On the management of nonfunctional requirements

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TU Delft, 12 November 2001

Outline of the talk

- ***What are nonfunctional requirements (NFR)***
  - ✓ **How do they differ from functional requirements**
  - ✓ **Where do they originate from and when**
- ***How do NFR impact the development process***
  - ✓ **What is the problem with them**
  - ✓ **Definition, engineering and verification issues**
- ***Strategies for incorporation***
  - ✓ **Integration versus separation**

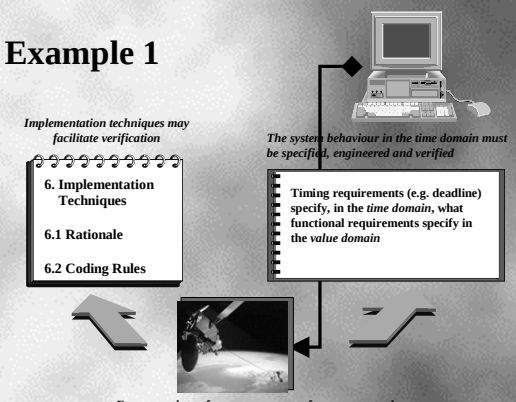
What are NFR

- ***NFR concern such characteristics as:***
  - ✓ Safety
  - ✓ Reliability
  - ✓ Timeliness (predictability)
  - ✓ Reusability
  - ✓ Portability, etc.
- ***Functional requirements tell*** *what* ***the system has to do***
- ***NFR tell*** *how* ***the system functions have to be achieved***

What are NFR (cont'd)

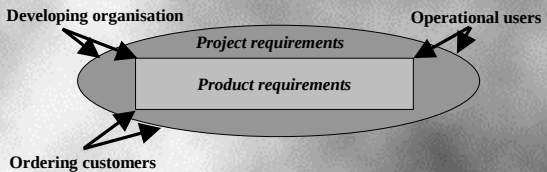
- ***NFR originate at system and at software level, for example:***
  - ✓ **Safety and reliability are system-level NFR**
  - ✓ **Reusability and portability are software-level NFR**
  - ✓ **Predictability pertains to both levels**
- ***NFR concern product and process aspects***

Example 1



What are NFR (cont'd)

- ***Project requirements*** *include* ***and exceed product requirements***
  - ✓ **Both sets originate from** multiple sources **with often independent and differing perspectives**



NFR impact

- ***A large proportion of software projects in virtually all application domains often fail in several respects, e.g.:***
  - ✓ **Late shipment, budget overrun**
  - ✓ **Underutilisation in operation**
  - ✓ **Laborious maintenance, scarce portability**

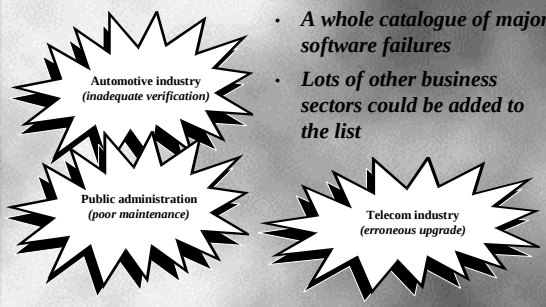
NFR impact (cont'd)

- ***The root of the failure can often be found in mismanaged NFR, e.g.:***
  - ✓ **Lack of specification or misinterpretation**
  - ✓ **Incomplete or erroneous specification**
  - ✓ **Insufficient verification**
- ***These deficiencies are*** *less apparent* ***than the violation of functional requirements***

NFR impact (cont'd)

- ***NFR are*** *more difficult to express* ***than functional requirements***
- ***NFR arise predominantly at*** *project* ***level***
- *Product* ***requirements are typically*** **functional** ***and often arise*** **earlier** ***than NFR***
- ***This independence of origin often makes them conflict in subtle ways***

Example 2



- ***A whole catalogue of major software failures***
- ***Lots of other business sectors could be added to the list***

NFR impact (cont'd)

- *Specification*
  - ✓ **Often poor**
  - ✓ **Spiral / evolutionary process models help but they are not quite the solution**
  - ✓ **They best at elic*iting and coping with (late) functional requirements***
  - ✓ **Less good for late or unclear or imprecise NFR**
  - ✓ **Translation from system NFR to software NFR is far from obvious**

Example 3

- ***How can we translate a system-level reliability requirement expressed as a*** *.9993 fphs* ***(<1 failure in 60 days of operation) to software requirements***

It takes a long ride to get there!

- ***How can we possibly verify it***

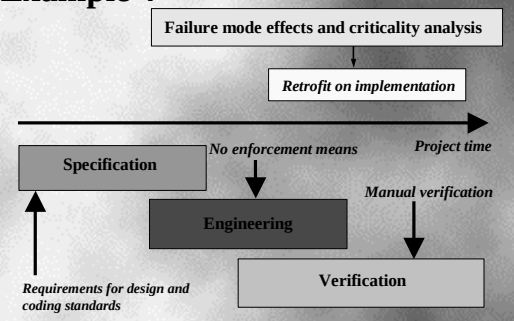
NFR impact (cont'd)

- *Specification (cont'd)*
  - ✓ ***NFR are often expressed in forms that are hard to quantitatively or objectively verify***
  - ✓ ***their verification is frequently qualitative and subjective***
  - ✓ ***we lack standardised and well-understood techniques to reduce subjectivity***
  - ✓ ***we have little support for the capture of NFR and poor means to raise them to proper design and / or process drivers***

NFR impact (cont'd)

- ***Specification (cont'd)***
  - ✓ ***Typical challenges:***
    - ***how can we align design methodology and design patterns to preferred/prescribed coding standards***
    - ***how can we avoid destructive implementation of fault tolerance provisions against late understanding of needs***

Example 4



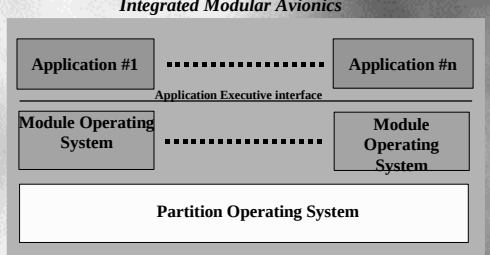
NFR impact (cont'd)

- ***Engineering***
  - ✓ ***The NFR implementation strategies are inherently multidisciplinary (e.g.: procurement, quality, safety, reuse)***
    - ***Some involve the deployment of specific implementation strategies (e.g.: assurance of design, coding rules)***
    - ***Others require the use of compliant infrastructures (e.g.: procurement of certified compilers and runtimes)***
    - ***Others demand the adoption of domain-specific architectures (e.g.: assurance of IMA and APEX compliance)***

NFR impact (cont'd)

- ***Engineering (cont'd)***
  - ✓ ***Typical challenges:***
    - ***How can we ensure that all concerned disciplines pull the project in one and the same direction***
    - ***How can we strike a good balance between efficiency, verifiability and reuse***

Example 5



An avionics standard like IMA will considerably restrain the design and implementation freedom, while allowing multi-threaded, multi-language, distributed applications

NFR impact (cont'd)

- *Verification*
  - ✓ *NFR are difficult to verify (at process level) and to validate (at product) level*
  - ✓ *Difficulties are:*
    - *Technical ('how to')*
    - *Technological ('by what means')*
    - *Programmatic ('when and to what extent')*

NFR impact (cont'd)

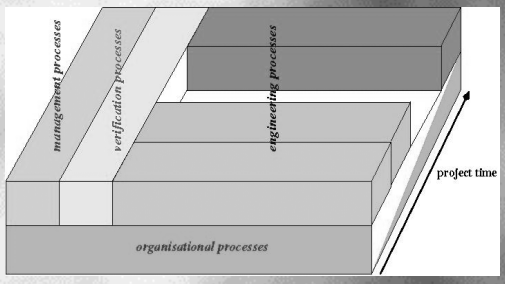
- *Verification (cont'd)*
  - ✓ *Definitions*
    - *Verification: confirmation, by examination or provision of objective evidence, that specified requirements have been fulfilled*
    - *Verification concerns the process*
    - *Validation: confirmation [...] that the product meets the specified requirements*
    - *Validation concerns the product*

Nominal process

- *Aims at the implementation of functional requirements*
  - ✓ *Includes processes specific to :*
    - *The developing organisation*
    - *The individual project within the organisation*
  - ✓ *Project-level processes include:*
    - *Management processes*
    - *Technical processes (development) encompassing:*
      - *Engineering processes*
      - *Verification processes*
  - ✓ *May all be carried out in full parallelism*

Nominal process (cont'd)

All processes may proceed in parallel

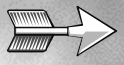


Nominal process (cont'd)

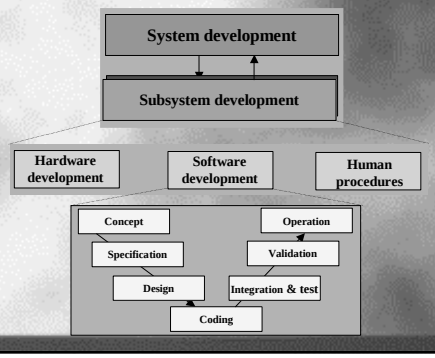
- *The purpose and order of execution of the nominal processes is determined by multiple factors, e.g.:*
  - ✓ *Application-domain specific constraints*
  - ✓ *Technical and organisational considerations*
- *These factors may change in weight and nature during the life cycle, e.g.:*
  - ✓ *Required team profile versus availability of personnel*

Nominal process (cont'd)

- *Irrespective of the extent of internal parallelism, the system life cycle proceeds across a set of stages*
  - ✓ *Each stage has a distinct purpose and contribution*
  - ✓ *The achievement of a stage represents a project milestone*
    - *This is a crucial measure of progress*



Nominal process (cont'd)



NFR management strategies

- *No standard definition of software NFR*
  - ✓ *Also referred to as 'characteristics'*
- *Two broad classes:*
  - ✓ *Explicit*
    - *Typically defined by users and customers*
    - *Also derived from system-level requirements*
    - *Influence the ultimate acceptance of the product*
  - ✓ *Implicit*
    - *Reflect specific developers' concerns*
    - *Need dedicated processes to warrant satisfaction*

NFR management strategies (cont'd)

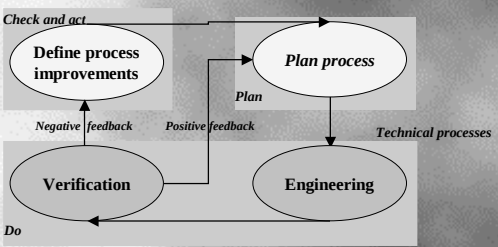
- *Explicit characteristics*
  - ✓ *Should be fully defined at the ' concept' stage of the software development*
    - *Use of int'l standard checklists may help the capture*
- *Implict characteristics*
  - ✓ *May concern the software product as a whole, e.g.:*
    - *Completeness, verifiability, compatibility*
  - ✓ *May concern constructive aspects of the product (technology, architecture), e.g.:*
    - *Timeliness (predictability), resource-efficiency*
  - ✓ *Should be defined during the 'specification / design' stages*

NFR management strategies (cont'd)

- *Can we use the same processes used for the implementation of functional requirements?*
- *Should we perform them in parallel or* in conjunction *with the nominal processes*
  - ✓ *No general criteria prevent* integration
  - ✓ *Separation allows independence of verification responsibility*
- *Integration is preferable (easier, cheaper) for most implicit characteristcs*
- *Separation is desirable for critical ones*

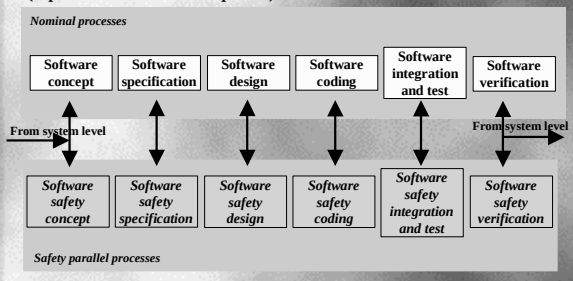
NFR management strategies (cont'd)

- *How to define adequate dedicated processes?*
  - ✓ *Use the* Plan-Do-Check-Act *model*



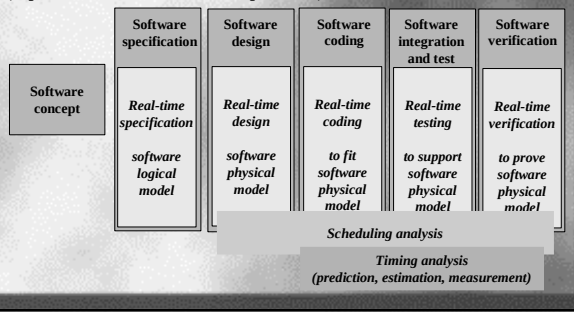
Example 6

Parallel processes for the management of safety characteristics (*explicit and crucial to acceptance*)



Example 7

Integrated processes for the management of timeliness requirements (*implicit and inherent to technical processes*)



Conclusion

- ***NFR will be increasingly more dominant in software-intensive systems***
- ***There is no 'best' solution to their management***
- ***Different solutions for different domains***
- ***Integration works well for 'consolidated' NFR***
- ***Separation sanctions the criticality of NFR***