Detecting Contradictory Beliefs About Complex Systems Using Ontologies

project model driven engineering

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What's an ontology again?

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1. Introduction

Train Control System (1)

European Train Control System (ETCS)

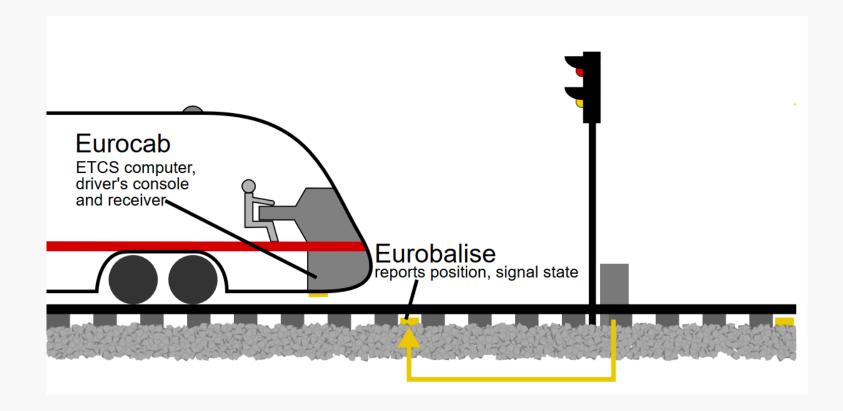


image adapted from https://en.wikipedia.org/wiki/European_Train_Control_System

Train Control System (2)

A balise or **contact** transmits position and signal information



image from https://en.wikipedia.org/wiki/European_Train_Control_System

introduction

Train Control System (3)

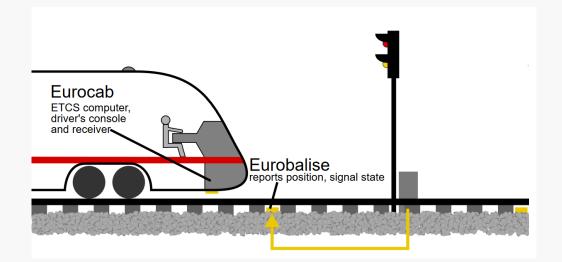
The Crocodile, still used in Belgium



image from https://en.wikipedia.org/wiki/Crocodile_(train_protection_system)

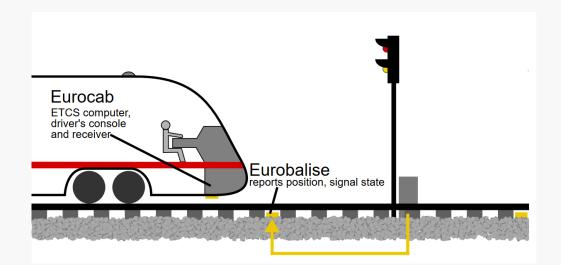
Some Requirements

 When a balise is passed, position and signal information is transmitted to the train.



Some Requirements

- When a balise is passed, position and signal information is transmitted to the train.
- Passing a yellow light triggers a warning. Driver must acknowledge warning, or train is stopped.



Tool Used

Open-source ontology editor protégé

traincontrolsystem (http://www.semanticweb.org/ob/ontolog	gies/2017/0/traincontrolsystem) : [C:\Users\ob\Dropbox\ua\4a_model_driven_engineering\projec	- 🗆 ×
File Edit View Reasoner Tools Refactor Window	Help	
Search		
Active Ontology × Entities × Individuals by class × OWLViz × DL Query × Debugger ×		
Annotation properties Datatypes Individuals	Vehicle — http://www.semanticweb.org/ob/ontologies/2017/0/traincontrolsystem#Vehicle	
Classes Object properties Data properties	Class Annotations Class Usage	
Class hierarchy: Vehicle	Annotations: Vehicle	
	Annotations 🛨	
▼-● CanTransmitFullDataFrame ● SafeSystem ● Contact ● Segment		-
Signal ColorLight	Description: Vehicle	
Semaphore	Equivalent To 🕂	_
▼	SubClass Of +	
▼ ⊜ Train ▼ ⊜ IntercityExpress	hasMaxVelocity exactly 1 xsd:double	0000
	hasWeight exactly 1 xsd:double	? @XO
← ICE-T → ICE-TD ▼ ← GTGV ↓ ← TGV-Atlantique	General class axioms 🕂	
GV-Reseau GV-Thalys	SubClass Of (Anonymous Ancestor)	
	Instances 🕀	
	Target for Key 🛨	•
	Reasoner state out of sync with active ontolog	y Show Inferences

http://protege.stanford.edu/

introduction

2. Ontology Recap

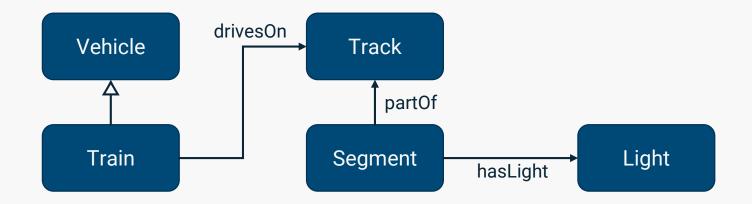
ontology recap

Definition

• An ontology is a model of a particular domain

- Concepts/Classes
- Relations
- Serves a purpose
 - Shared understanding
 - Automated reasoning
 - Interoperability

Example



Ontology Languages (1)

"A train is a vehicle"

- Predicate Logic $\forall x[Train(x) \rightarrow Vehicle(x)]$
- Description Logic
 Train ⊑ *Vehicle*
- OWL Web Ontology Language XML-based, Description Logic semantics

Ontology Languages (2)

- Concept constructors: ⊔, ⊓, ¬, ∀r.C, ∃r.C, ≥_n r.C
 (common ones)
- Concept axioms: \sqsubseteq , \equiv

Ontology Languages (2)

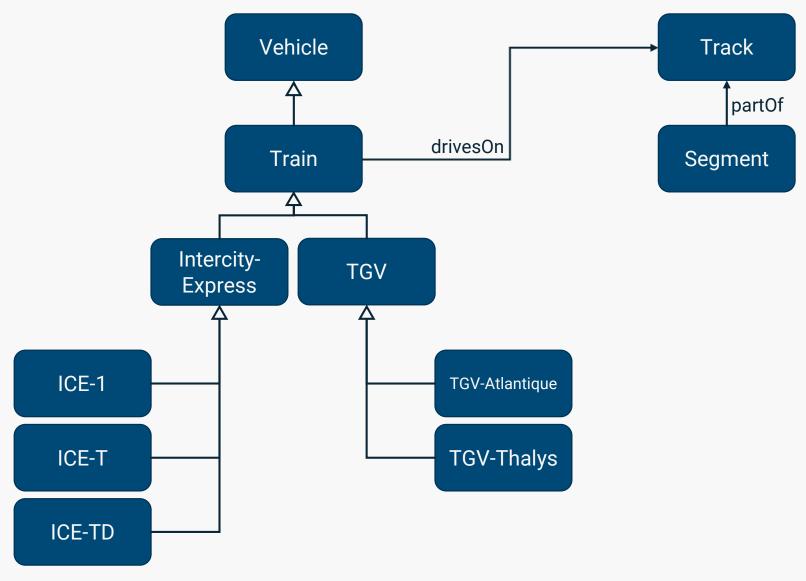
- Concept constructors: ⊔, ⊓, ¬, ∀r.C, ∃r.C, ≥_n r.C
 (common ones)
- Concept axioms: \sqsubseteq , \equiv
- Example:

Vehicle $\sqcap \leq_2 hasPart.Wheel$

3. Train Control System Ontology

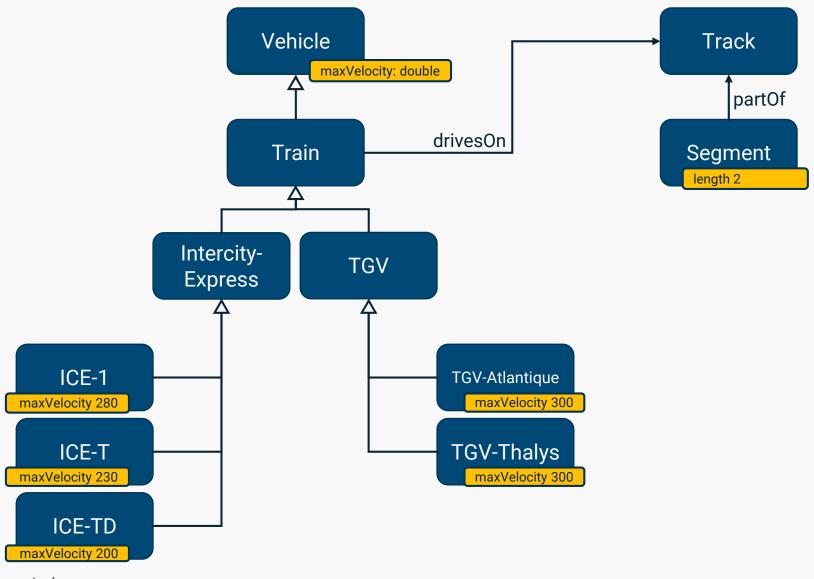
system ontology

System Ontology



system ontology

System Ontology

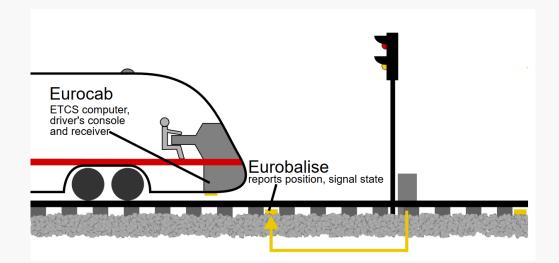


system ontology

4. Detecting Inconsistencies

Requirement

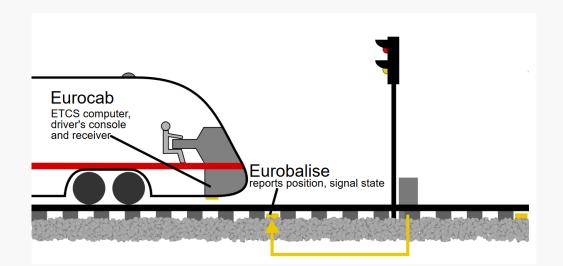
Requirement. Passing a yellow light triggers a warning. Driver must acknowledge warning, or train is stopped.



Requirement

Requirement. Passing a yellow light triggers a warning. Driver must acknowledge warning, or train is stopped.

Question. Can the train stop in time to prevent a collision?



Verifying Properties

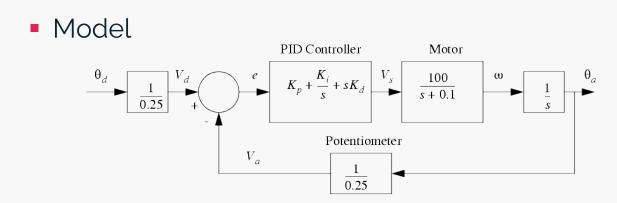
Assumptions

- Train's velocity is at most 300km/h
- Track segments are at least 2km in length

Verifying Properties

Assumptions

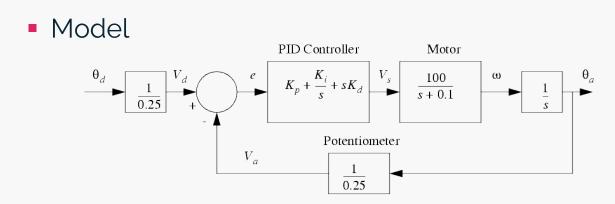
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Verifying Properties

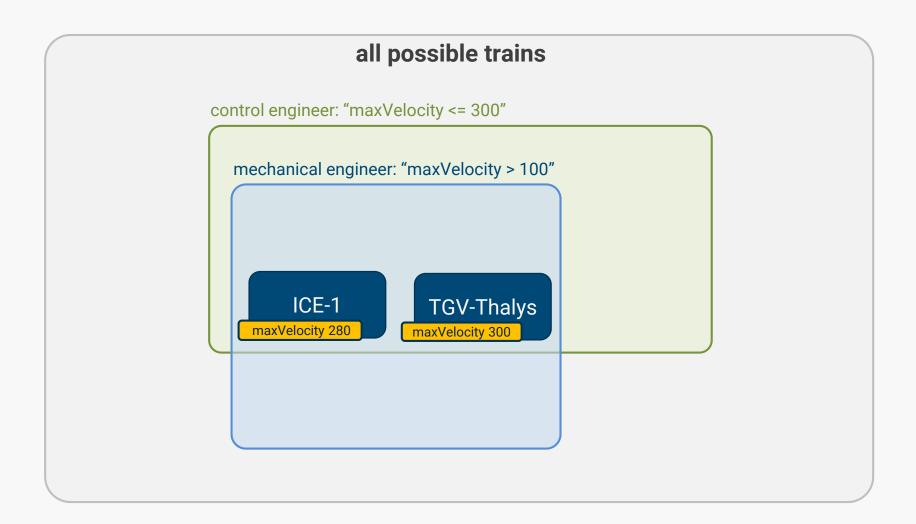
Assumptions

- Train's velocity is at most 300km/h
- Track segments are at least 2km in length

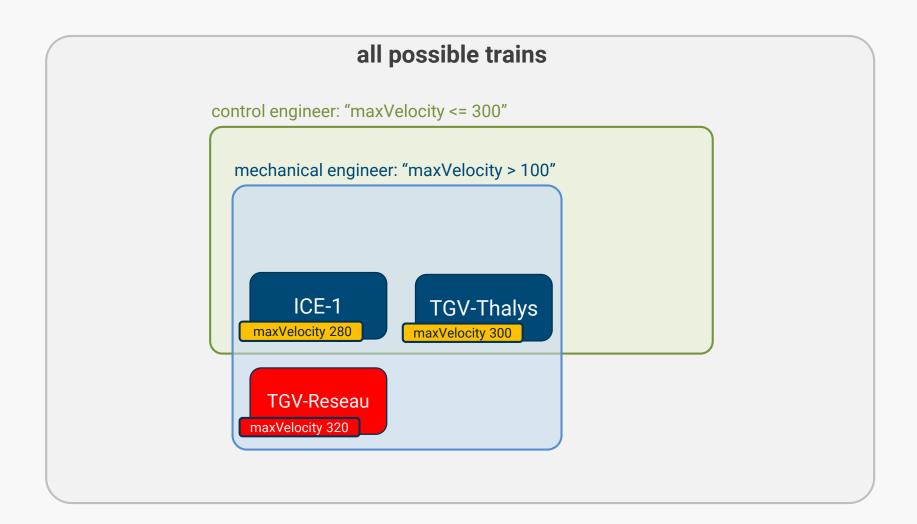


- Conclusions
 - Braking distance is 1.92km. The train can brake in time to prevent collisions.

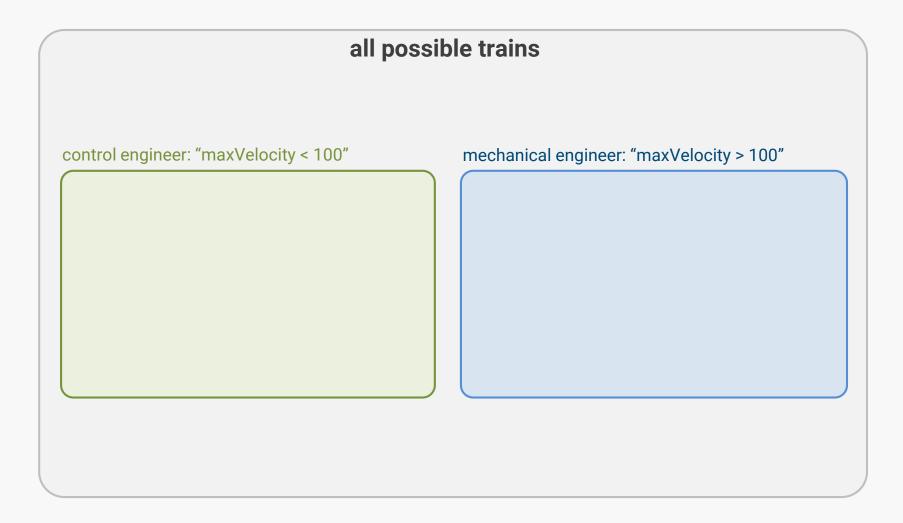
Constraining Entities (1)



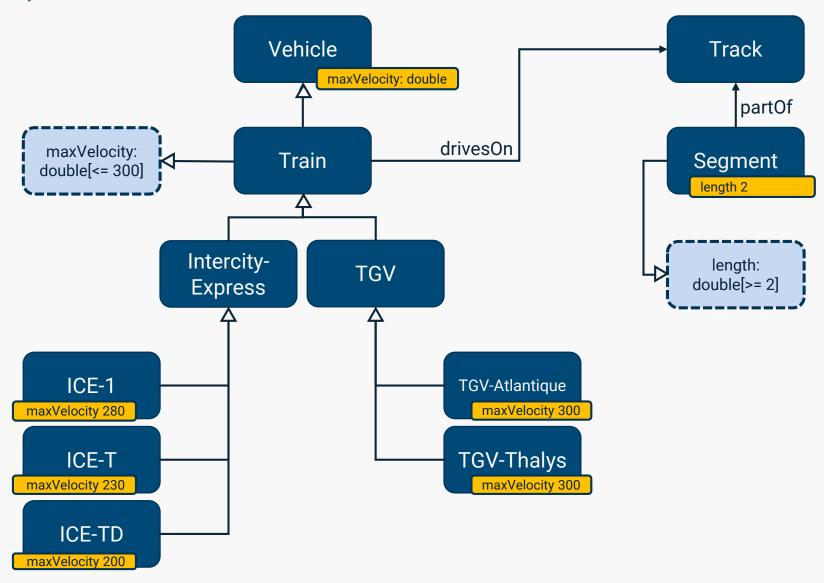
Constraining Entities (1)



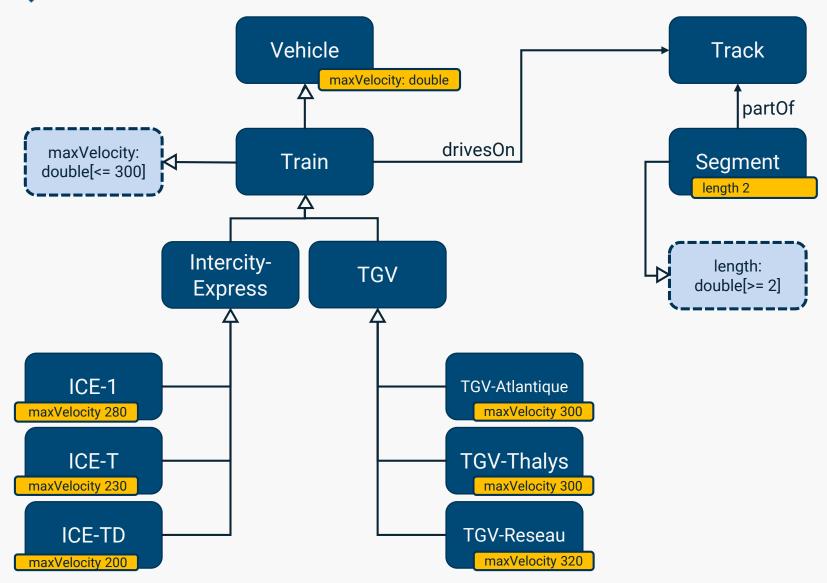
Constraining Entities (2)



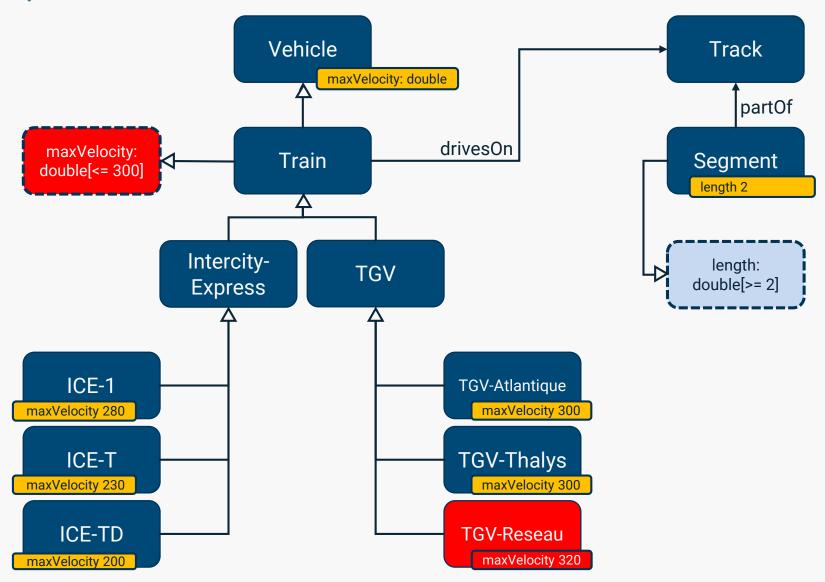
Introducing an Inconsistency



Introducing an Inconsistency



Introducing an Inconsistency



Pitfalls

Some OWL peculiarities

- Open world assumption
- No unique name assumption

Questions

References

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