?

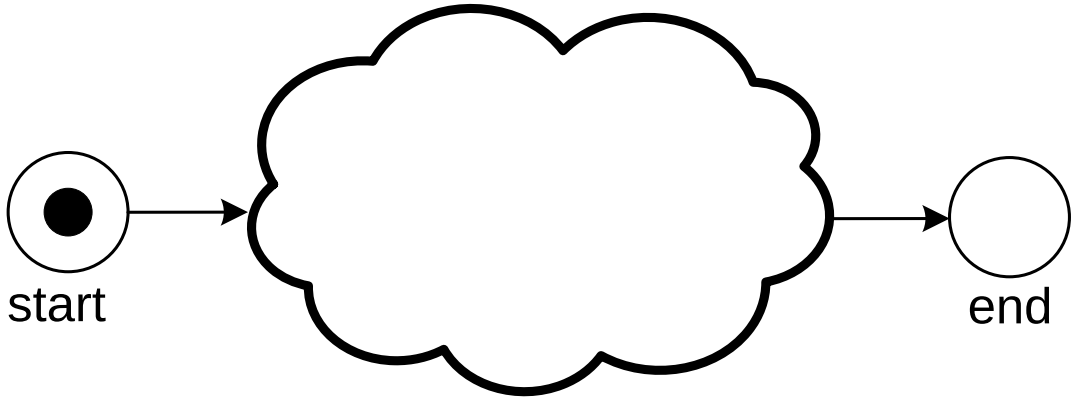


Yes, but why?

TU/e

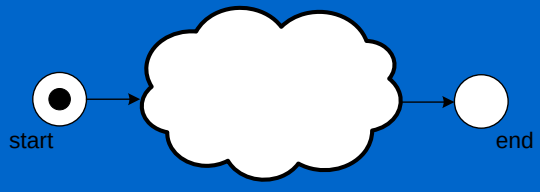
WF-nets

A WorkFlow net (WF-net) has one source place (typically called *start* or *i*) and one sink place (typically called *end* or *o*) and all other nodes are on a path from source to sink.



TU/e

Soundness

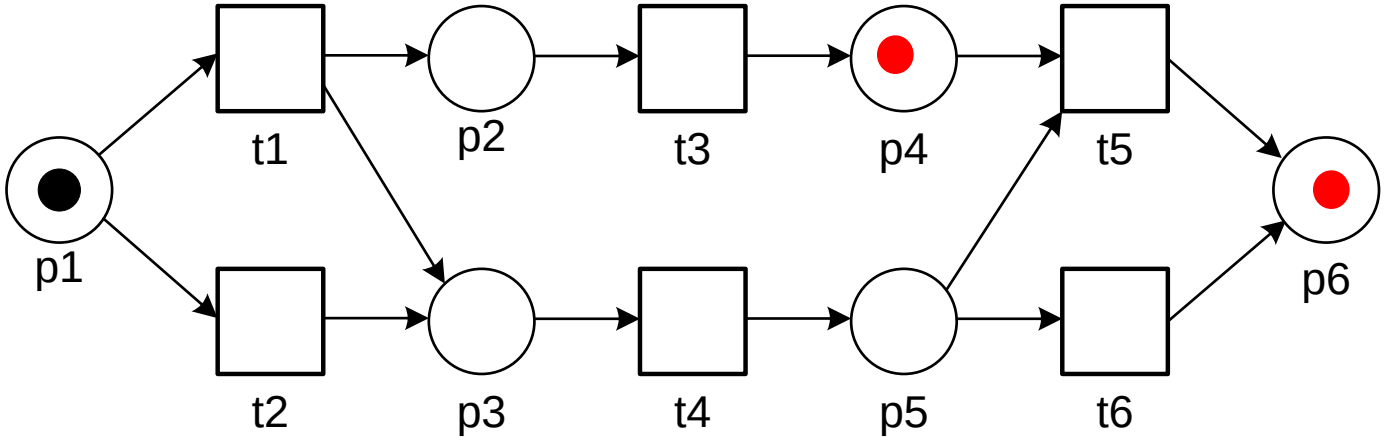


A WF-net is sound if and only if the following properties hold:

- **safeness: places cannot hold multiple tokens at the same time,**
- **proper completion: if the sink place is marked, all other places are empty,**
- **option to complete: it is always possible to reach the marking that marks just the sink place, and**
- **absence of dead parts: for any transition there is a firing sequence enabling it.**

TU/e

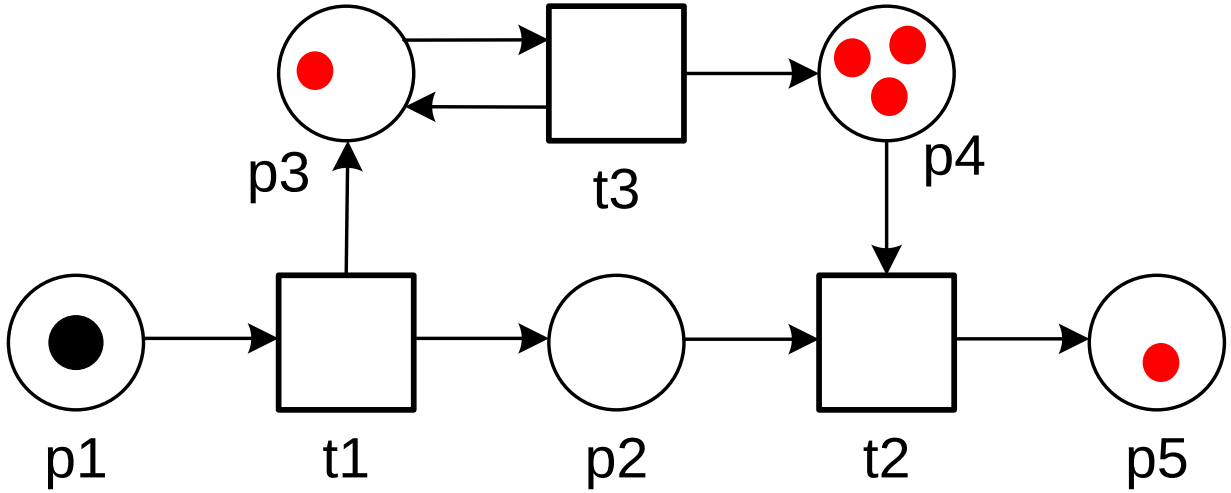
Sound?



- **safeness**: places cannot hold multiple tokens at the same time
- ~~**proper completion**~~: if the sink place is marked, all other places are empty
- ~~**option to complete**~~: it is always possible to reach the final target marking
- **absence of dead parts**: for any transition there is a firing sequence enabling it

TU/e

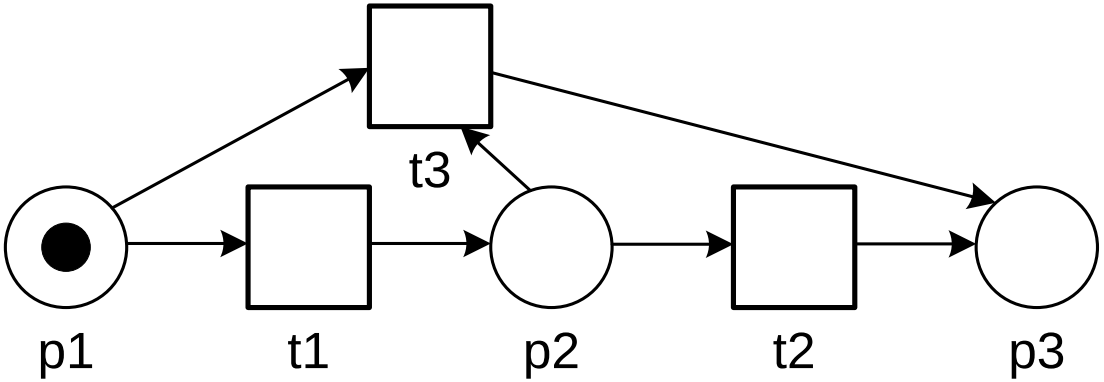
Sound?



- ~~**safeness**~~: places cannot hold multiple tokens at the same time
- ~~**proper completion**~~: if the sink place is marked, all other places are empty
- ~~**option to complete**~~: it is always possible to reach the final target marking
- **absence of dead parts**: for any transition there is a firing sequence enabling it

TU/e

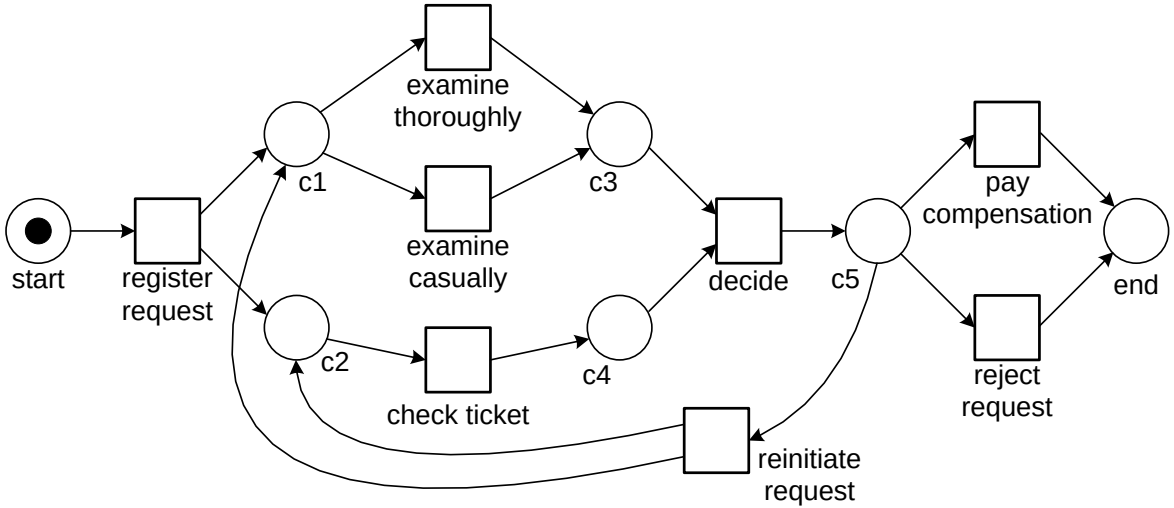
Sound?



- **safeness**: places cannot hold multiple tokens at the same time
- **proper completion**: if the sink place is marked, all other places are empty
- **option to complete**: it is always possible to reach the final target marking
- ~~**absence of dead parts**~~: for any transition there is a firing sequence enabling it

TU/e

Sound?



- **safeness**: places cannot hold multiple tokens at the same time
- **proper completion**: if the sink place is marked, all other places are empty
- **option to complete**: it is always possible to reach the final target marking
- **absence of dead parts**: for any transition there is a firing sequence enabling it

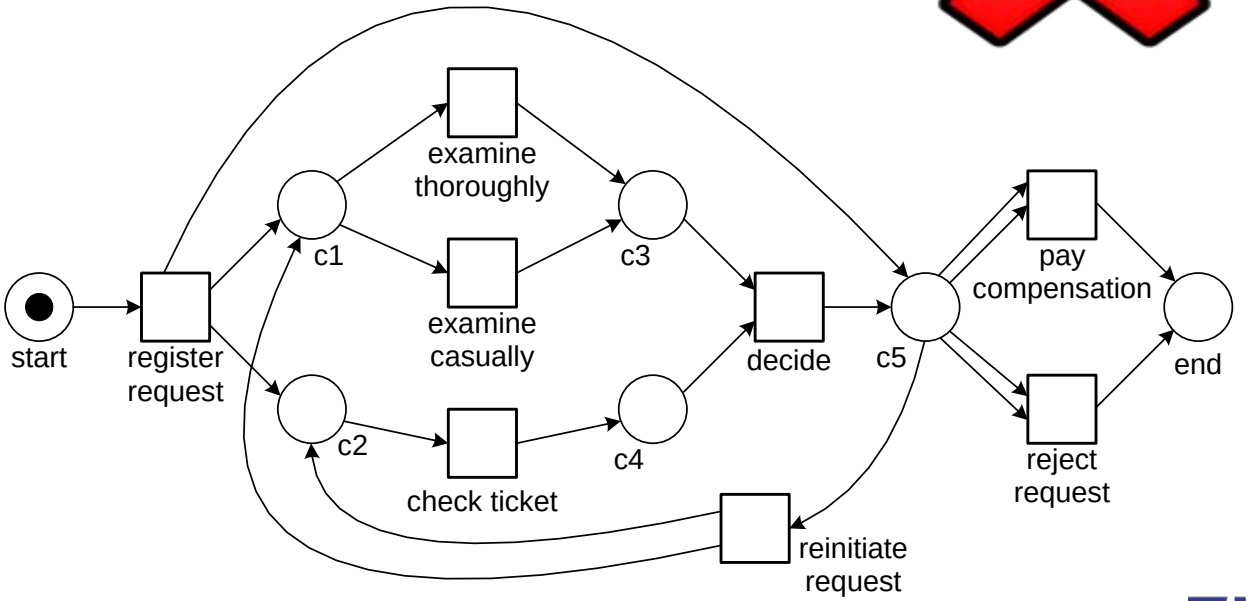
TU/e

Checking soundness may be far from trivial for larger examples.

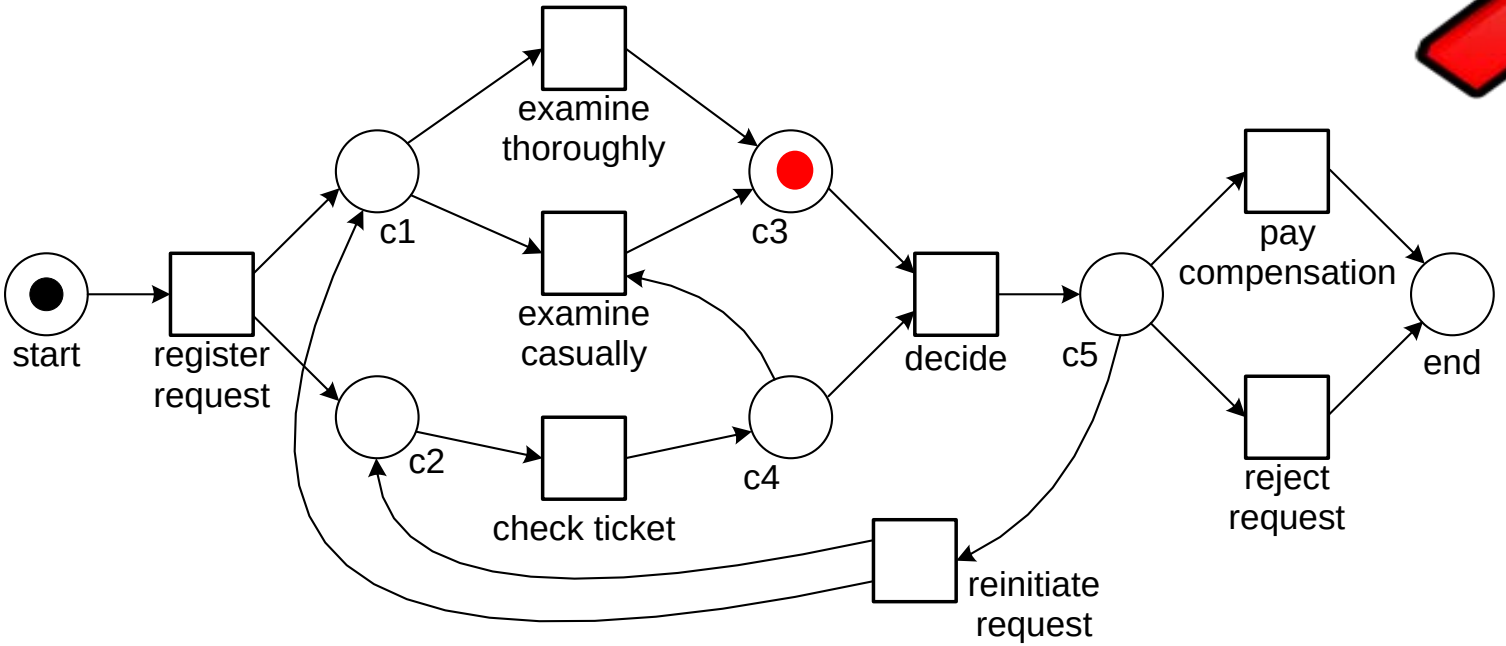
Not sound: Unsafe

Examples of reachable markings:

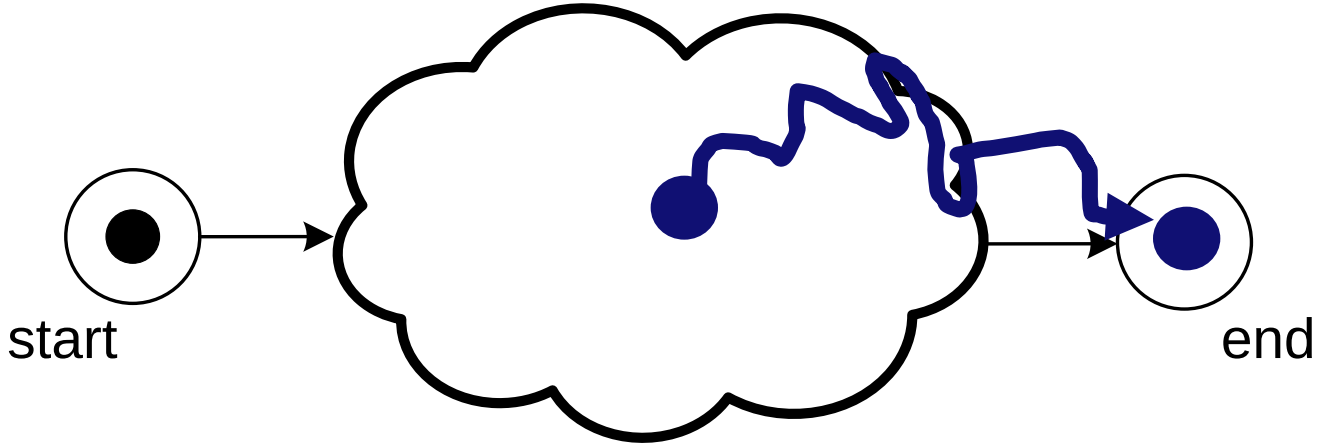
- $[c5^2]$
- [c1,c2,c3,c4]
- $[c1^2,c2^2]$
- etc.



Not sound: No option to complete in [c3]



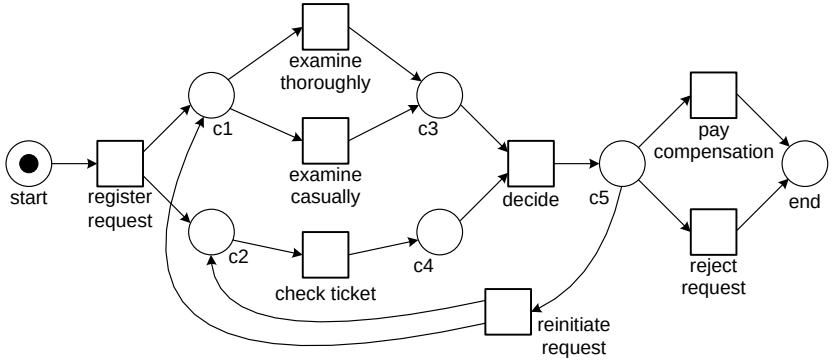
No need to check proper completion:
It is implied by other properties

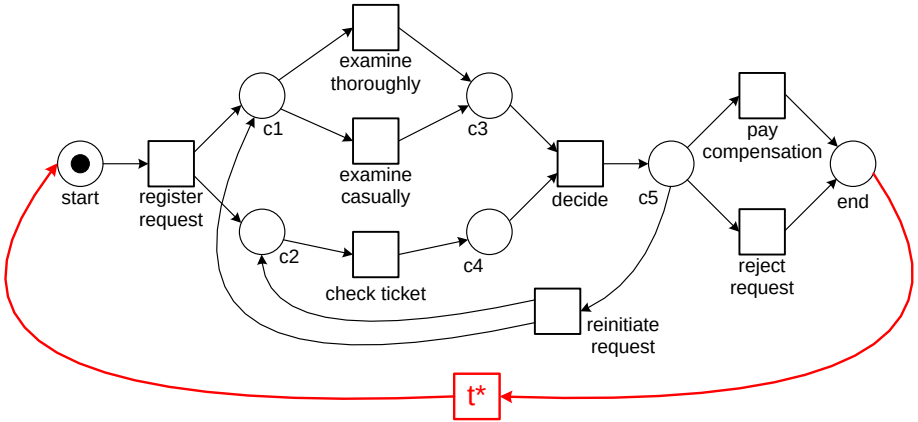


option to complete (it is always possible to reach the marking that marks just the sink place) implies proper completion (if the sink place is marked all other places are empty)

TU/e

Link between soundness and classical Petri net properties





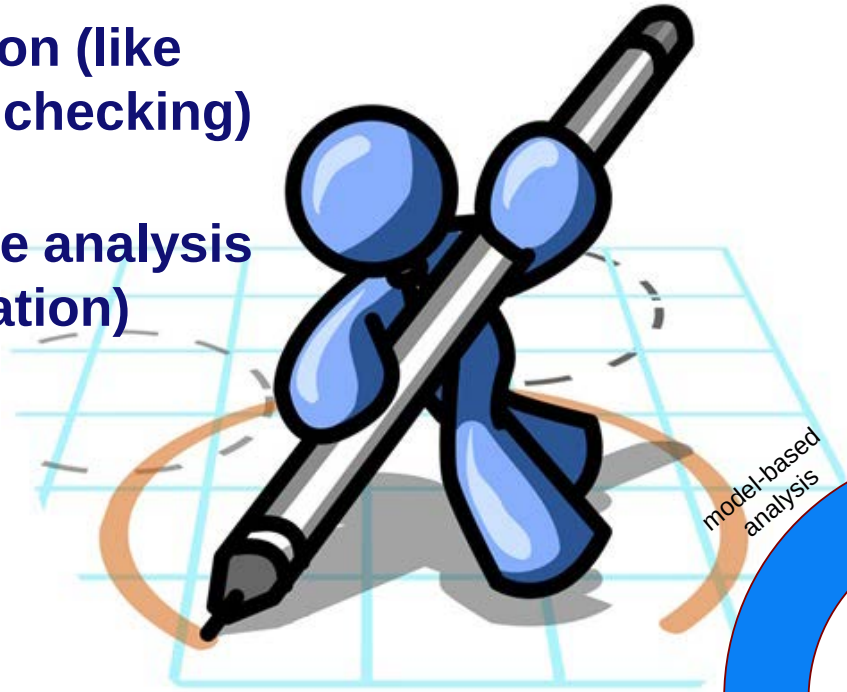
A WF-net is sound if and only if the corresponding "short-circuited" Petri net is live and bounded!

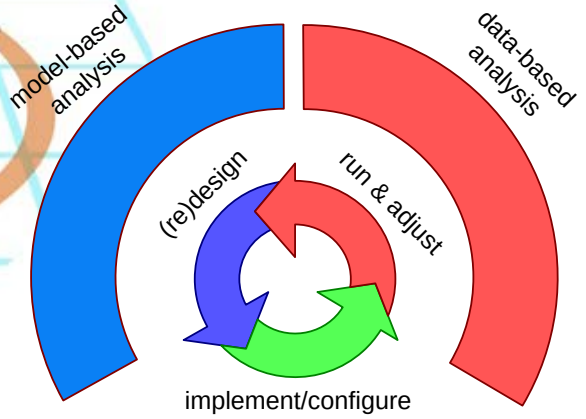
TU/e

Main types of model-based analysis

verification (like soundness checking)

performance analysis (simulation)



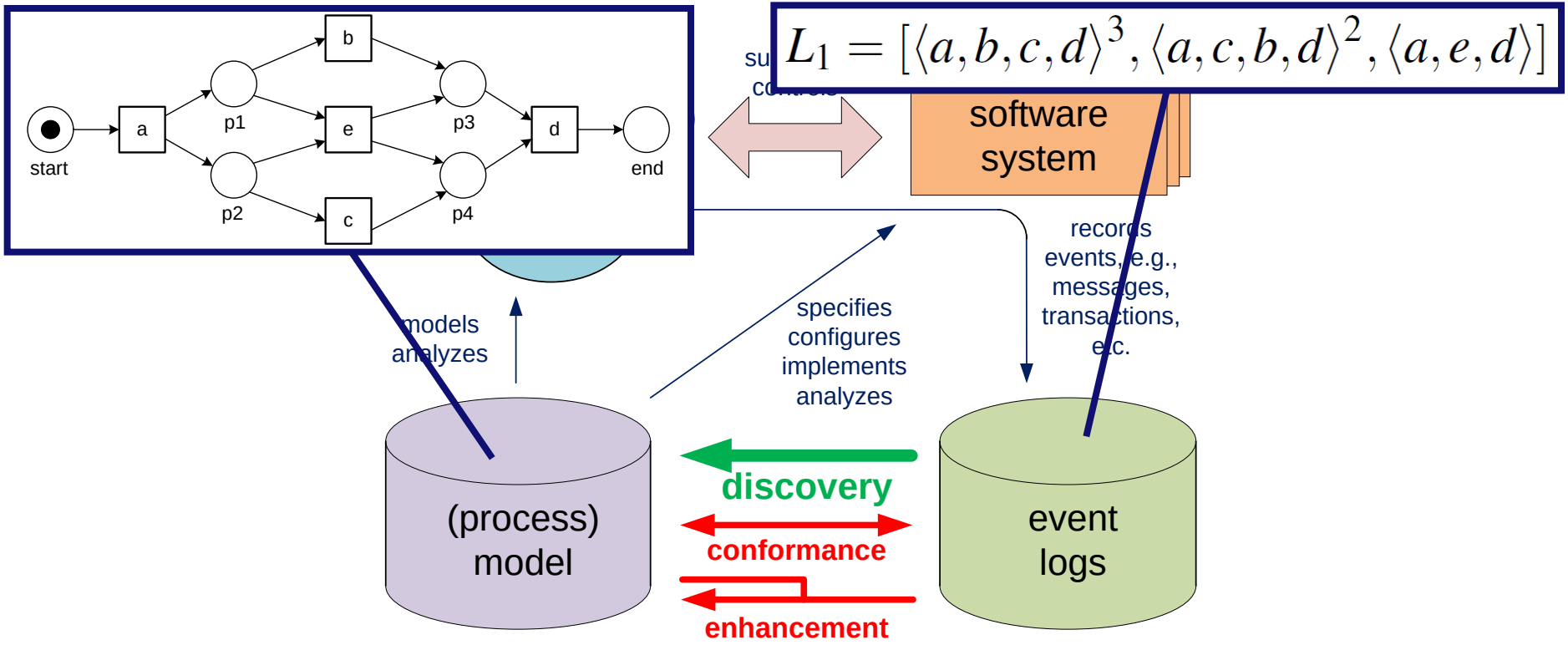


TU/e

Limitations of model-based analysis

- Verification and performance analysis heavily rely on the availability of high quality models.
- When the models and reality have little in common, model-based analysis does not make much sense!
- There is often a poor alignment between hand-made models and reality.
- Process mining aims to address these problems by establishing a direct connection between the models and actual event data about the process.

Next: Using the Alpha Algorithm to discover WF-nets from event logs



TU/e

Part I: Preliminaries

- Chapter 1: Introduction
- Chapter 2: Process Modeling and Analysis
- Chapter 3: Data Mining

Part II: From Event Logs to Process Models

- Chapter 4: Getting the Data
- Chapter 5: Process Discovery: An Introduction
- Chapter 6: Advanced Process Discovery Techniques

Part III: Beyond Process Discovery

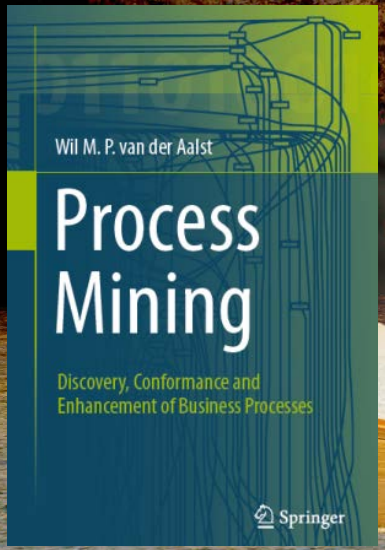
- Chapter 7: Conformance Checking
- Chapter 8: Mining Additional Perspectives
- Chapter 9: Operational Support

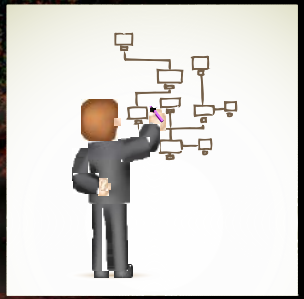
Part IV: Putting Process Mining to Work

- Chapter 10: Tool Support
- Chapter 11: Analyzing "Lasagna Processes"
- Chapter 12: Analyzing "Spaghetti Processes"

Part V: Reflection

- Chapter 13: Cartography and Navigation
- Chapter 14: Epilogue





TU/e