Software Improvement Group

Benchmark-based Software Product Quality

Tiago L. Alves

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T +31 20 314 0950
info@sig.eu
www.sig.eu

Background

Software Improvement Group

About me

- Degree + MSc Informatics and System Engineering, University of Minho, Braga, PT
- 2006: Young Graduate Trainee at ESOC, Darmstadt, Germany
- Currently: PhD Researcher at University of Minho hosted at the Software Improvement Group, Amsterdam, Netherlands (finishing thesis)

Research interests

- Source code analysis techniques
- Software metrics and quality models to assess quality
- Industrial applications

Software Improvement Group

Who are we?

- Highly specialized research company for quality of software, founded in 2000 as a spin-off of the Centre for Mathematics and Information Technology
- Independent and therefore able to give objective advice
- Decorated with the Innovator Award 2007 and ICT Regie Award 2008

What do we do?

- Fact-based consultancy supported by our automated toolset for source code analysis
- Assessment across technologies by use of technology-independent methods

Our mission: **We give you control over your software.**

Services

Software Improvement Group

Software Risk Assessment

- In-depth investigation of software quality and associated business risks
- Answers to specific research questions

Software Monitoring

- Continuous measurement, feedback, and development consultancy
- Guard quality from start to finish

Software Product Certification

- Five levels of technical quality (maintainability)
- Evaluation by SIG, certification by TÜV Informationstechnik

Who is using our services?

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Financial and Insurance companies

ABN·AMRO
PGGM
ING
InterBank
Rabobank
Zorg en Zekerheid
achmea
GENERALI verzekeringsgroep
Friesland Bank
delta lloyd
LeasePlan
Eurobank EFG
Interpolis
ZwitserLeven
Bank Mendes Gans
KAS BANK
globalcollect
SNS Bank
Allianz
Volvo OtoFinans

Government

Rijksoverheid
kadaster
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Belastingdienst
Raad voor Rechtsbijstand
POLITIE
cwi
SVB
RDW

Logistical

DHL
KLM
TNT
EUROMAXX TERMINAL
norfolkline DOVER - DUNKERQUE FERRIES
ProRail
Port of Rotterdam

IT

Getronics PinkRoccade
CENTRIC
Capgemini CONSULTING.TECHNOLOGY.OUTSOURCING
Exact software
IBM
CHESS
logica

Other

ENECO energie
PRICEWATERHOUSECOOPERS
essent
SWISSLEX
KPMG
NXP founded by Philips
Gasunie
TNO
IKEA
Alcatel·Lucent
Electrabel

Bermuda triangle of software quality assurance

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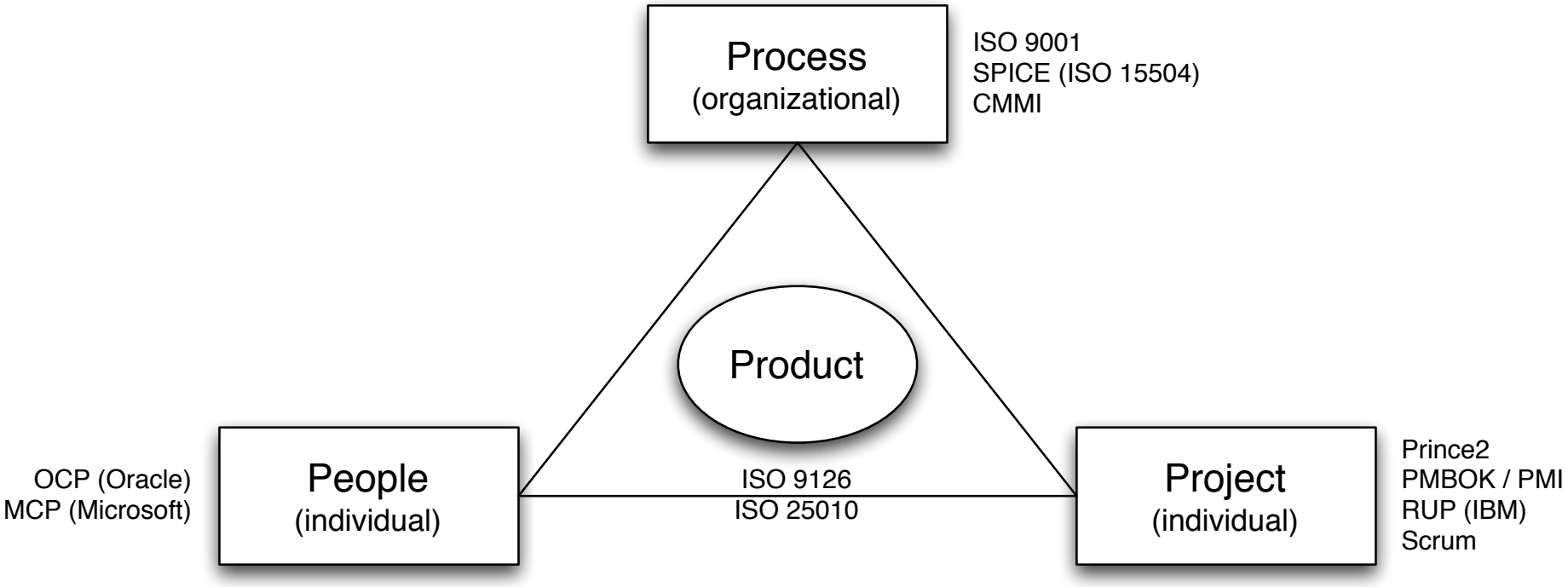

SIG Quality Model for Maintainability (operationalization of the ISO 9126)

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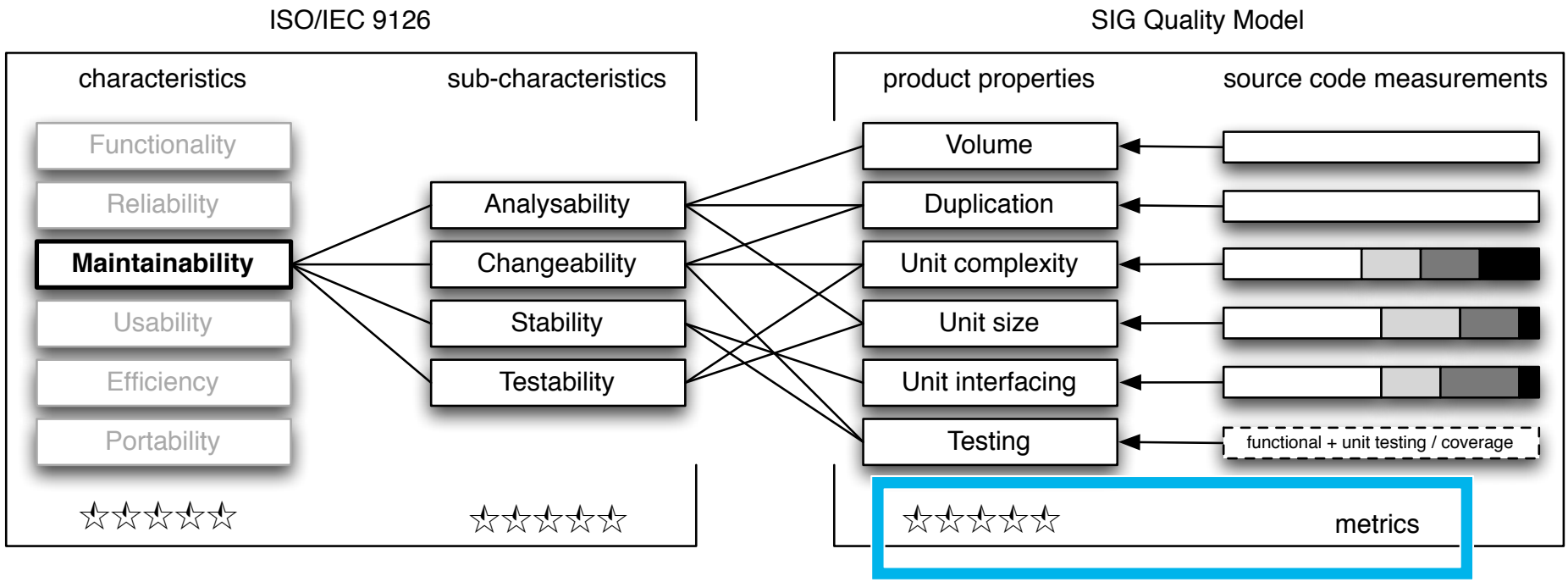

Benchmarking metrics to ratings

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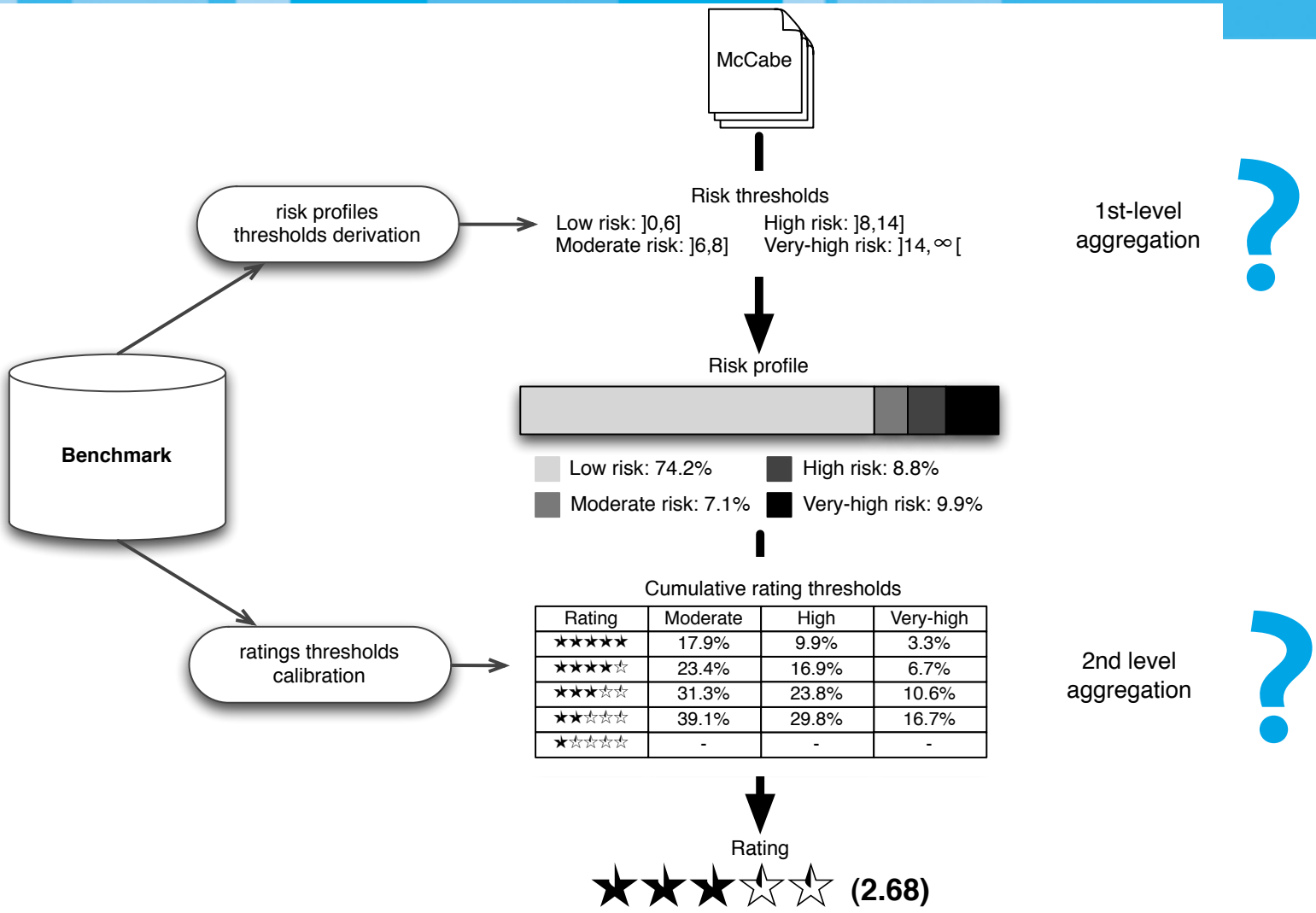

Rating	Moderate	High	Very-high
★★★★★	17.9%	9.9%	3.3%
★★★★☆	23.4%	16.9%	6.7%
★★★☆☆	31.3%	23.8%	10.6%
★★☆☆☆	39.1%	29.8%	16.7%
★☆☆☆☆	-	-	-

Part I
Derivation of risk thresholds

How to derive thresholds?
Life sciences vs. software sciences

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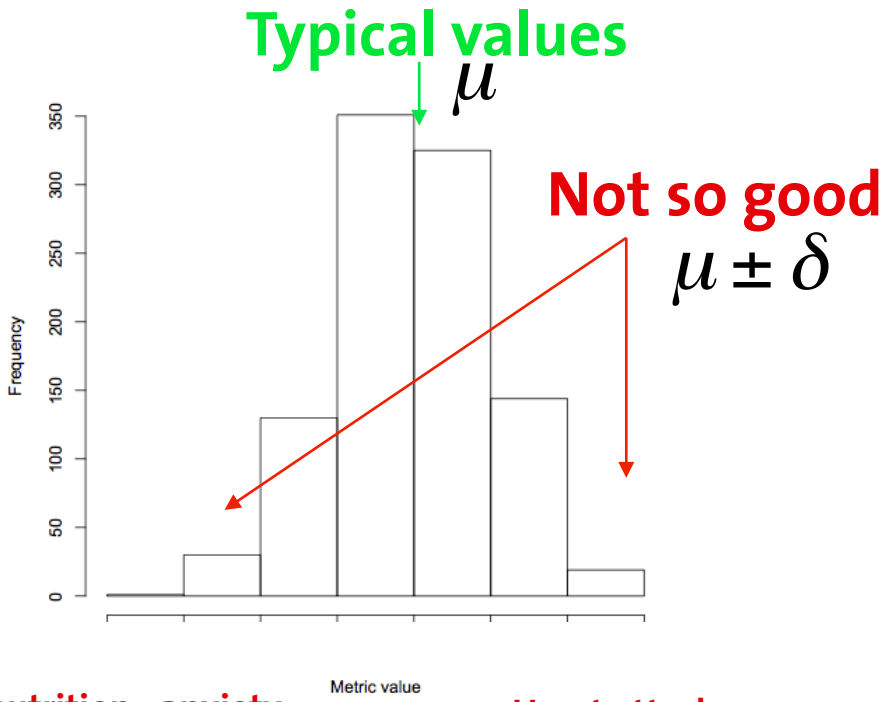
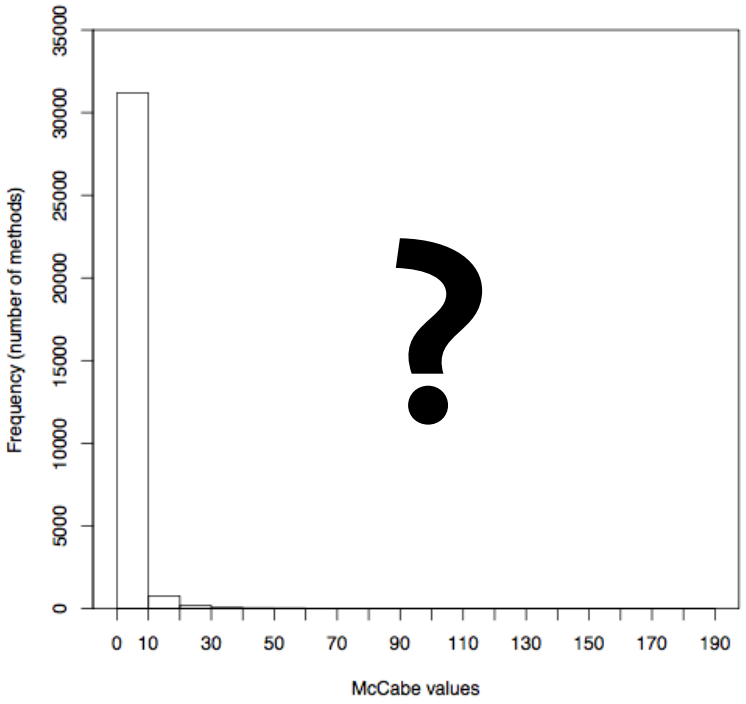
Cholesterol levels



Malnutrition - anxiety, depression, suicide

Heart attack

Complexity



Derivation of risk thresholds: requirements

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Requirements

1. Respect the statistical properties of the metric (scale and distribution)
2. Based on data analysis from a representative set of systems (benchmark)
3. Repeatable, transparent, and of straightforward execution.
4. Enable traceability of results

Experimental benchmark

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Technology	License	n	LOC
Java	Proprietary	60	8,435K
	OSS	22	2,756K
C#	Proprietary	17	794K
	OSS	1	10K
	Total	100	11,996K

Derivation of risk thresholds: methodology

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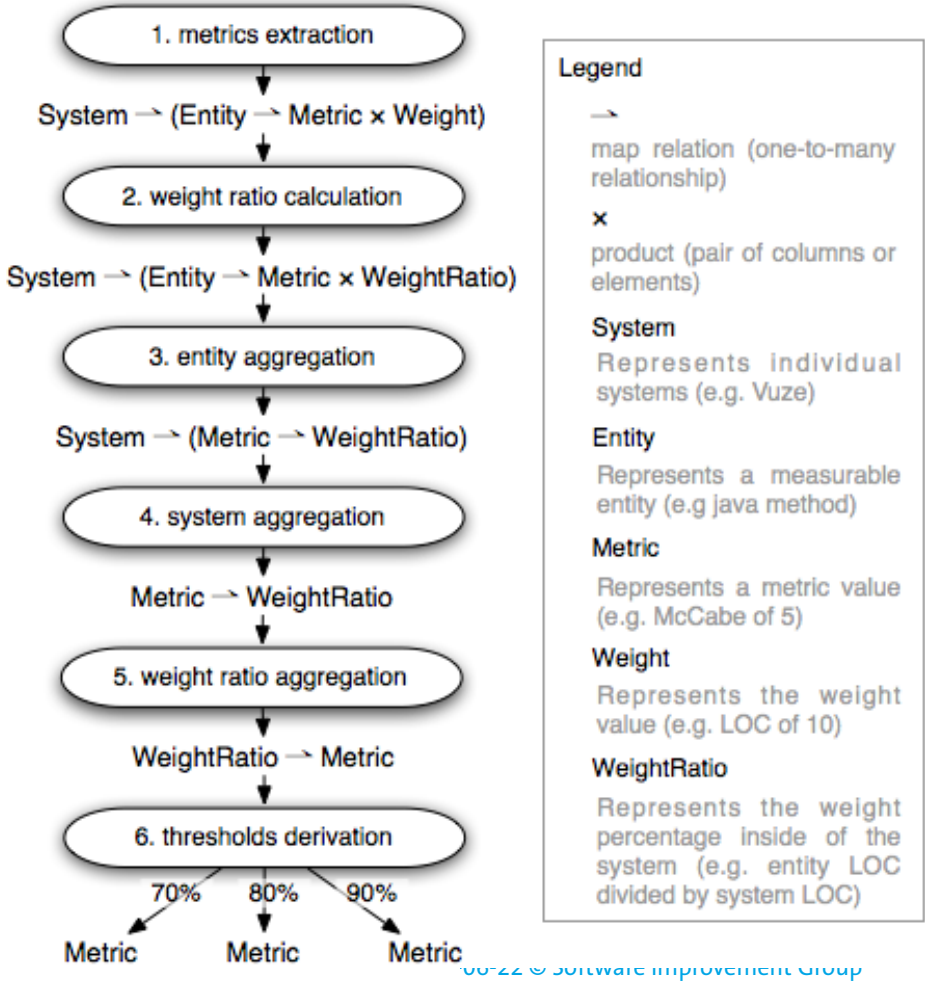

Derivation of risk thresholds: background Histogram vs. Quantile plots

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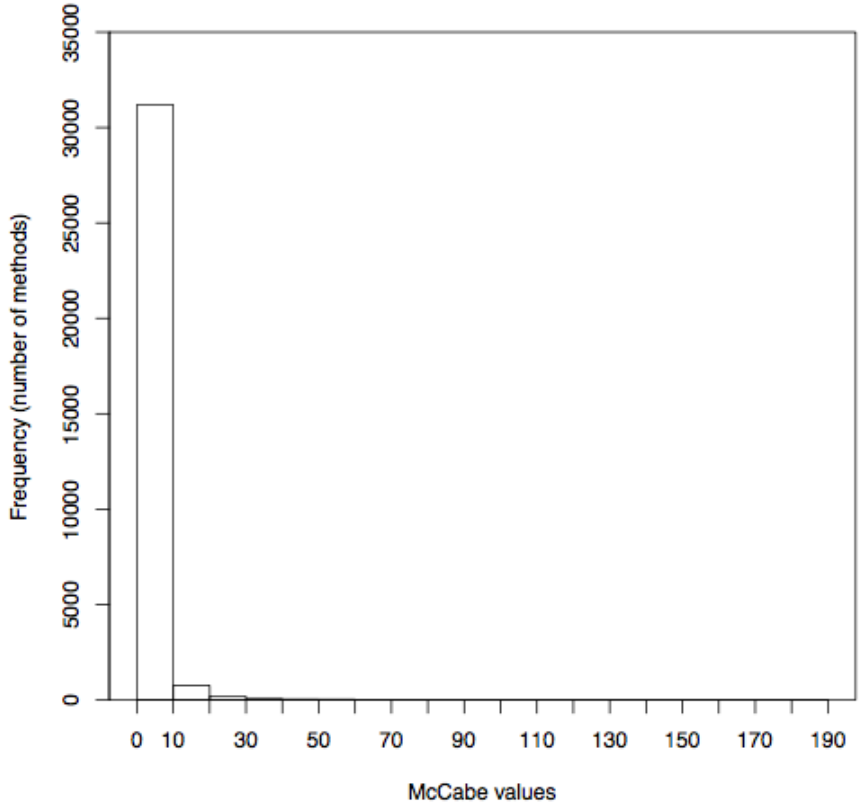

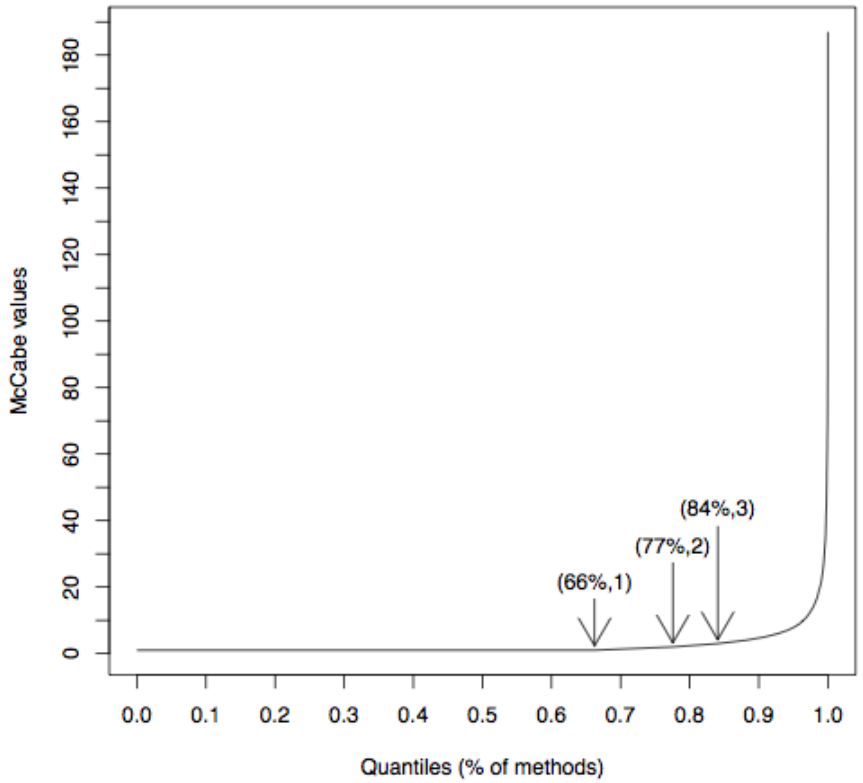

Derivation of risk thresholds: Weight by size

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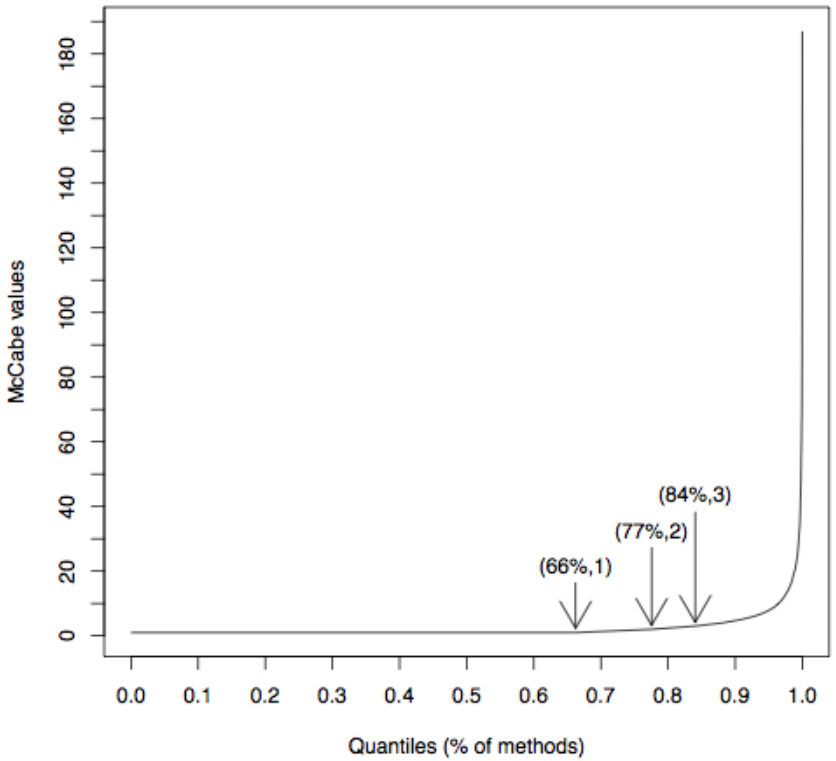

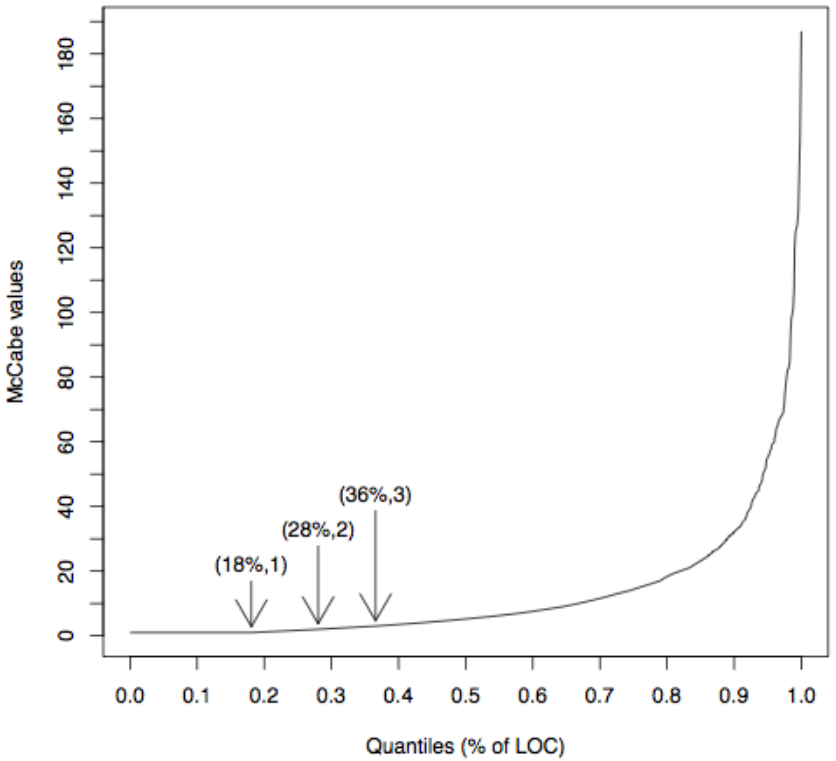

Derivation of risk thresholds
Summarizing a metric distribution

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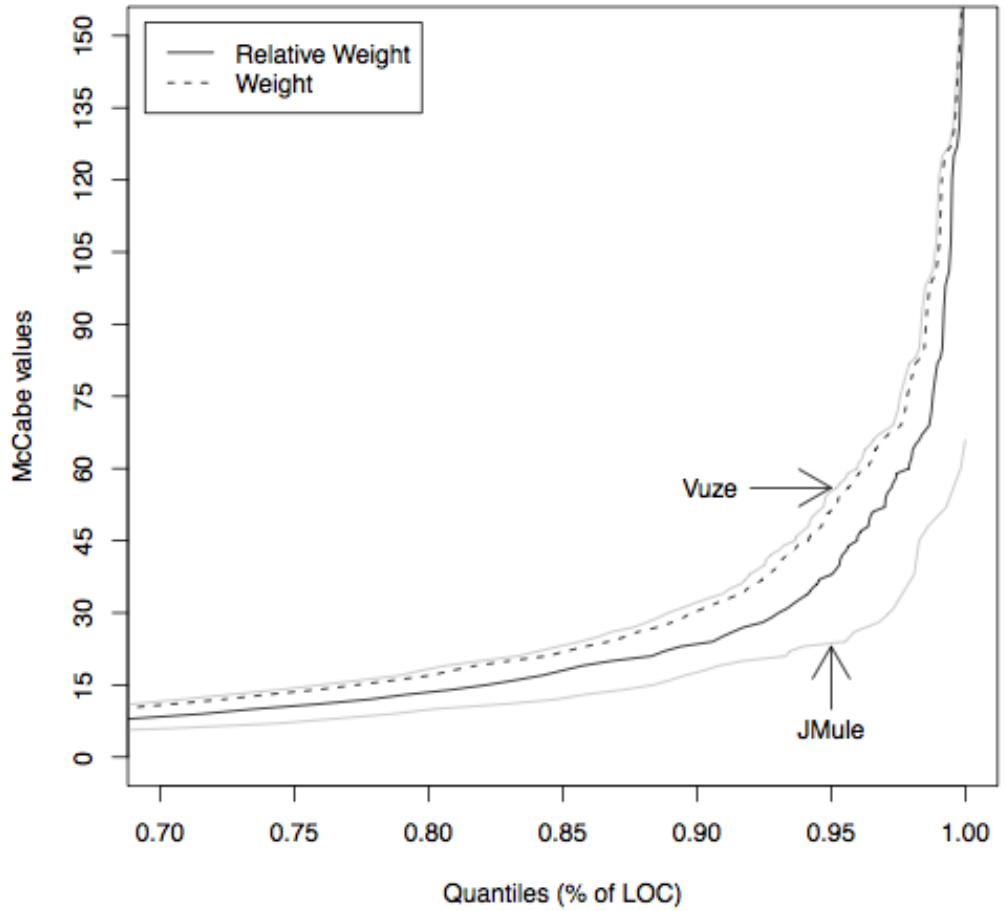

Derivation of risk thresholds
Relative weighting

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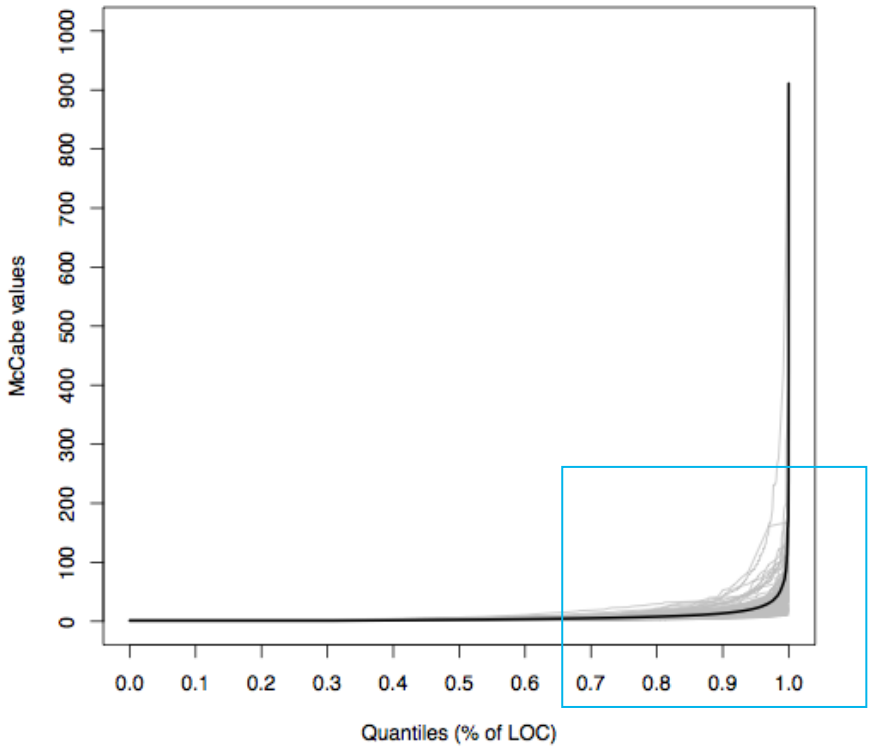

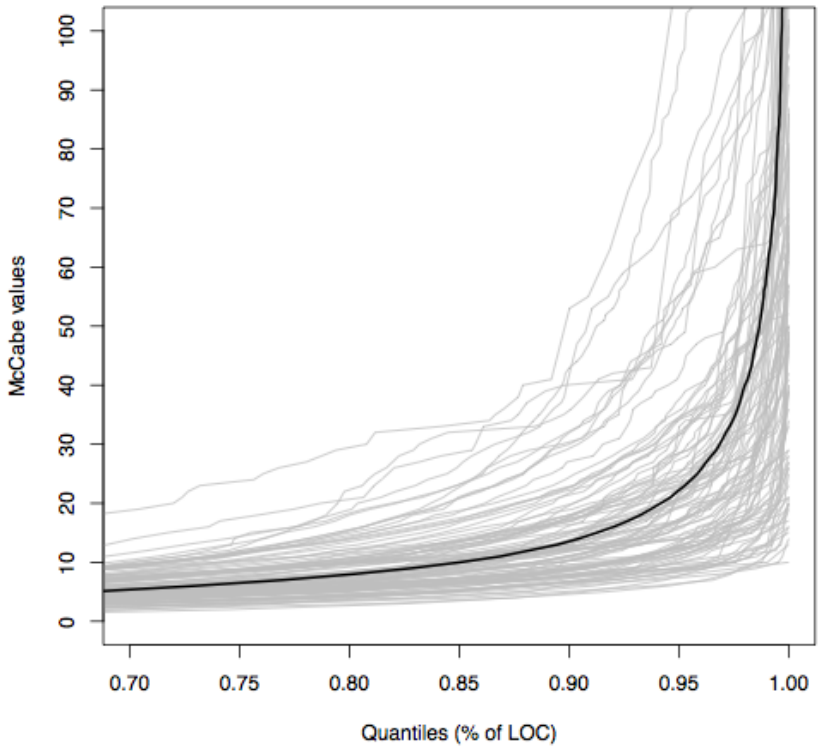

Derivation of risk thresholds: values

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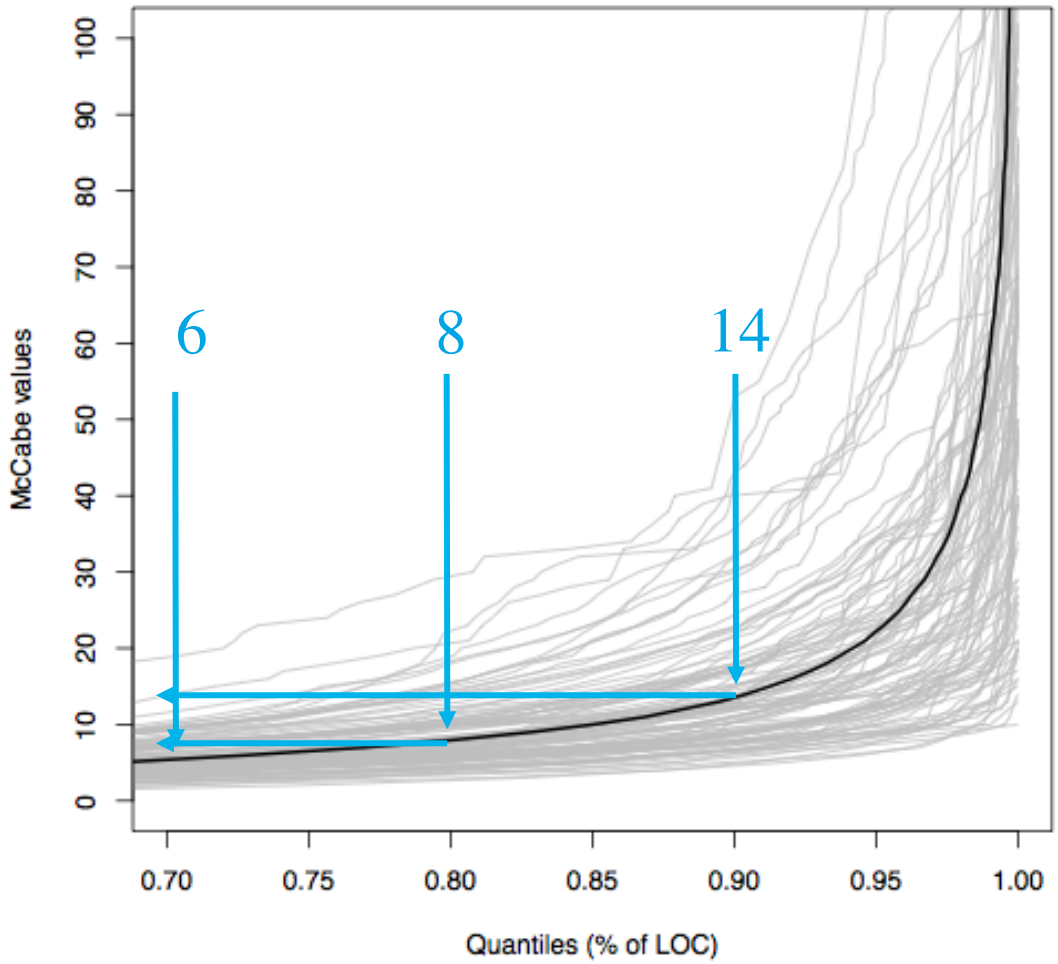

Risk Thresholds for the SIG Quality Model

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Metric / Quantiles	70%	80%	90%
Unit complexity	6	8	14
Unit size	30	44	74
Module inward coupling	10	22	56
Module interface size	29	42	73

Metric / Quantiles	80%	90%	95%
Unit interfacing	2	3	4

Analysis of risk thresholds

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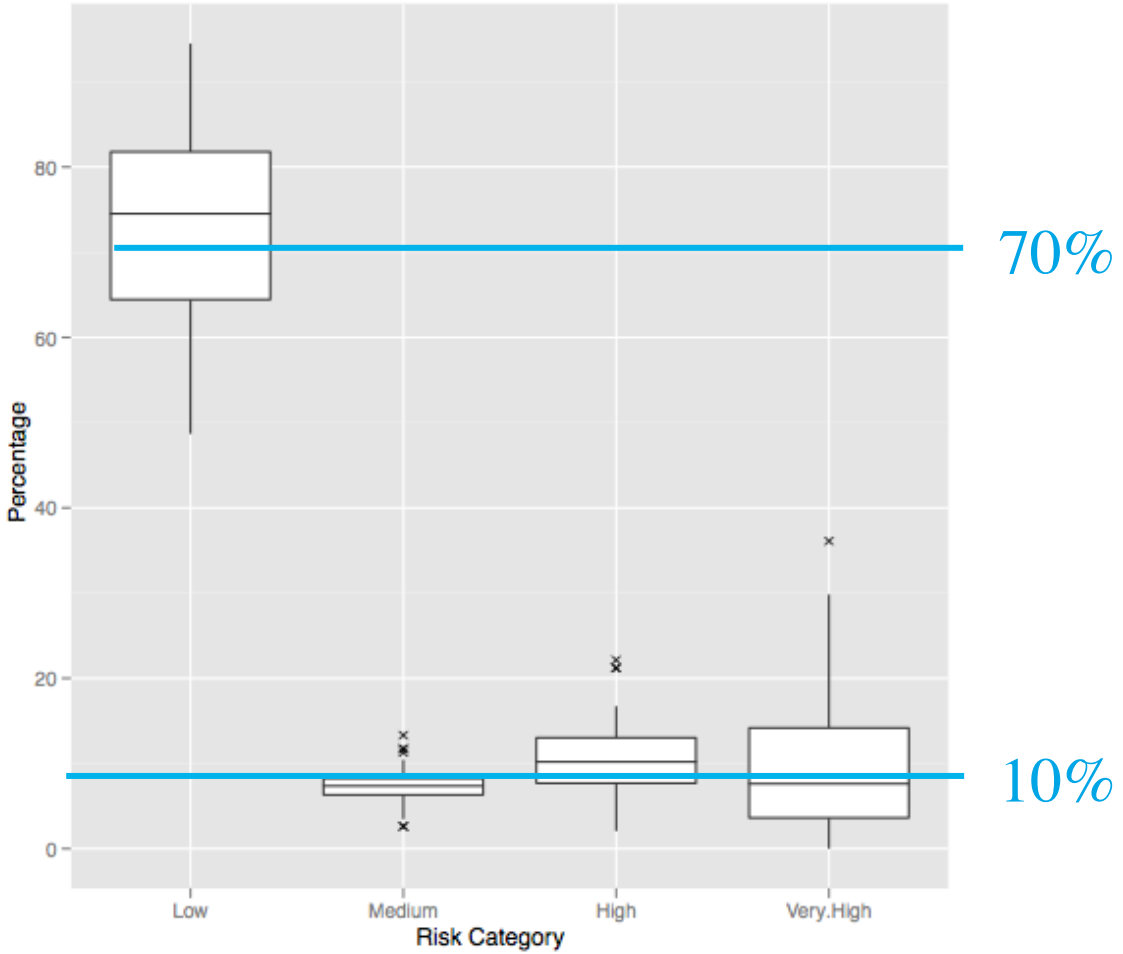

Novel methodology to derive metric thresholds

- Solid methodology based on benchmark (depart from expert opinion)
- Agrees with expert opinion (thresholds are sensible)

Plans for the future

- Validate with external characteristics

"The" Lessons

- We can attribute meaning to thresholds
- Benchmarks are of extreme importance

Benchmarking metrics to ratings

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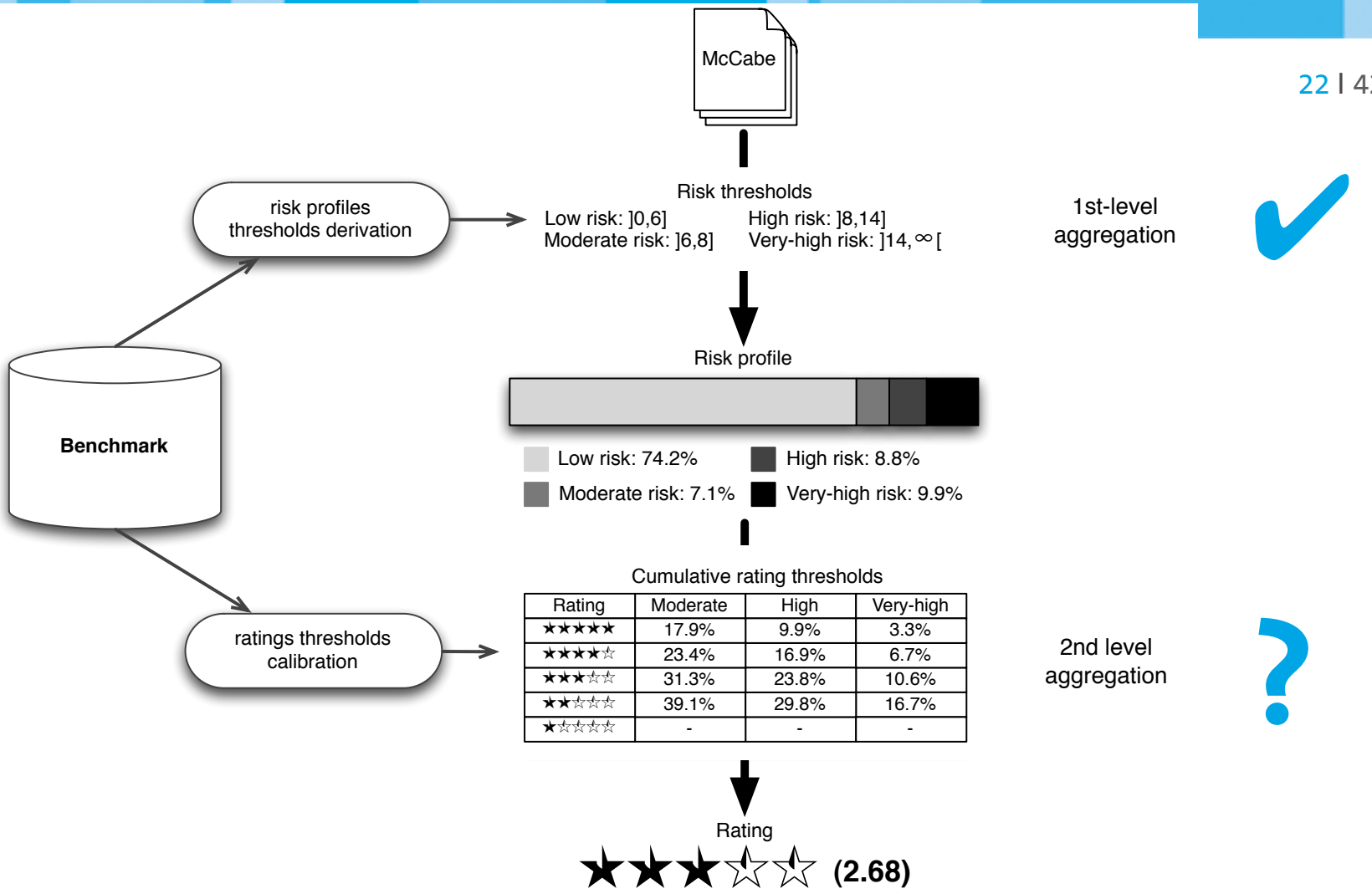

Rating	Moderate	High	Very-high
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★★☆☆☆	39.1%	29.8%	16.7%
★☆☆☆☆	-	-	-

Part II
Calibration of rating thresholds

Benchmark partitioning
The problem

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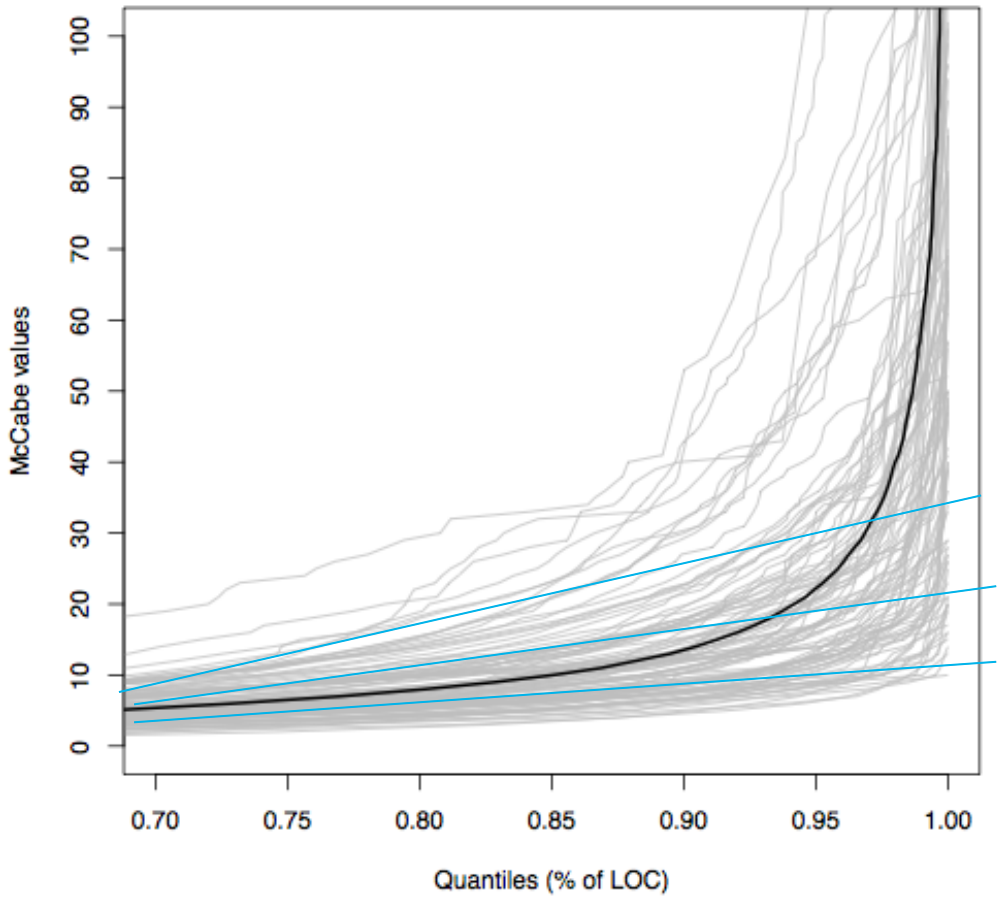

?

P2 ★★★★

P1 ★★★★★

Benchmark partitioning
The problem #2

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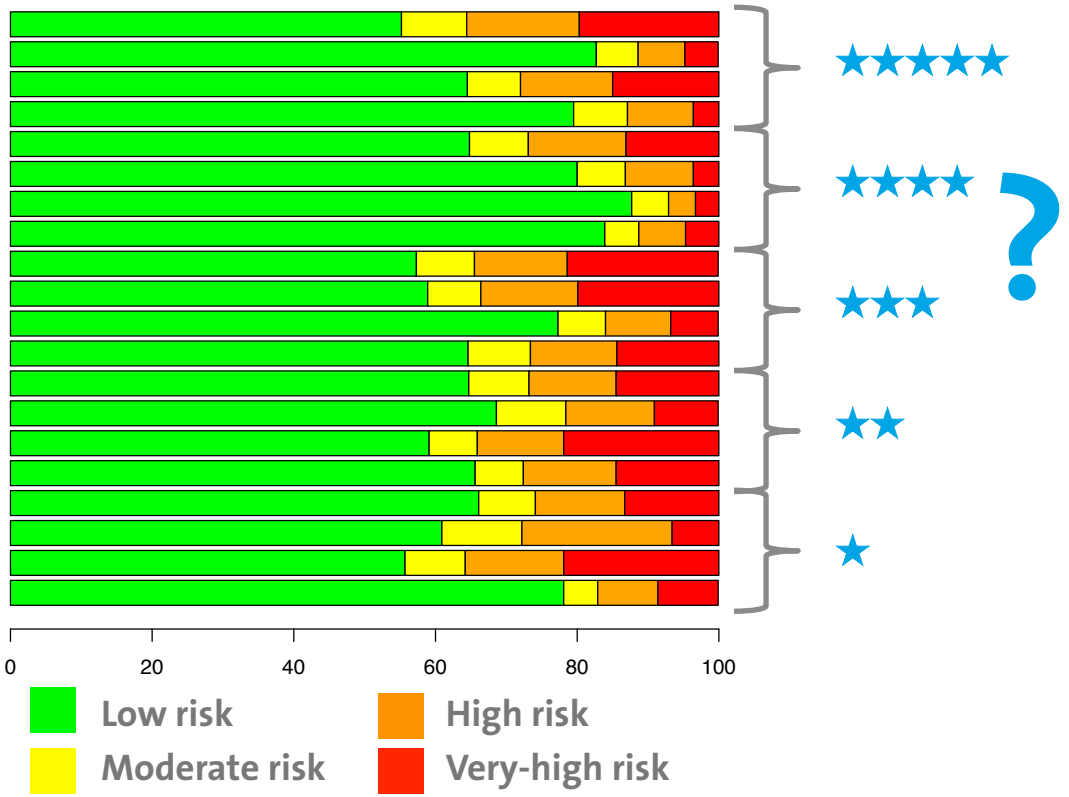
Unit complexity risk profiles for 20 random systems



Benchmark partitioning
Order by Very-high risk category

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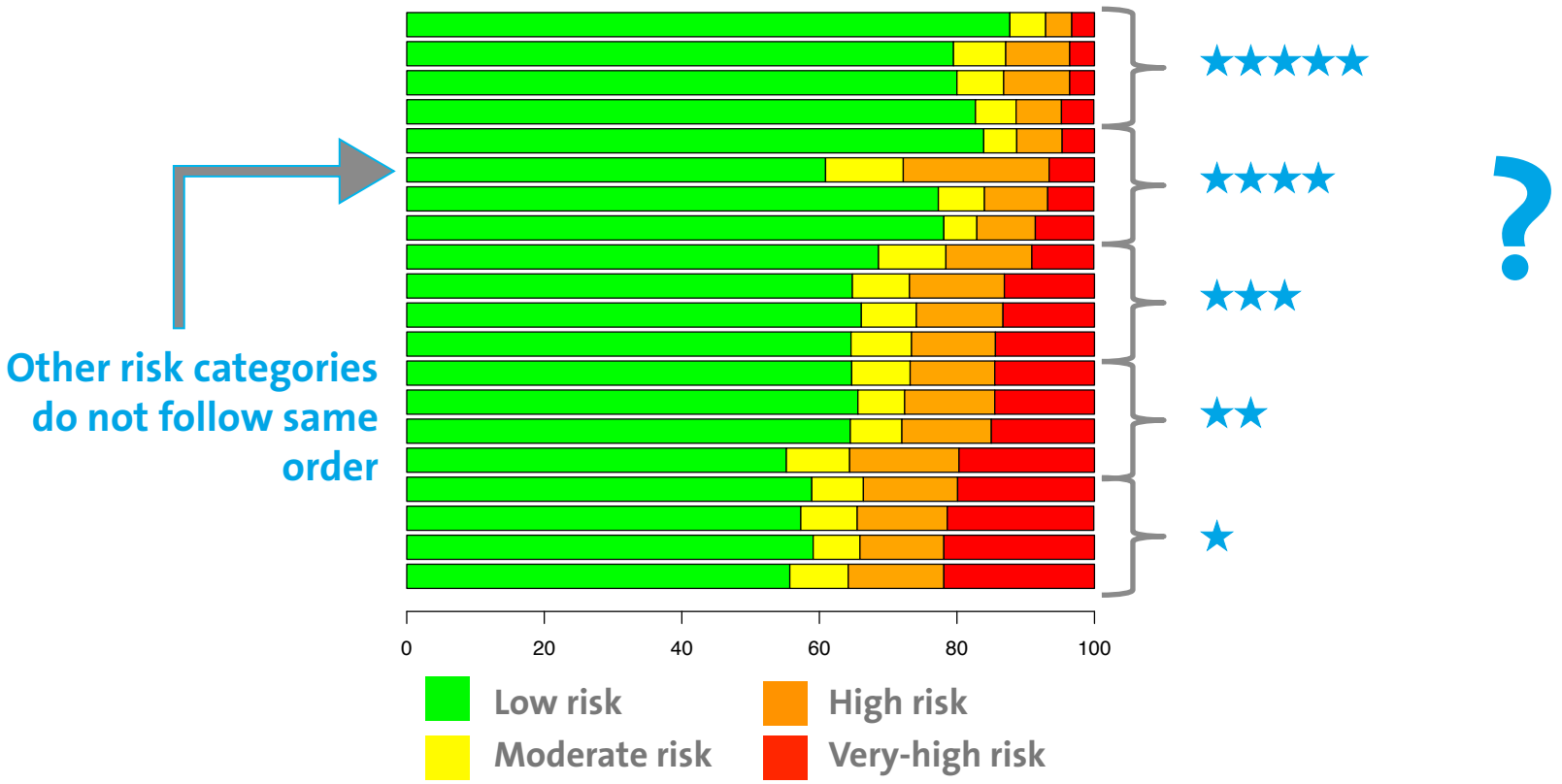
Unit complexity risk profiles for 20 random systems



Ratings calibration algorithm

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Require: $riskprofiles : (Moderate \times High \times VeryHigh)^*$, $partition^{N-1}$

1: $thresholds \leftarrow ()$
2: $ordered[Moderate] \leftarrow order(riskprofiles.Moderate)$
3: $ordered[High] \leftarrow order(riskprofiles.High)$
4: $ordered[VeryHigh] \leftarrow order(riskprofiles.VeryHigh)$
5: **for** $rating = 1$ **to** $(N-1)$ **do**
6: $i \leftarrow 0$
7: **repeat**
8: $i \leftarrow i + 1$
9: $thresholds[rating][Moderate] \leftarrow ordered[Moderate][i]$
10: $thresholds[rating][High] \leftarrow ordered[High][i]$
11: $thresholds[rating][VeryHigh] \leftarrow ordered[VeryHigh][i]$
12: **until** $distribution(riskprofiles, thresholds[rating]) \leq partition[rating]$ **and** $i < length(riskprofiles)$
13: $index \leftarrow i$
14: **for all** $risk$ in $(Moderate, High, VeryHigh)$ **do**
15: $i \leftarrow index$
16: $done \leftarrow False$
17: **while** $i > 0$ **and not** $done$ **do**
18: $thresholds.old \leftarrow thresholds$
19: $i \leftarrow i - 1$
20: $thresholds[rating][risk] \leftarrow ordered[risk][i]$
21: **if** $distribution(riskprofiles, thresholds[rating]) < partition[rating]$ **then**
22: $thresholds \leftarrow thresholds.old$
23: $done \leftarrow True$
24: **end if**
25: **end while**
26: **end for**
27: **end for**
28: **return** $thresholds$

Benchmark partitioning
Calibration algorithm result

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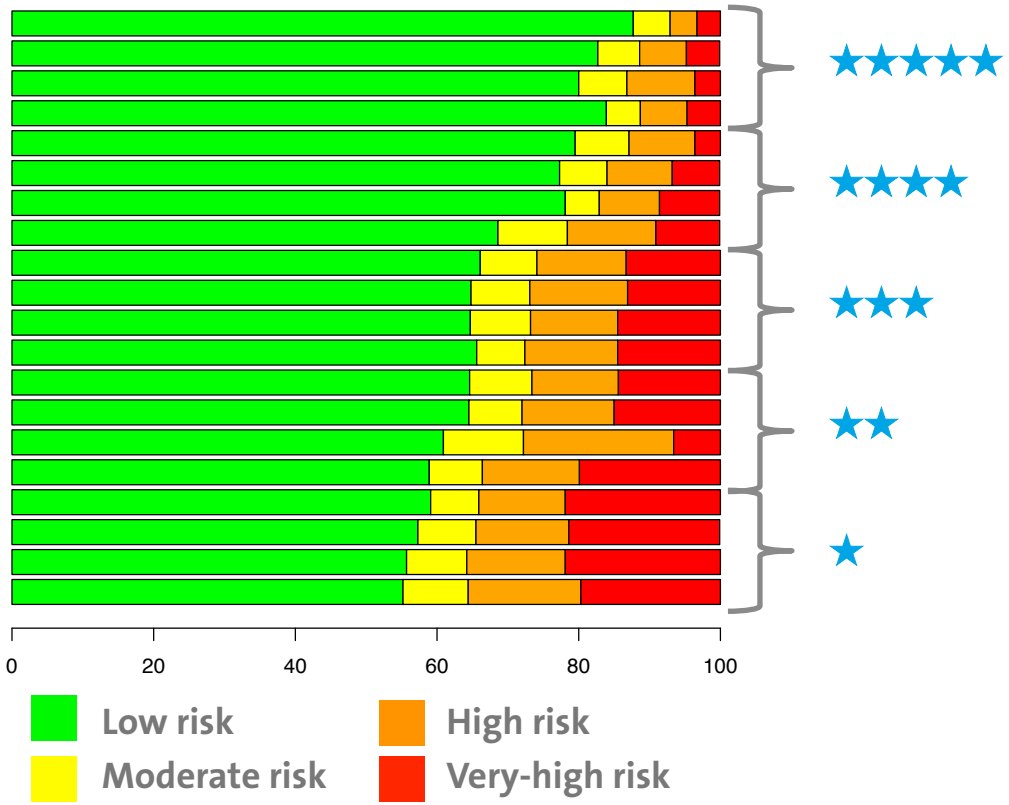
Unit complexity risk profiles for 20 random systems



Calibrated rating thresholds
Unit complexity (McCabe)

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Cumulative rating thresholds calibrated from 100 system benchmark

Rating	Low]0,6]	Moderate]6,8]	High]8,14]	Very-High > 14
★★★★★	-	17.9%	9.9%	3.3%
★★★★	-	23.4%	16.9%	6.7%
★★★	-	31.3%	23.8%	10.6%
★★	-	39.1%	29.8%	16.7%
★	-	-	-	-

Calibration of rating thresholds
Concluding remarks

Novel methodology to aggregate metric to ratings

- Support of N-point scale (used 5-point star rating)
- Solid methodology based on benchmark
- Enables traceability using thresholds and risk profiles

Plans for the future

- Validate with external characteristics
- Step for building quality models

"The" Lessons

- We can attribute meaning to ratings
- Ratings can be used to rank and evaluate software systems

Benchmarking metrics to ratings

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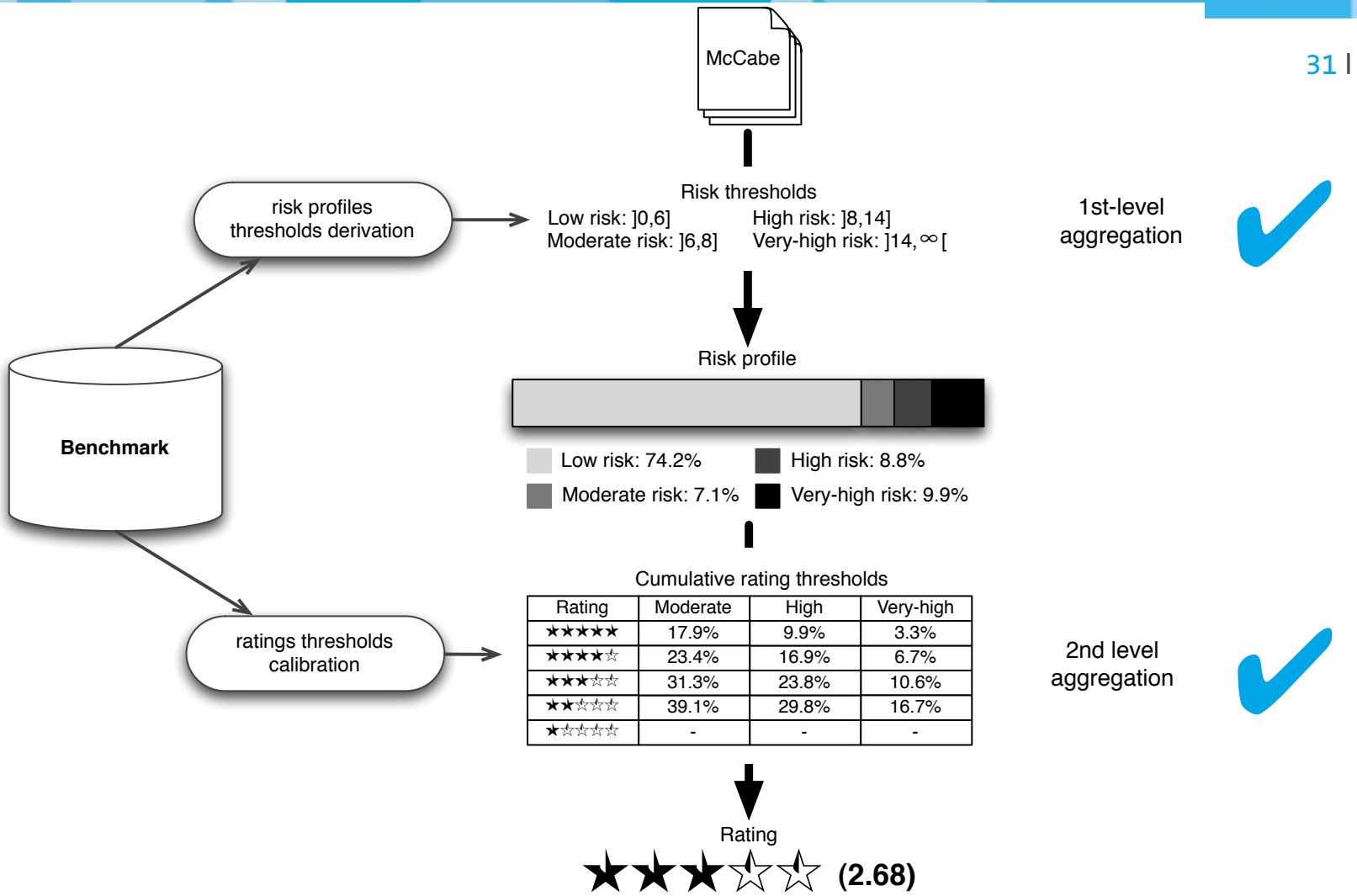

Part III
Using ratings for quality evaluation

Simulators for Space Domain

EuroSim

- Commercial simulator
- Consortium: Dutch Space, NLR, TASK24
- Supports hardware-in-the-loop and man-in-the-loop
- Hard real-time
- Has non-space applications (e.g. aircraft simulation)

ESA/ESOC SimSat

- ESA owned (free)
- Mainly used for spacecraft telecommunication simulation
- Real-time

Technical Analysis on EuroSim
Research Motivation

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Comparison of the technical quality between systems of the same domain

- Dutch Space EuroSim mk4.1.5
- ESA SimSat v4.0.1 issue 2

Research question

- How does the technical quality of EuroSim compare to SimSat?
  (how to use ratings to evaluate and compare quality)

Scope of the analysis

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Analyzed programming languages

- C/C++
- Java

Considerations

- Production and test code analyzed separately
- Excluded documentation code and examples
- Excluded generated code (Icon files generated by XMP)
- Excluded open-source libraries
- Excluded drivers supplied by hardware suppliers
  - device drivers developed by EuroSim Consortium were included in the analysis
- Excluded code not in use: PerfIGS, LibCadese

Unit Complexity definition

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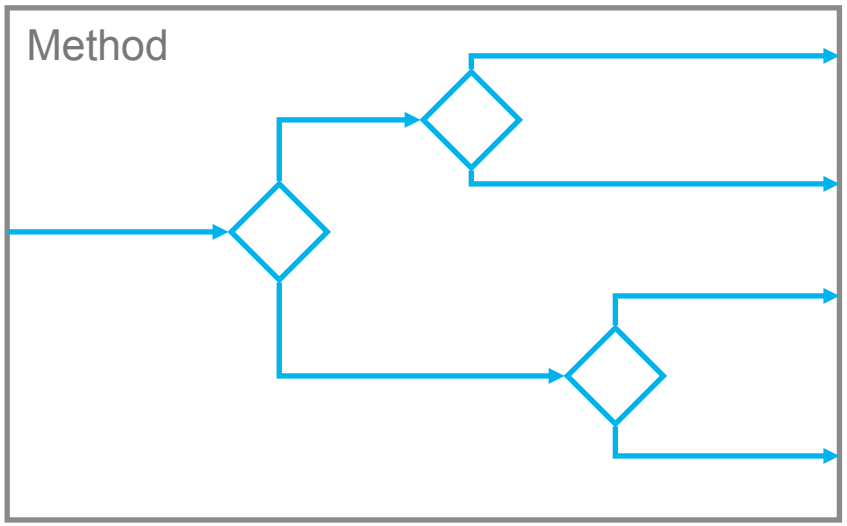
- McCabe, *IEEE Transactions on Software Engineering*, 1976
- Cyclomatic Complexity = Number of decision points per unit (method/function)

- Widely accepted measurement for code complexity
- Should be as small as possible



McCabe: 4

Unit Complexity comparison

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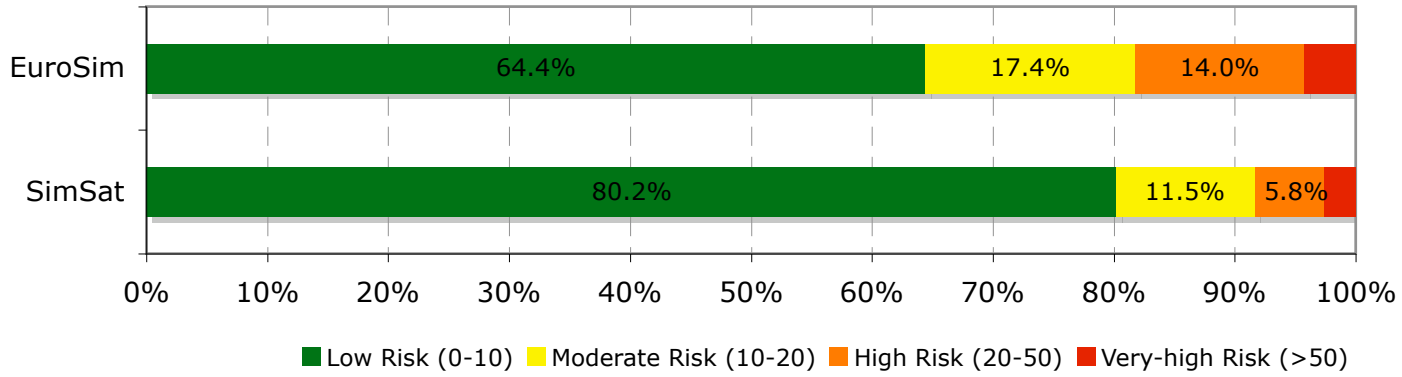

Discussion

- Both EuroSim and SimSat rank two stars
- Very-high complexity was found: 4.2% for EuroSim and 2.6% SimSat
- For EuroSim, very-high complexity is localized in 16 methods.
- Taking the last three risk categories, EuroSim has almost twice the risk of SimSat
- For EuroSim, comparing versions reveals slow decrease of the quality

ISO 9126 Maintainability
Comparison between EuroSim and SimSat

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		Volume	Duplication	Unit size	Complexity	Unit interfacing	Test quality	
Dutch Space EuroSim	Score	★★★★	★★★	★★	★★	★★	★★	Score
	Analysability	X	X	X				★★★
	Changeability		X		X		X	★★
	Stability					X	X	★★
	Testability			X	X			★★

ESA SimSat	Score	★★★	★★	★★	★★	★★★	★★	Score
	Analysability	X	X	X				★★★
	Changeability		X		X		X	★★
	Stability					X	X	★★★
	Testability			X	X			★★

Dutch Space Eurosim Maintainability: ★★★

ESA SimSat Maintainability: ★★

Conclusion

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Contributions

- Generic methodology to use metrics for quality evaluation
- Demonstration of the methodology using space-domain software

Benchmark-based approach benefits

- Meaningful (relation with industrial systems)
- Operational (thresholds can be obtained automatically)

Future work

- Use the methodology to validate metrics external characteristics
- Finalize PhD thesis!!!

Shameless Commercial Alert

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- Internships (currently hosting 3 PhD + 4 MSc students)
- Jobs
- Research cooperation

- Very interesting clients
- You get to see lots and lots of source code from all over the world
- Software Engineering or Consultancy skills (or both)

- See www.sig.eu

More info? Feel free to contact...

Software Improvement Group

Tiago L. Alves

E: t.alves@sig.eu
W: www.sig.eu
T: +31 20 3140950