1 The Topic
2 Tasks
3 Modeling
4 Diagnosis
  4.2 Component-oriented Diagnosis
     4.2.3 Fault localization - a second glance

Goal:
- Problem of fault localization
- Script: Chap. 10.4.1
Yet Another Simple Example

- Head lights work
- Starter and rear light don’t
- Obvious diagnosis: Starter and rear light are broken
Fault Localization for the Simple Example - Conflicts 1 and 2

• \( \text{ok}(\text{Battery}) \land \text{ok}(\text{Wire}_1) \land \text{ok}(\text{Wire}_2) \land \text{ok}(\text{Starter}) \Rightarrow \text{active}(\text{Starter}) \)
• OBS \( \Rightarrow \neg \text{active}(\text{Starter}) \)
• \( \rightarrow \) Conflict
  \(-\text{ok}(\text{Battery}) \lor -\text{ok}(\text{Wire}_1) \lor -\text{ok}(\text{Wire}_2) \lor -\text{ok}(\text{Starter}) \)

Analogously:
• \( -\text{ok}(\text{Battery}) \lor -\text{ok}(\text{Wire}_1) \lor -\text{ok}(\text{Wire}_2) \lor -\text{ok}(\text{Wire}_3) \lor -\text{ok}(\text{Wire}_4) \lor -\text{ok}(\text{RLight}) \)
Fault Localization for the Simple Example - Conflicts 3 and 4

- \( \text{lit(HLight)} \land \text{ok(HLight)} \land \text{ok(Wire}_5) \land \text{ok(Wire}_6) \land \text{ok(RLight)} \Rightarrow \text{lit(RLight)} \)
- OBS \( \Rightarrow \neg \text{lit(RLight)} \)
- \( \rightarrow \) Conflict
  \( \neg \text{ok(HLight)} \lor \neg \text{ok(Wire}_5) \lor \neg \text{ok(Wire}_6) \lor \neg \text{ok(RLight)} \)

Analogously:
- \( \neg \text{ok(HLight)} \lor \neg \text{ok(Wire}_5) \lor \neg \text{ok(Wire}_6) \lor \neg \text{ok(Wire}_3) \lor \neg \text{ok(Wire}_4) \lor \neg \text{ok(Starter)} \)
Fault Localization for the Simple Example - Hitting Sets

- \{\text{Battery, Wire}_1, \text{Wire}_2, \text{Starter}\}
- \{\text{Battery, Wire}_1, \text{Wire}_2, \text{Wire}_3, \text{Wire}_4, \text{RLight}\}
- \{\text{HLight, Wire}_5, \text{Wire}_6, \text{RLight}\}
- \{\text{HLight, Wire}_5, \text{Wire}_6, \text{Wire}_3, \text{Wire}_4, \text{Starter}\}
- \{\text{Starter, RLight}\}
- \{\text{Battery, HLight}\}
- \{\text{Wire}_1, \text{Wire}_5\}
- + 19 more!

Model-Based Systems & Qualitative Reasoning
Group of the Technical University of Munich
What Makes Most of the Fault Localizations Implausible?

- If the battery were broken, the headlights would not be lit
- Broken headlights cannot be lit
- → Knowledge about faults can reduce the set of fault localizations

- \{\text{Starter, Rlight}\}
- \{\text{Battery, HLight}\}
- \{\text{Wire}_1, \text{Wire}_5\}
- + 19 more!
Fault Models - “Physical Negation”

- If the battery were broken, the headlights would not be lit
- Broken headlights cannot be lit
- → Knowledge about faults can reduce the set of fault localizations

- \( \neg \text{ok}(C_i) \) Negation logically:
  Anything but the normal behavior holds
- “Physical negation”:
  The broken component still behaves in a restricted way
- Captured by fault models

- \( \neg \text{ok}(C_i) \Rightarrow \lor \text{fault}_{ij}(C_i) \)

- \( \land \neg \text{fault}_{ij}(C_i) \Rightarrow \text{ok}(C_i) \)
Refuting Fault Modes

- Flat (Battery) \( \land \) ok(Wire_1) \\
  \( \land \) ok(Wire_3) \( \land \) ok(Wire_5) \\
  \( \land \) ok(Wire_6) \( \land \) ok(Wire_4) \\
  \( \land \) ok(Wire_2) \( \land \) ok(HLight) \\
  \( \Rightarrow \) \( \neg \) lit(HLight)
- OBS \( \Rightarrow \) lit(HLight)
- \( \rightarrow \) ok(Wire_1) \( \land \) ok(Wire_3) \\
  \( \land \) ok(Wire_5) \( \land \) ok(Wire_6) \\
  \( \land \) ok(Wire_4) \( \land \) ok(Wire_2) \\
  \( \land \) ok(HLight) \( \Rightarrow \) \( \neg \) Flat (Battery)
- \( \Rightarrow \) ok(Battery)

- Physical negation eliminates all but one minimal fault localizations
- \( \{ \text{Starter, Rlight} \} \)
The Stupid System – Possible Fault Localizations?

- A different scenario
- Cmd: nominal
- Flow sensor: negative deviation
- Pressure sensor: positive deviation