

# Software Evolution: the Challenges

## Software Evolution – L1T3

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# Cyber-Physical Systems

- Beyond “just software”
- More complex systems evolve in more complex ways
- CPS are feedback systems
  - distributed/networked
  - adaptive/predictive
  - intelligent
  - real time

# Cyber-Physical Systems

- **Humans** in the loop
  - ecosystems, communities, individuals
  - notoriously hard to model
- **Environment** in the loop
  - energy consumption, carbon footprint
  - sustainability
- **Economics** in the loop
  - cost optimisation

# Cyber-Physical Systems: Bit Flip

- Software-Implemented Hardware Fault Tolerance (**SIHFT**)
- Measurement unit:
  - **FIT** (Failure in 1'000'000'000 hours  $\approx$ 114155 years)
- Reasons for **SEU** (Single Event Upsets)
  - natural radiation
  - chip temperature instability
  - malicious intervention
  - experimental technology
- Known victims: Sun, Toyota

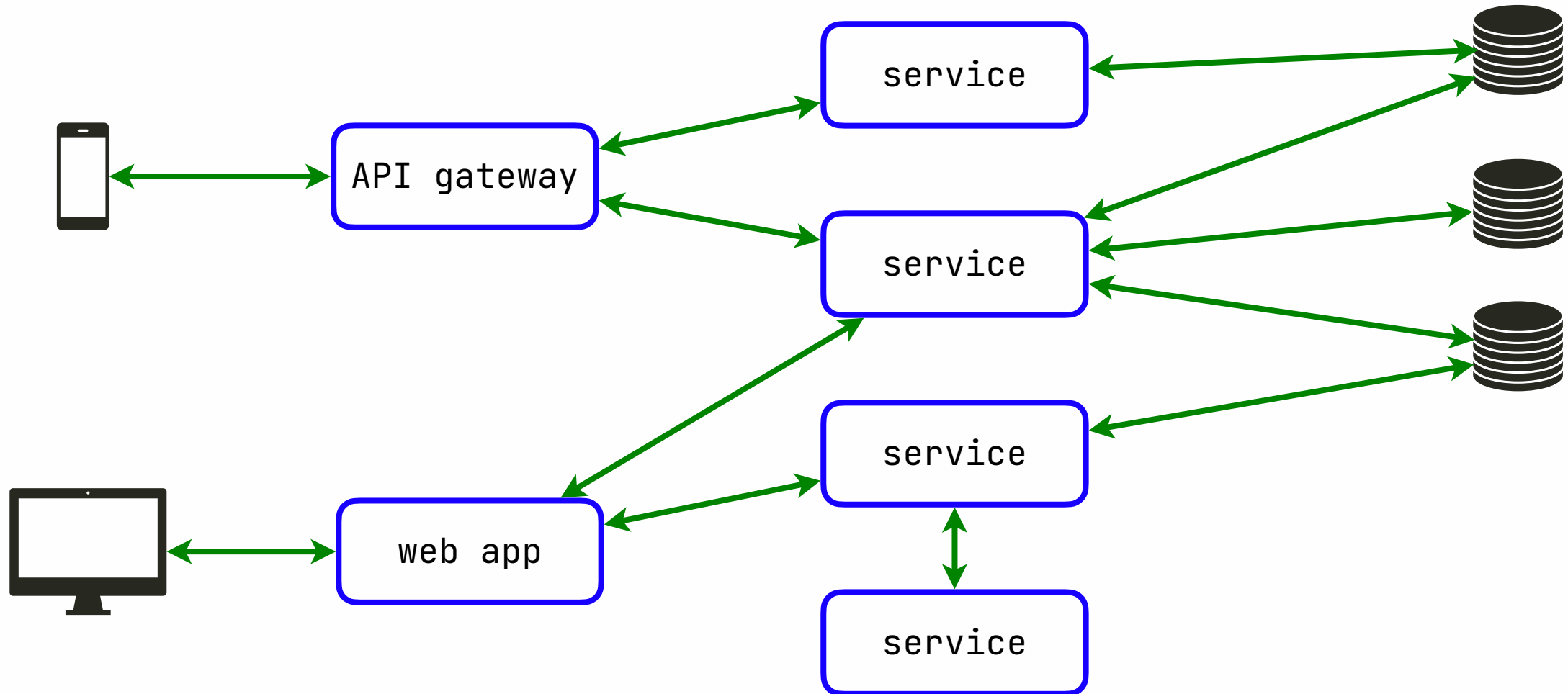
# Consistency

- Consistent  $\iff$  no **contradictions**
- **Structural** and **behavioural** consistency
  - models conform to their metamodel
  - relational; conditional; trace equivalence
- **Inner** and **outer** consistency
  - does not contradict itself
  - contract among 2+ artefacts
- (In)consistency **management**

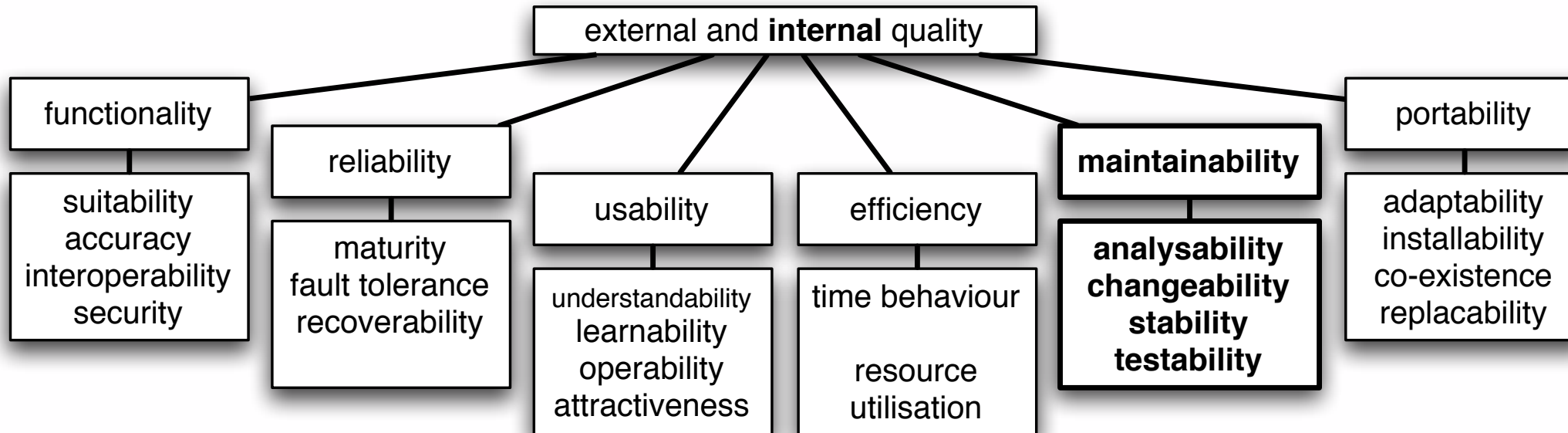
# Consistency Management

- Compute & sync views on models in MDSE
- Maintain GUIs in MVC
- Interact with visualisations
- Sync data in different formats
- Runtime value conversions in embedded DSLs
- Updatable views in DBMS
- Edit complex data in structure editors
- (De)serialise data in/from memory

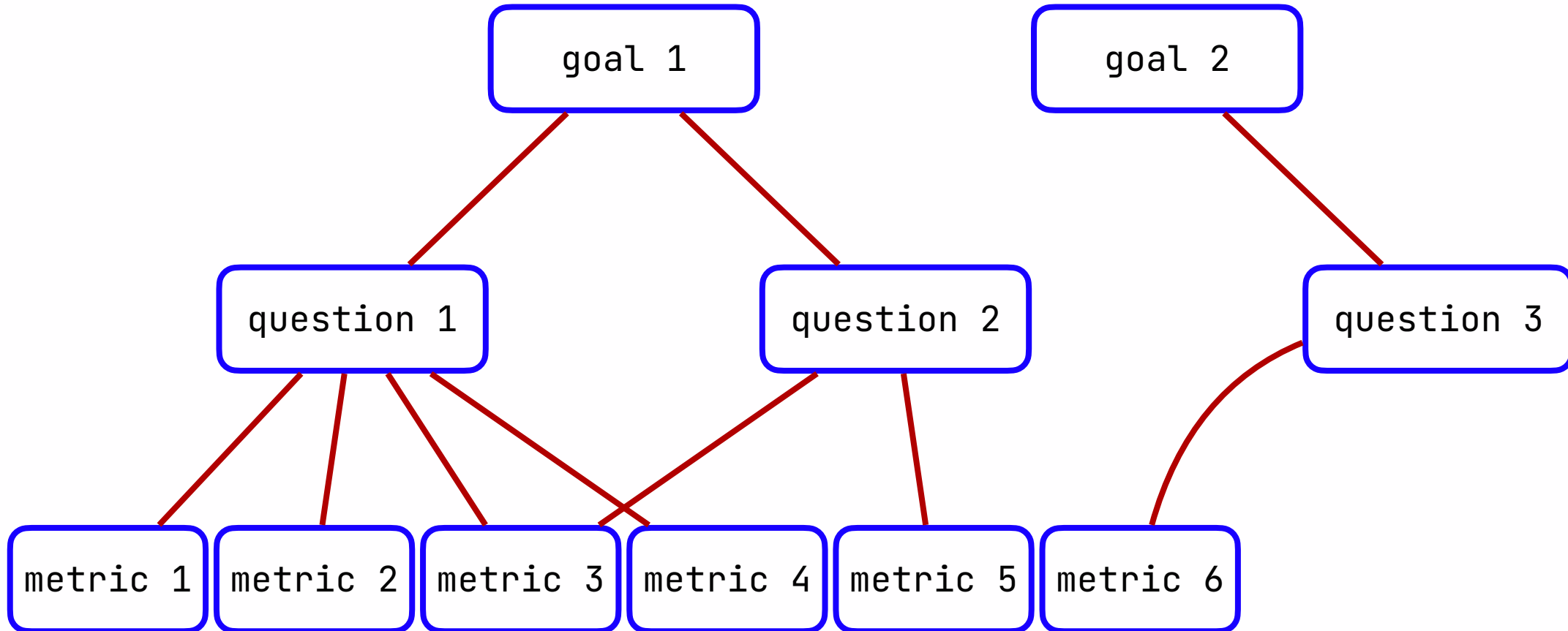
# Consistency: Microservices



# Quality



# Quality: Goal-Question-Metric



# Adaptability

- Adaptation is necessary
- Adaptability improves viability & quality
- **Parametric** adaptation
  - tweak parameters over time
- **Algorithmic** adaptation
  - switch among algorithms
- **Resource** adaptation
  - relocate utilised resources

# Adaptable Software Factors

- Extensibility
  - easy to change the *amount* of capabilities
- Flexibility
  - easy to change the *kind* of capabilities
- Tunability
  - easy to *tweak* to change
- Fixability
  - easy to fix *one* thing separately

# Two Kinds of Adaptation

- Adaptation through **tolerance**
  - change comes from the environment
  - aim to preserve the original behaviour
- Adaptation through **adjustment**
  - the change is welcome
  - unchanged artefacts must sync

# Conclusion

- CPS: consider **humans, environment, economics**
- **Consistency** and synchronisation
- **Quality** has many faces
- Demand for **adaptation** will only go up
  
- Q&A Sessions @ Canvas
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  - ⇒ <https://discord.gg/n7VQAPNBPD>