Cyclomatic Complexity Revisited

A Leading Provider of Smart, Connected and Secure Embedded Solutions

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Introduction

- Contribution to the July IEEE P802.3dm meeting (“On Complexity and Reliability”) introduced the concept of “Cyclomatic Complexity” <jonsson_3dm_01_07_28_25>

- This contribution examines whether that concept is potentially applicable and relevant to the state diagrams in P802.3dm

Applicability

- As noted in <jonsson_3dm_01_07_28_25> slide 2, it pertains to “Cyclomatic Complexity evaluation that is commonly used in SW *[software]* development”

- It concludes with the assertions:
  - “The complexity of the New-TDD state diagram is so high that
    - “The New-TDD state diagram is high risk or very high risk
    - “The New-TDD state diagram is probably ”untestable”
    - “The New-TDD state diagram will probably not satisfy any typical ASIL levels”

- Each of these assertions should be evaluated.

- The first question to consider is how commonly is this tool used and how helpful is it considered to be.
  - The results of a simple web search are revealing.

Applicability

- Typical quotes comments from publicly available sources include:
  - https://www.researchgate.net/publication/264881926_Cyclomatic_complexity_as_a_Software_metric
    - "McCabe's family has taken a thorough study and proposed metrics that are used in calculating cyclomatic complexity. In fact, studies have shown that existing metrics **consistently fail** to capture complexity or cohesion well."
    - "For instance, the use of flow graphs discussed here can be evaluated with respect to numbers of decisions and control flow **but cannot evaluate complexity** due to convoluted variable plans, to linear algorithms nested between the decision nodes of the flow graph or due to cognitive difficulties."
  - Publicly available summary of https://articles.researchsolutions.com/a-critique-of-cyclomatic-complexity-as-a-software-metric/doi/10.1049/sej.1988.0003
    - From the public summary: "This critique demonstrates that McCabe's cyclomatic complexity metric is based upon **poor theoretical foundations and an inadequate model** of software development …"
- Conclusion: Cyclomatic Complexity is not widely accepted as a useful metric

Applicability

- Second, regarding the risk due to complexity
  - The complexity of the proposed TDD state diagram is very comparable to the 802.3ch state diagram
    - This triggered no concerns regarding 3ch, nor have there been any reports of problems.
  - Note also that multiple chip vendors are known to have implemented to ASA without expressing complexity concerns.

Applicability

- Third, regarding the assertion of it being “probably untestable” there are multiple key points to consider
  - First, as noted above, Cyclomatic Complexity is a software evaluation tool.
    - The state diagrams cited in the contribution cover core regularly used functions that would not change over time.
    - Consequently, for cost and chip complexity reasons they would be implemented as hardware state machines and never be implemented in software.
    - Hardware state machines are thoroughly tested in the validation and verification process.
      - These are transparent to the customer
      - Thorough validation and verification ensure that they impose **NO** risk to the customer
  - Further, the state diagram analysis in <jonsson_3dm_01_07_28_25> pertains to a multi-part flow, which in practice would be decomposed into multiple modules, which greatly simplifies validation.
  - Based on my experience with very large (several 100M gate) extremely complex OTN devices, the cited state diagrams are trivial in comparison

Observations regarding ASIL

- Regarding functional safety and ISO 26262:
  - In general, with rising ASIL level, the criticality of “complexity” does not change. Instead, e.g., testability becomes a key factor.
  - As noted above, the chip vendor is responsible for testing and validating the design, as several have already done
  - While OEMs require certain ASIL levels, I am not aware of an OEM having stated SW complexity metrics

Conclusions

- **While Cyclomatic Complexity is an interesting tool, it has no clear relevance to the state diagrams of P802.3dm**
  - It's a software evaluation tool of limited value
  - These would inherently be hardware-based implementations, which would be thoroughly tested and validated as part of the chip design process
- **There is significant real-world evidence that the TDD state diagrams can be implemented reliably**
- **Consequently, we see no value in using this metric in the ongoing P802.3dm considerations**

Thank You