

# Maintainability Index

YEGOR BUGAYENKO

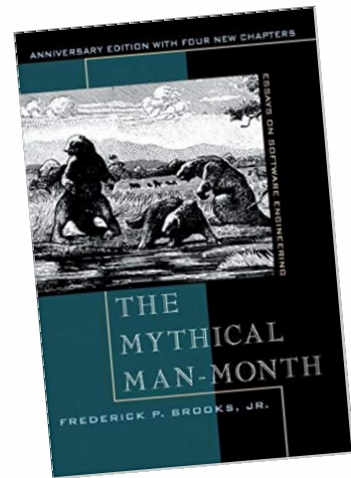
Lecture #5 out of 24

80 minutes

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FRED BROOKS

“The total cost of maintaining a widely used program is typically 40 percent or more of the cost of developing it.”

— Frederick P. Brooks. *The Mythical Man-Month: Essays on Software Engineering*. Addison-Wesley, 1978. doi:[10.5555/540031](https://doi.org/10.5555/540031)



RICHARD G. HAMLET

“It is a truism that good software is easy to maintain.”

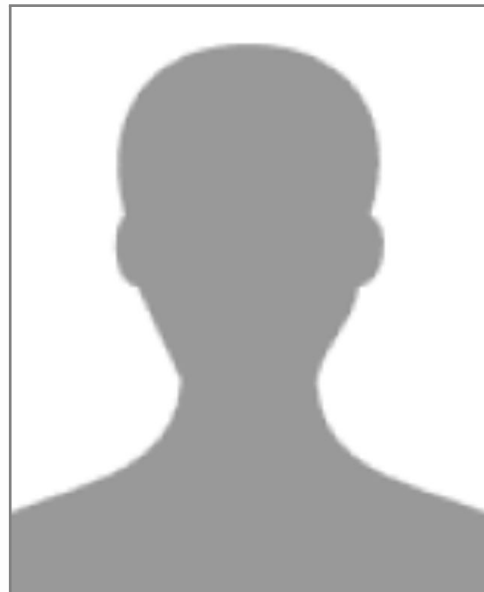
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WARD CUNNINGHAM

“Shipping first time code is like going into debt. A little debt speeds development so long as it is paid back promptly with a rewrite. The danger occurs when the debt is not repaid. Every minute spent on not-quite-right code counts as interest on that debt.”

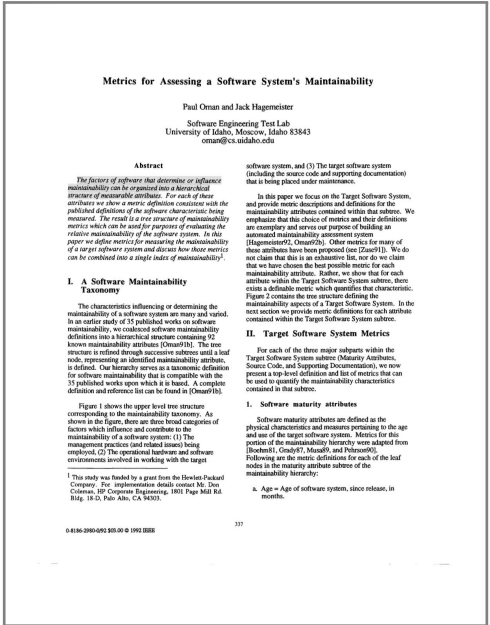
— Ward Cunningham. Experience Report — The WyCash Portfolio Management System. In *Proceedings of the Conference on Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA)*, pages 29–30, 1992. doi:[10.1145/157710.157715](https://doi.org/10.1145/157710.157715)



PAUL OMAN

“Before developers can claim that they are building maintainable systems, there must be some way to measure maintainability”

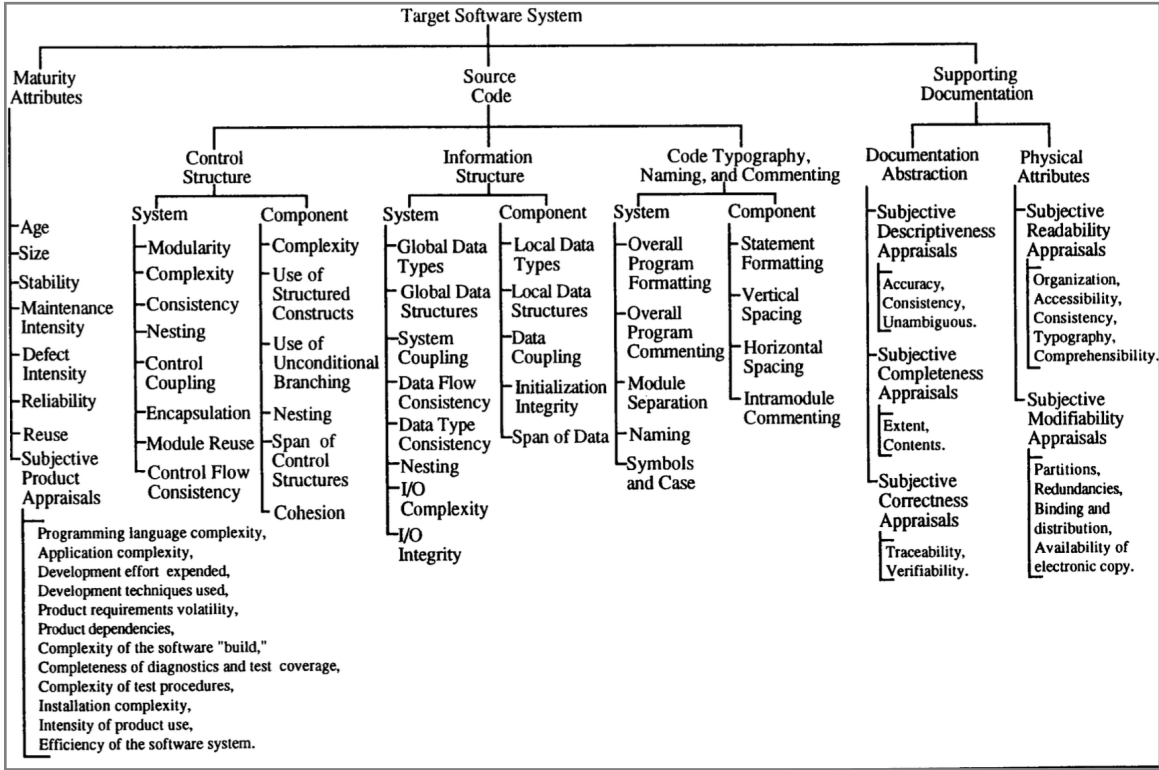
— Don Coleman, Dan Ash, Bruce Lowther, and Paul Oman. Using Metrics to Evaluate Software System Maintainability. *Computer*, 27(8), 1994.  
[doi:10.1109/2.303623](https://doi.org/10.1109/2.303623)



“The factors of software that determine or influence maintainability can be organized into a hierarchical structure of measurable attribute. Our hierarchy serves as a taxonomic definition for software maintainability that is compatible with the 35 published works upon which it is based.”

— Paul Oman and Jack Hagemeyer. Metrics for Assessing a Software System’s Maintainability. In *Proceedings of the International Conference on Software Maintenance*, pages 337–338. IEEE, 1992. doi:10.1109/icsm.1992.242525

# Software Maintainability Taxonomy





Source: Paul Oman and Jack Hagemeister. Metrics for Assessing a Software System's Maintainability. In *Proceedings of the International Conference on Software Maintenance*, pages 337–338. IEEE, 1992.  
doi:[10.1109/icsm.1992.242525](https://doi.org/10.1109/icsm.1992.242525)

## Maintainability Formula

To quantify the maintainability of a tree we can then use the following formula:

$$\prod_{i=1}^m W_{D_i} \left( \frac{\sum_{j=1}^n W_{A_j} M_{A_j}}{n} \right)_i$$

where

$W_{D_i}$  = Weight of influence of maintainability  
Dimension  $D_i$

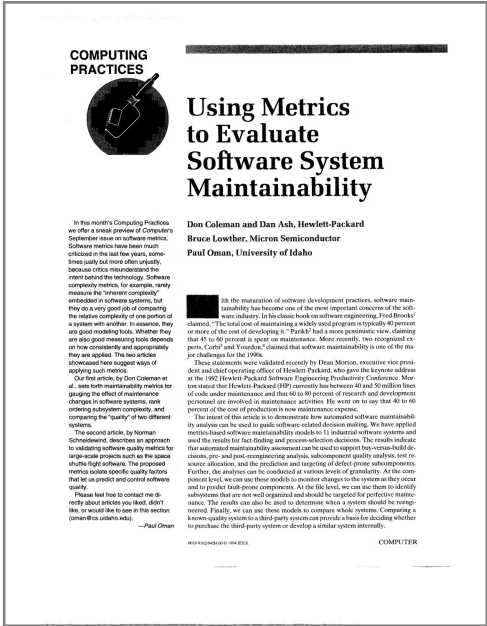
$W_{A_j}$  = Weight of influence of maintainability  
Attribute  $A_j$

$M_{A_j}$  = Metric or measure of maintainability  
Attribute  $A_j$

“This formula represents the product of the weighted dimensions, where each dimension is measured as the average deviation from a known value of ‘goodness’ for that maintainability attribute.”

Source: Paul Oman and Jack Hagemester. Metrics for Assessing a Software System’s Maintainability. In *Proceedings of the International Conference on Software Maintenance*, pages 337–338. IEEE, 1992.  
doi:[10.1109/icsm.1992.242525](https://doi.org/10.1109/icsm.1992.242525)





“A software maintainability model is only useful if it can provide developers and maintainers in an industrial setting with more information about the system.”

— Don Coleman, Dan Ash, Bruce Lowther, and Paul Oman. Using Metrics to Evaluate Software System Maintainability. *Computer*, 27(8), 1994. doi:10.1109/2.303623

## First Approximation

$$\begin{aligned}\text{Maintainability} &= 171 \\ &- 3.42 \times \ln(\text{ave}E) \\ &- 0.23 \times \text{ave}V(g') \\ &- 16.2 \times \ln(\text{ave}LOC) + \text{ave}CM\end{aligned}$$

where *aveE*, *aveV(g')*, *aveLOC*, and *aveCM* are the average effort, extended V(G), average lines of code, and number of comments per submodule (function or procedure) in the software system.

“Approximately 50 regression models were constructed in an attempt to identify simple models that could be calculated from existing tools and still be generic enough to apply to a wide range of software systems. The regression model that seemed most applicable was a four-metric polynomial based on 1) Halstead’s effort, 2) extended cyclomatic complexity, 3) lines of code, and 4) number of comments.”



## The Formula of Maintainability Index

$$\begin{aligned}\text{Maintainability} = & 171 \\ & - 5.2 \times \ln(\text{aveVol}) \\ & - 0.23 \times \text{ave } V(g') \\ & - 16.2 \times \ln(\text{aveLOC}) \\ & + (50 \times \sin(\sqrt{2.46 \times \text{perCM}}))\end{aligned}$$

*aveVol* — average Halstead Volume in a module

*ave V(g')* — average total cyclomatic complexity in a module

*aveLOC* — average lines of code in a module

*perCM* — average percent of comments in a module

## Maintainability Index by Visual Studio

$$MI = \max \left[ 0, 100 \frac{171 - 5.2 \ln V - 0.23G - 16.2 \ln L}{171} \right]$$

Source: Introduction to Code Metrics, by Radon

■	MI >= 20	High Maintainability
⚠	10 <= MI < 20	Moderate Maintainability
●	MI < 10	Low Maintainability

Source: Think Twice Before Using the “Maintainability Index”, by Arie van Deursen

“We decided to be conservative with the thresholds. The desire was that if the index showed red then we would be saying with a high degree of confidence that there was an issue with the code.” — Code metrics — Maintainability index range and meaning by Microsoft, 2011.





RAINER NIEDERMAYR

“We are convinced that Maintainability Index is nonsense. We think that it is not sensible to reduce the maintainability of a whole software system to one single indicator.”

— Rainer Niedermayr. Why We Don't Use the Software Maintainability Index. <https://teamscale.com/blog/en/news/blog/maintainability-index>, 2016. [Online; accessed 15-03-2024]


“The Maintainability Index does not provide information about the impact on development activities. A value of 57 does not express which maintainability aspects are affected by a bad value.” — Rainer Niedermayr



ARIE VAN DEURSEN

“If you are a researcher, think twice before using the maintainability index in your experiments. Make sure you study and fully understand the original papers published about it.”

— Arie van Deursen. Think Twice Before Using the “Maintainability Index”.  
<https://jttu.net/deursen2014>, 2014. [Online; accessed 15-03-2024]




“Tool smiths and vendors used the exact same formula and coefficients as the 1994 experiments, without any recalibration.” — Arie van Deursen



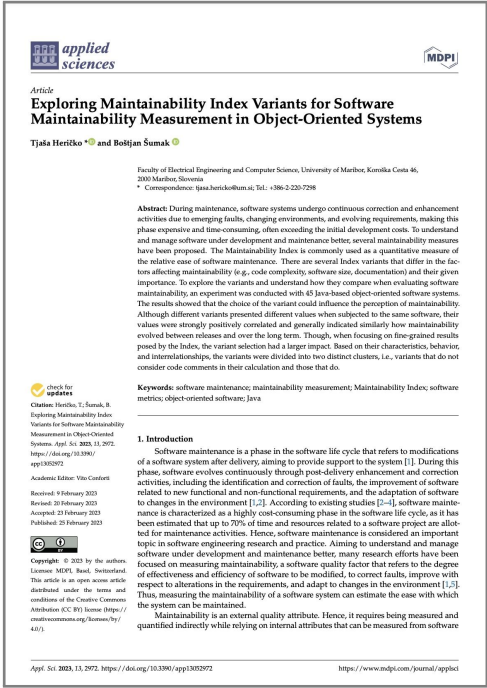
TIM GILBOY

“If we’re going to use the Maintainability Index we should use it to measure relative maintainability within our project rather than use it as an absolute metric.”

— Tim Gilboy. Maintainability Index — What Is It and Where Does It Fall Short? <https://sourcery.ai/blog/maintainability-index/>, 2022. [Online; accessed 15-03-2024]



“Extending the length can significantly decrease Maintainability Index, even if all of the changes cause the code to be clearer and more understandable.” — Tim Gilboy



TJAŠA HERIČKO

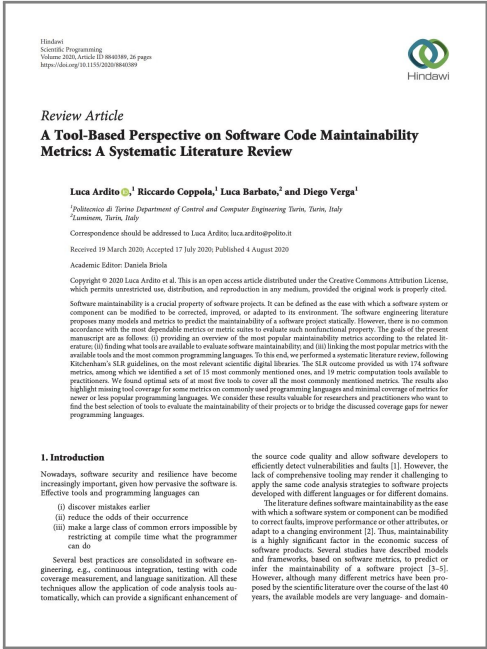
“When comparing maintainability measurements from several Index variants, the perception of maintainability could be impacted by the choice of the Index variant used.”

— Tjaša Heričko. Exploring Maintainability Index Variants for Software Maintainability Measurement in Object-Oriented Systems, 2023

Maintainability Index is supported by a few tools:

- Visual Studio for C++ and others
- SonarQube for Java
- Testwell for Java and C++ (not free)
- Radon for Python
- jscomplexity for JavaScript
- maintidx for Go





“The SLR outcome provided us with 174 software metrics, among which we identified a set of 15 most commonly mentioned ones, and 19 metric computation tools available to practitioners.”

— Luca Ardito, Riccardo Coppola, Luca Barbato, and Diego Verga. A Tool-Based Perspective on Software Code Maintainability Metrics: A Systematic Literature Review. *Scientific Programming*, 2020(1):8840389, 2020. doi:10.1155/2020/8840389

TABLE 7: Metrics (suites) with citation count and score above the median.

Metric	Total mentions	Score
CC, McCabe’s cyclomatic complexity	14	12
CE, efferent coupling	3	3
CHANGE, number of lines changed in class	4	4
C&K, Chidamber and Kemerer suite	13+	11+
CLOC, comment lines of code	6	6
Halstead’s suite	6+	4+
JLOC, JavaDoc lines of code	3	3
LOC, lines of code	14	11
LCOM2, lack of cohesion in methods	3	3
MI, maintainability index	6	4
MPC, message passing coupling	4	4
NOM, number of methods	4	4
NPM, number of public methods	4	4
STAT, number of statements	4	4
WMC, McCabe’s weighted method count	7	7

Source: Luca Ardito, Riccardo Coppola, Luca Barbato, and Diego Verga. A Tool-Based Perspective on Software Code Maintainability Metrics: A Systematic Literature Review. *Scientific Programming*, 2020(1): 8840389, 2020. doi:[10.1155/2020/8840389](https://doi.org/10.1155/2020/8840389)

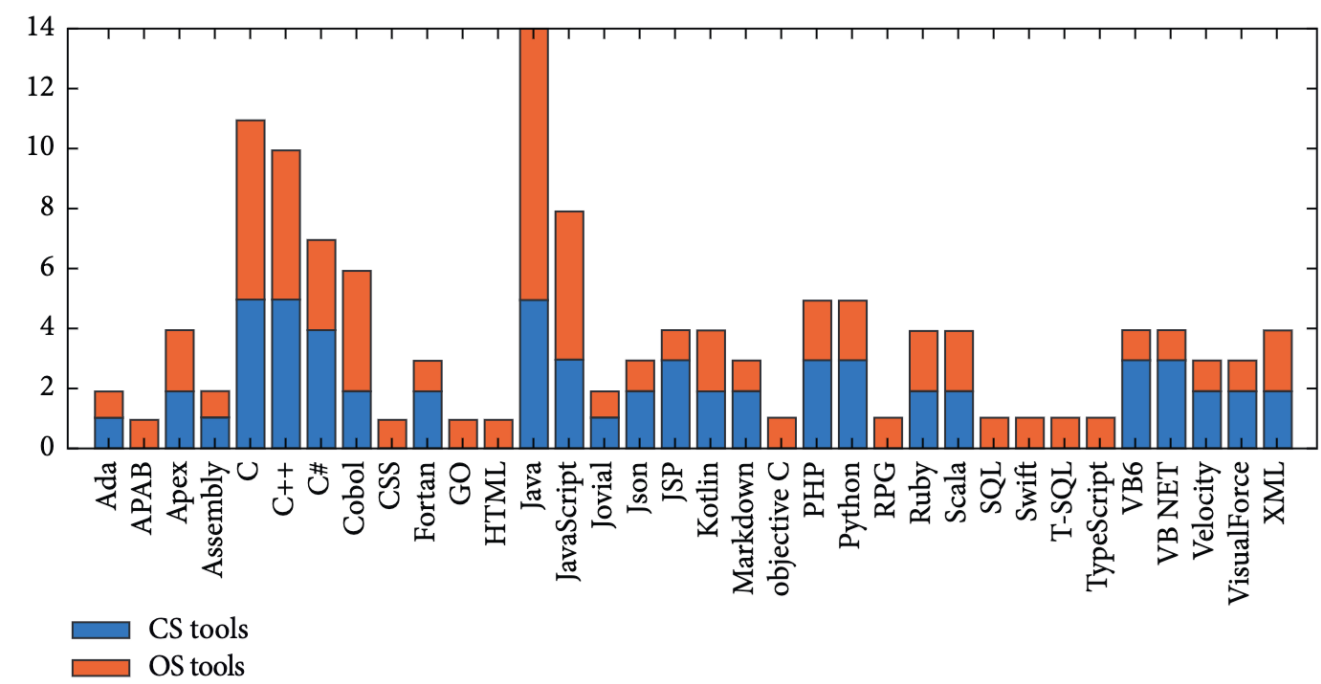


FIGURE 5: Number of tools (closed or open source) per language.

Source: Luca Ardito, Riccardo Coppola, Luca Barbato, and Diego Verga. A Tool-Based Perspective on Software Code Maintainability Metrics: A Systematic Literature Review. *Scientific Programming*, 2020(1):8840389, 2020. doi:[10.1155/2020/8840389](https://doi.org/10.1155/2020/8840389)

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