intecs informatica e tecnologia del software

Safety Issues in Automotive Software

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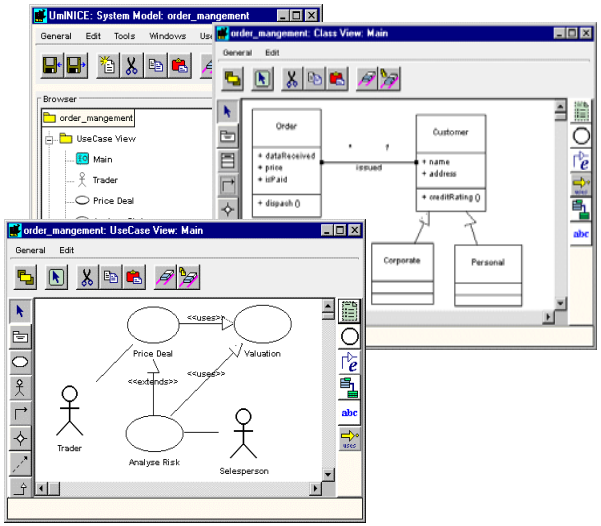
INTECS S.p.A.



“SAFEWARE”

INTECS & Safety

- A very large number of safety software development, V&V activities and research project on safety, since 1974 (defense, space, nuclear, railway, automotive)
- SW RAMS Methods for the European Space Agengy, ECSS standards contribution (on board sw)
- Software Reliability Modeling (with Center for Software Reliability, UK)
- International Workshop on Software Reuse and Safety, Turin, June 2006 (Program Organization)

Common misconceptions

- Software “per-se” does not harm anybody

  (but it can order to harm !)

- Software Safety = Software Reliability

  (“a car that does not start is safe”)

Nancy Leveson

Safety vs. Reliability

- Reliability has to cope with MTBF while safety has to cope with failure occurences, consequences and severity

- A number of safety **protective measures** may even adversely affect reliability (in suspect => fail safe).

Quantitative Analysis

- The application of quantitative analysis to automotive software is generally considered **impractical** since it is not possible to quantify the probability of software failure

- An increasing level of rigour is applied, **instead**, to the development and verification process (e.g. ASIL A,B,C,D)

Automotive “safeware” examples

- ABS *(Anti-lock Braking Systems)*
- ACC *(Adaptive Cruise Control)*
- ESC *(Electronic Stability Control)*
- BBW, EPB
- SBW
- Airbags, light control, dashboard
- Tyre pressure, lane departure warning
- etc.

Automotive Safety Standards

- **IEC 61508 Part 3 (generic, cross domain)**
- **MISRA Integrity Guidelines**
- **MISRA C:2004**
- WD 26262 part 6 (work in progress, started Nov. 2005)
- MIL STD 882D, DO 178B, ECSS Q30/Q40, DEF STAN
- Studies/Projects (examples)
  - DRIVE Safely
  - PASSPORT
  - EASIS

Safety relevant functions

- software function output =>
  system malfunction =>
  driver loss of control =>
  accident =>
  harm

- if a software function output may lead to an harm that software function is said **safety relevant (safety critical)**

Safety Integrity Level

Safety relevant software function implies to:

1. Verify that what is **specified is safe**
2. Ensure **implementation meets specification:** adopt a rigorous (high integrity) process for its development and verification
3. Develop anyhow **protective measure** (either HW or SW or both) (includes Fault Detection, Isolation and Recovery - FDIR)

Software Failure Modes

- Omission (output is not provided)
- Commission (output is provided when not required)
- Late
- Early
- Wrong Value coarse (detectable/not palusible)
- Wrong Value subtle (undetectable/plausible)
- Stuck (Value does not change)

FAILURE TOLERANCE

- FAIL
- FAIL SILENT
- FAIL SAFE
- FAIL DEGRADATED/FAIL REDUCED
- FAIL (FULL) OPERATIONAL

FAULT TREATMENTS

- FAULT PREVENTION
- FAULT REMOVAL
- FAULT DETECTION/RECOGNITION
- FAULT ISOLATION/CONTAINMENT
- FAULT RECOVERY

FAULT PREVENTION

- Mature and rigorous software process (e.g. SPICE, CMMI)
- Software life cycle (e.g V life cycle)
- Simplicity (KISS), FMEA
- Semi-formal methods (e.g. UML, Simulink)
- Standard architectures (AutoSAR)
- MISRA C, Certified compilers, kernels, libs (e.g. OSEK)
- Dual programming
- Metrics conformances (e.g. nesting depth, cyclomatic complexity, also at Model level)
- Schedulability Analysys (WCETA)
- Memory Usage Analysis (WCMUA)
- Safety oriented organization (independence, competence, planning, verification, assessment, suppliers control)

FAULT REMOVAL

- Peer Reviews/Code inspections
- Static Analysis Tools (on code*, on models)
- Unit test (100% MD/MC, branch coverage)
- Re-run the test with no instrumentation and on the target
- Boundary value and Equivalence class Partitioning tests
- Integration test (100% call-pair coverage)
- Validation test (100% requirement coverage)
- Defects seeding/Fault injection

(*) Tools like polyspace perform an extensive analysis capable to intercept typical run time errors. Run time errors may be as high as 30%- 40% of total errors

FAULT DETECTION

- Plausibility checks/defensive programming/assertions/pre-post conditions
- Checksum
- Data redundancy

- Watchdog
- Intelligent watch dog (Reference value check Q/A game)
- Redundant/diversified function

ISOLATION/CONTAINMENT

- Damage assessment
- Fault region identification
- Confinement
- Prevent propagation/cascade

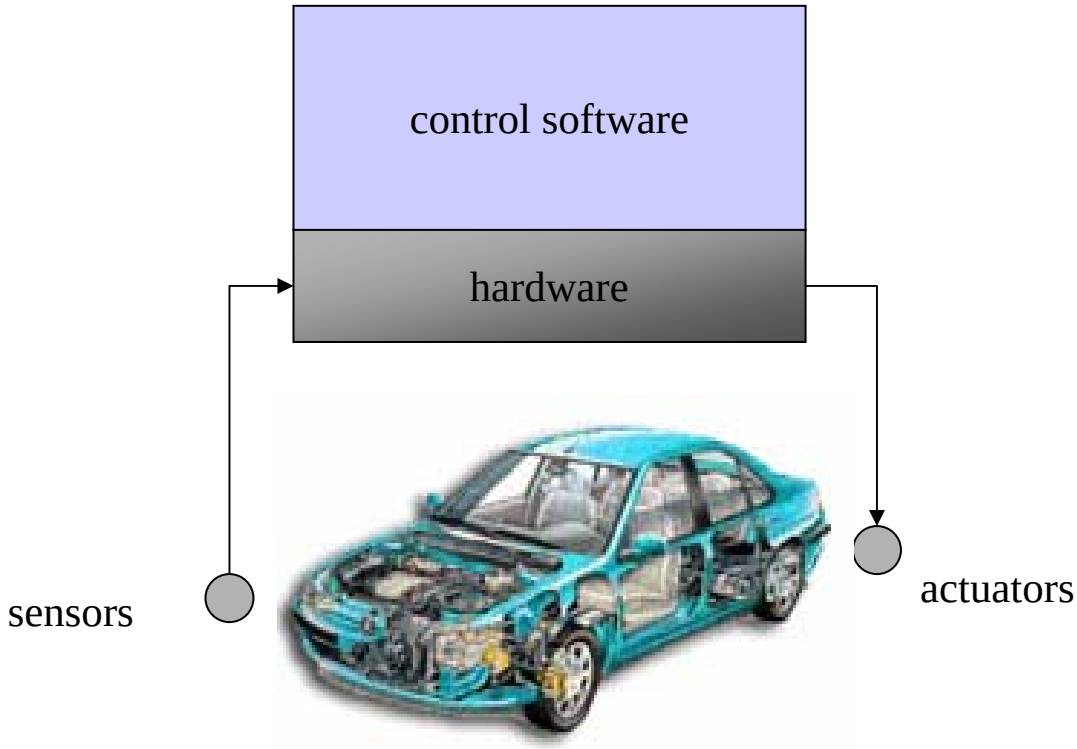
FAULT RECOVERY/HANDLING

- REMAIN SILENT / SEND ERROR CODE/STORE Diagnostic Trouble Code
- CORRECT (e.g. parity checks)
- RESET/RETRY
- ALTERNATIVE SAFE (e.g. switch to mechanical link)
- ALTERNATIVE DEGRADATED (e.g. simplified break control based only on the pedal stroke value)
- ALTERNATIVE OPERATIONAL (diversified programming/N version programming)

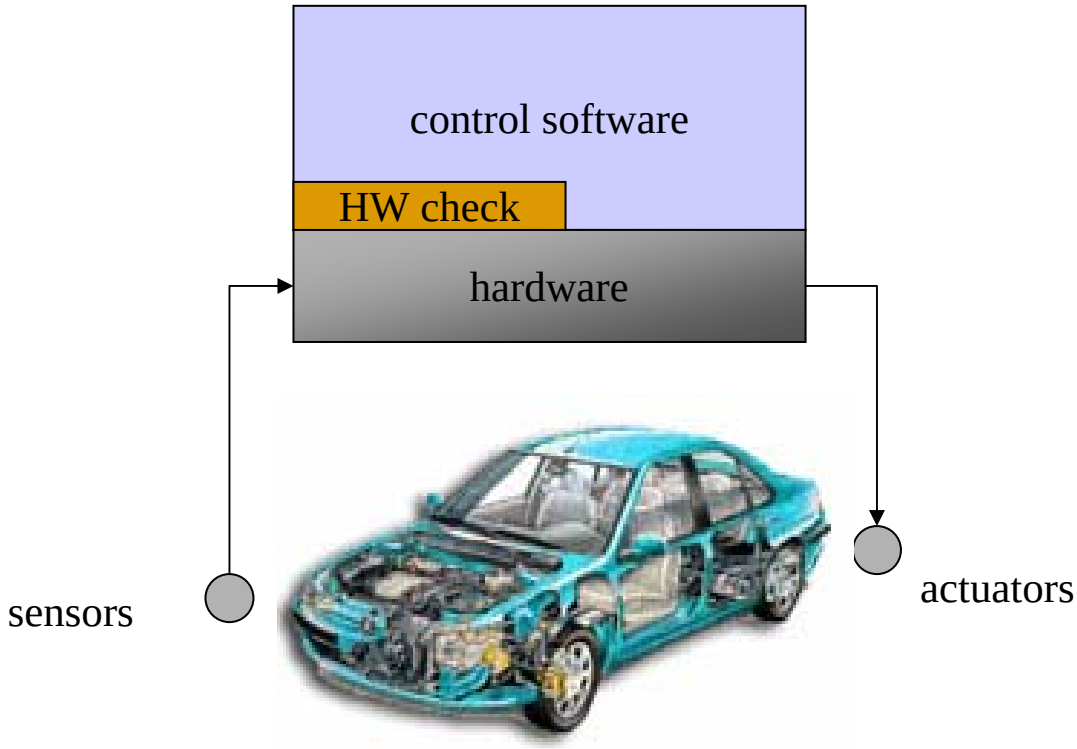
Software Safety Architectures

an overview

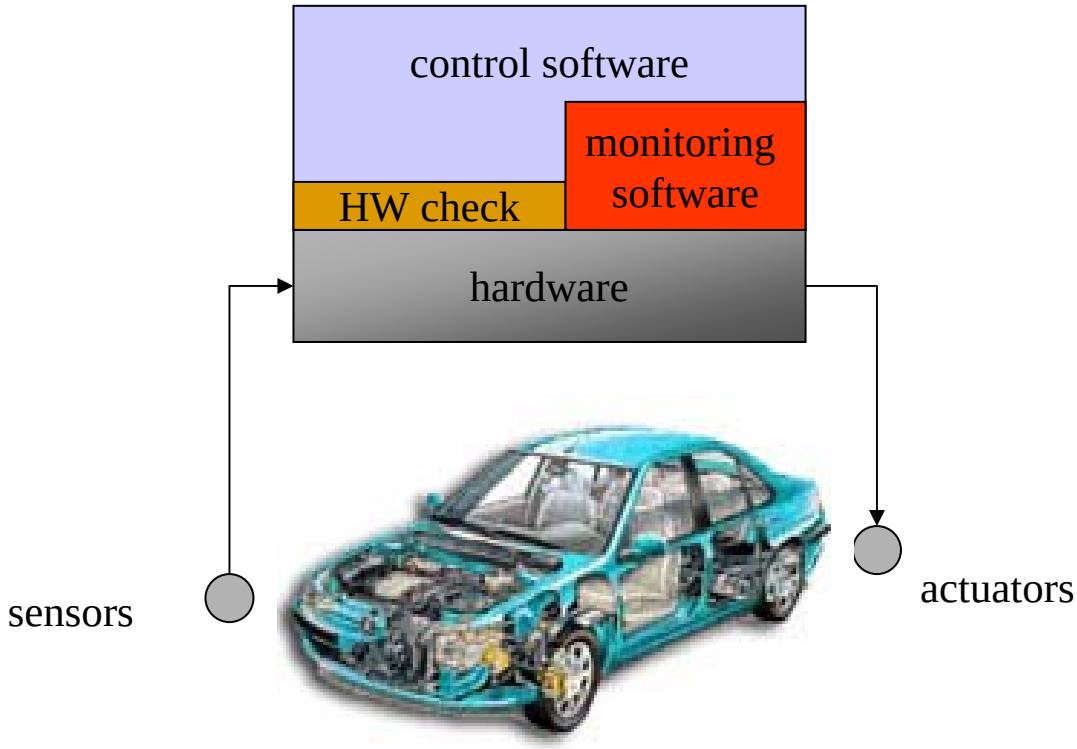
Simplex approach



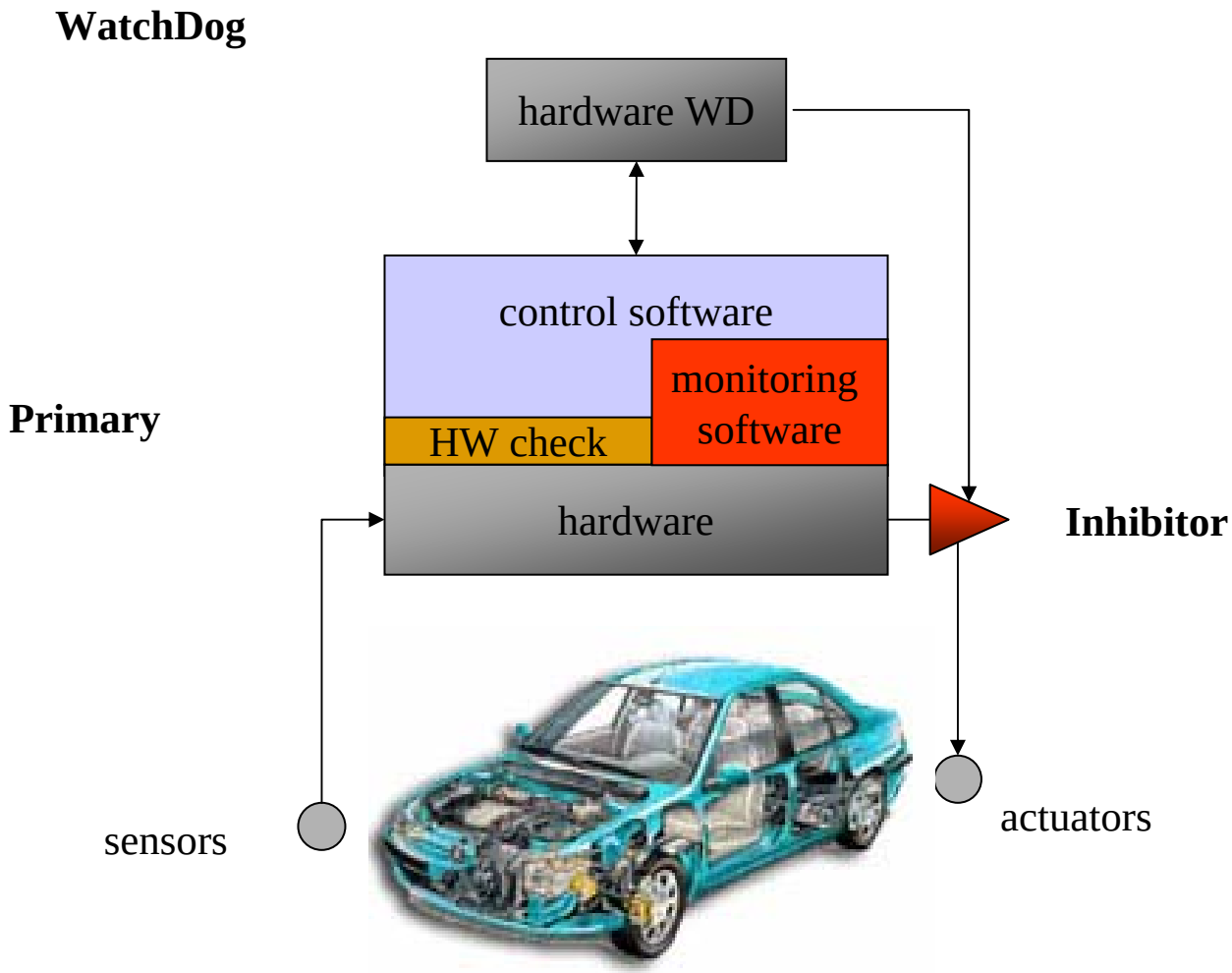
Software checks Hardware



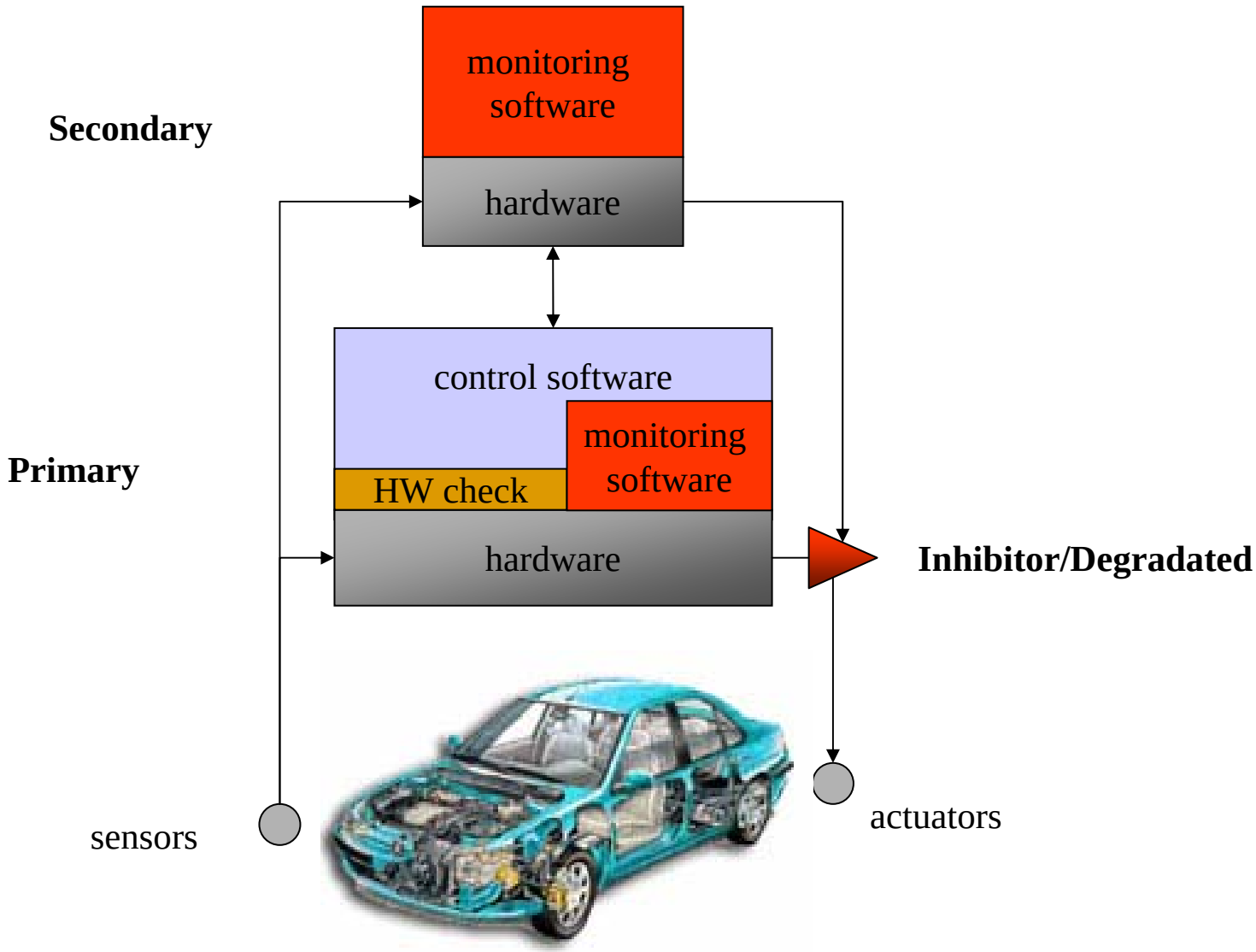
Self checking software



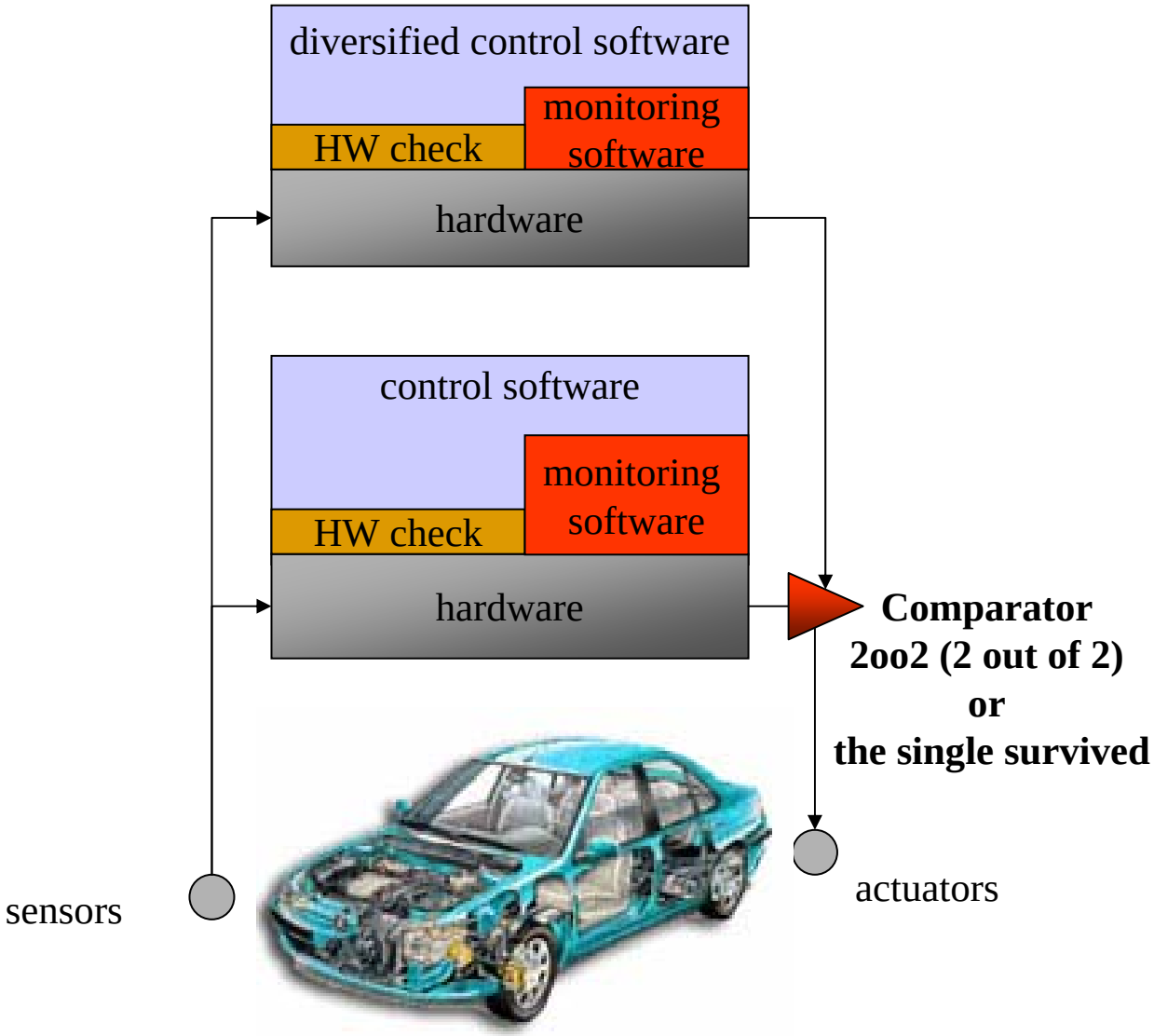
Watchdog


WatchDog
hardware WD
control software
monitoring software
HW check
Primary
hardware
Inhibitor
sensors
actuators

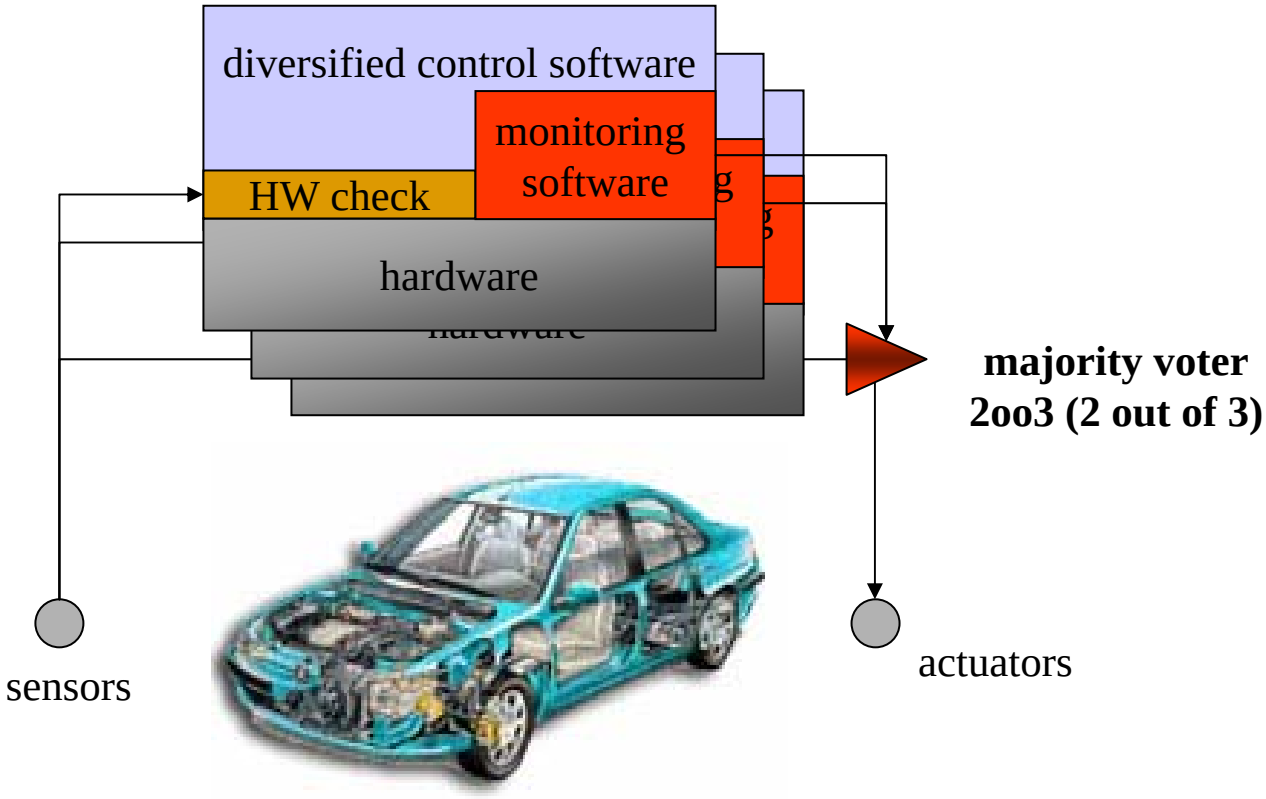
Asymmetric/Intelligent Watchdog



Duplex/Dual redundant



Triplex/Triple Redundant



It is not proven that the effort required to develop diversified software versions provides better results than building a **single** roboust software version (golden version)
Common Mode failures may be very high