Modeling with UML, with semantics

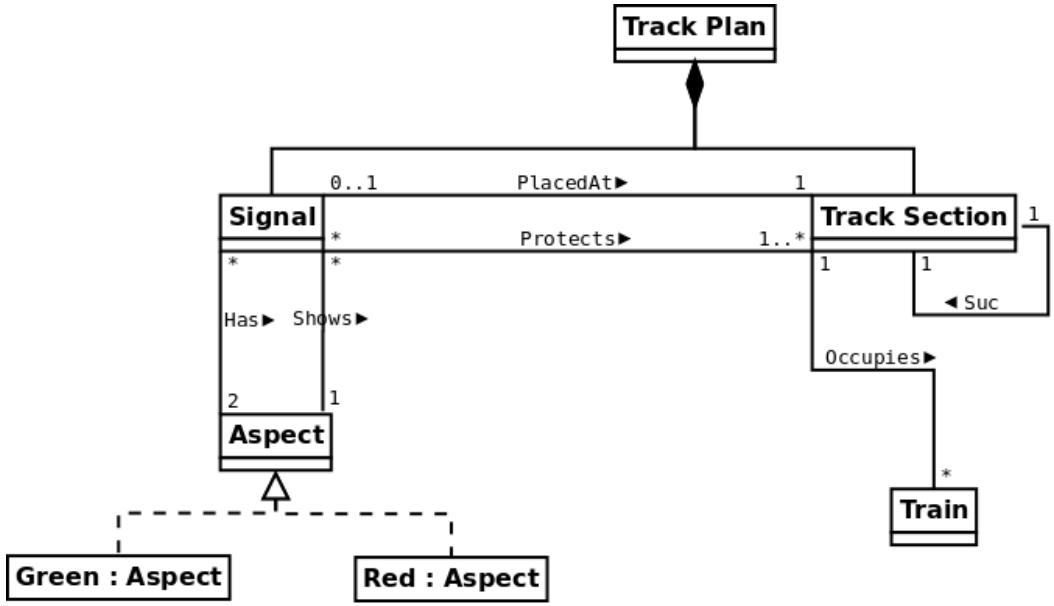
Lecture at Otto-von-Guericke University Magdeburg, May 2014

Signatures

Signatures $\Sigma \in |\mathrm{Sig}|$ comprise

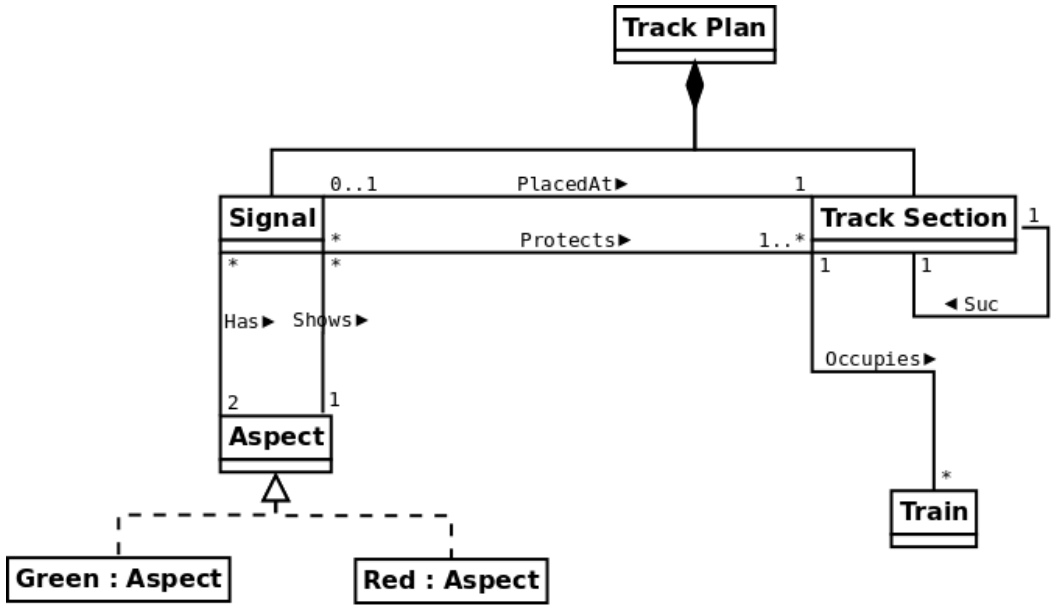
- Classifier hierarchy $(C, \leq)$
- Instance specifications $k : c$
- Property declarations $c.p : c'$
- Composition declarations $c \blacklozenge r : c'$
- Association declarations $z(\{r_1 : c_1, \ldots, r_n : c_n\})$

Signature Example: Circle DSL (1)



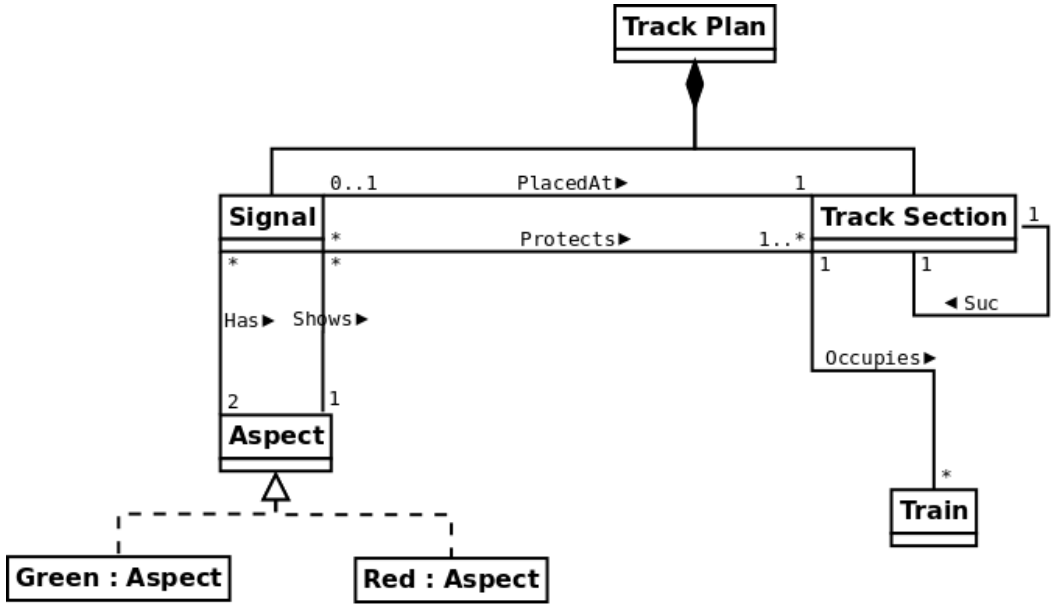
- Classifiers: TrackPlan, Signal, TrackSection, Aspect, Train

Signature Example: Circle DSL (2)



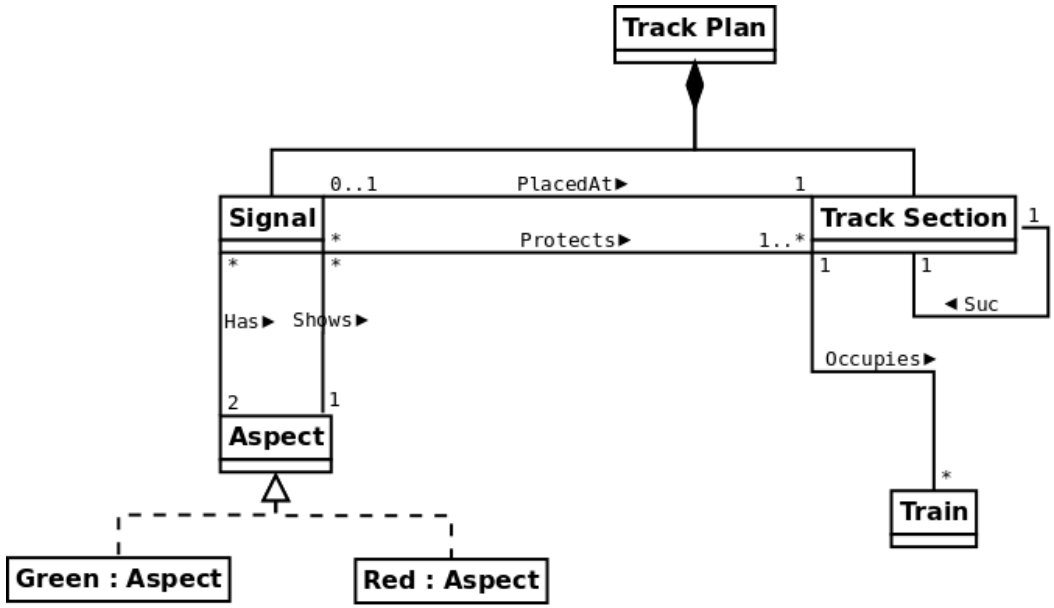
- Compositions:
  TrackPlan◆signal : Signal,
  TrackPlan◆trackSection : TrackSection

Signature Example: Circle DSL (3)



- Associations, e.g.:
  $\mathrm{PlacedAt}(\{\mathrm{signal} : \mathrm{Signal}, \mathrm{trackSection} : \mathrm{TrackSection}\})$,
  $\mathrm{Protects}(\{\mathrm{signal} : \mathrm{Signal}, \mathrm{trackSection} : \mathrm{TrackSection}\})$,
  $\mathrm{Suc}(\{\mathrm{trackSection1} : \mathrm{TrackSection}, \mathrm{trackSection2} : \mathrm{TrackSection}\})$

Signature Example: Circle DSL (4)



- Instance specifications:
  Green : Aspect, Red : Aspect

Structures

Structures $\mathcal{O} \in |Mod(\Sigma)|$ describe *states*

- Objects for each classifier $c^{\mathcal{O}}$
- Instance valuations $(k : c)^{\mathcal{O}} \in c^{\mathcal{O}}$
- Property valuations $(c.p : c')^{\mathcal{O}} \in c^{\mathcal{O}} \rightharpoonup c'^{\mathcal{O}}$
- Composition valuations $(c\blacklozenge r : c')^{\mathcal{O}} \in c^{\mathcal{O}} \to \wp(c'^{\mathcal{O}})$
  - At most one owner
    $o' \in (c_1\blacklozenge r_1 : c_1')^{\mathcal{O}}(o_1) \cap (c_2\blacklozenge r_2 : c_2')^{\mathcal{O}}(o_2) \Rightarrow o_1 = o_2$
- Association valuations
  $(z(\{r_1 : c_1, \ldots, r_n : c_n\}))^{\mathcal{O}} \subseteq$
  $\{\{r_1 \mapsto o_1, \ldots, r_n \mapsto o_n\} \mid o_1 \in c_1^{\mathcal{O}}, \ldots, o_n \in c_n^{\mathcal{O}}\}$

Sentences and Satisfaction

Sentences $\varphi \in |Sen(\Sigma)|$ capture *multiplicities*

- Comparing carnality's $e \leq \ell$, $e \geq \ell$ (ℓ a natural number)

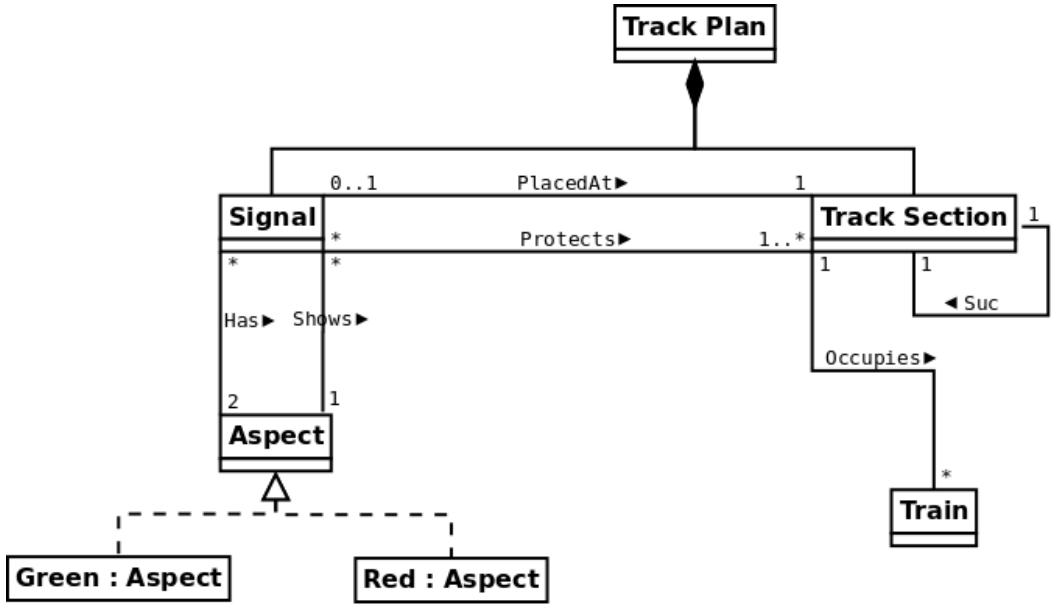
Cardinality expressions e

- ... of compositions
  - How many owned instances? $\#(c \blacklozenge r : c')$
    - For each $o \in c^{\mathcal{O}}$, cardinality of $(c \blacklozenge r : c')^{\mathcal{O}}(o)$
  - How many owners? $\#(c \blacklozenge r : c')[\text{owner}]$
- ... of associations
  - How many tuples, when fixing a subset of roles? $\#z(\{r_1 : c_1, \ldots, r_n : c_n\})[r_{i_1}, \ldots, r_{i_m}]$

Satisfaction relation $\mathcal{O} \models_\Sigma e \leq \ell$, $\mathcal{O} \models_\Sigma \ell \leq e$

- Compare each cardinality resulting from evaluating e to ℓ

Sentences Example: Circle DSL



- Cardinality of associations, e.g. :
  $\#\text{PlacedAt}(\{\text{signal} : \text{Signal}, \text{trackSection} : \text{TrackSection}\})[\text{signal}] \leq 1$
  $\#\text{PlacedAt}(\{\text{signal} : \text{Signal}, \text{trackSection} : \text{TrackSection}\})[\text{signal}] \geq 1$