Assignment 2

SEM Group 26A

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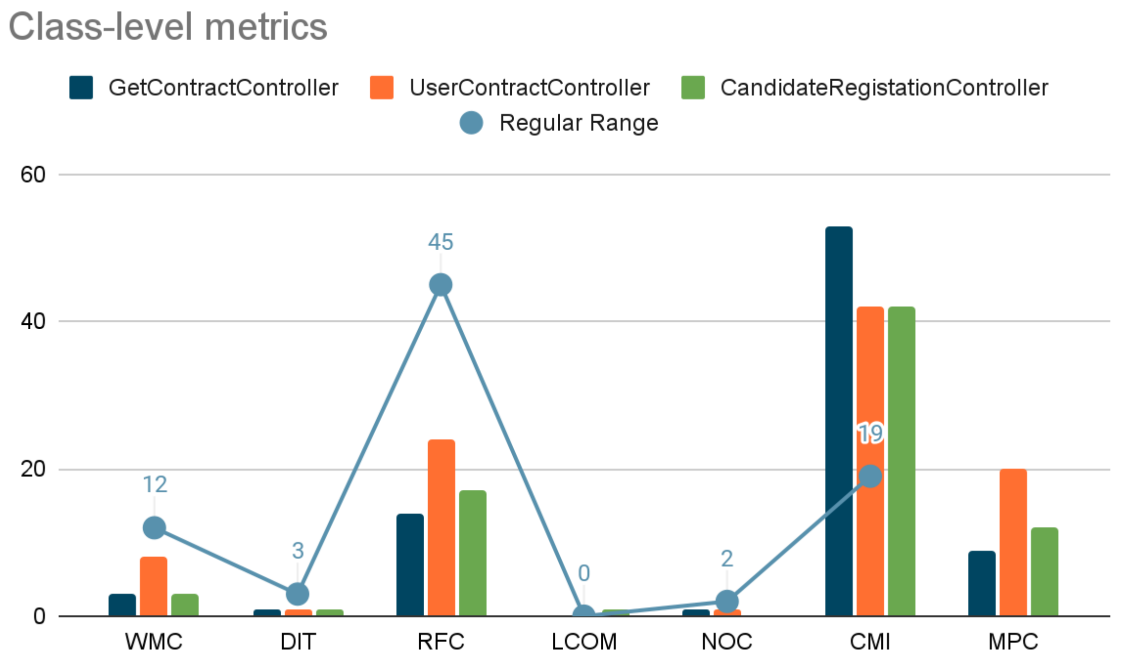
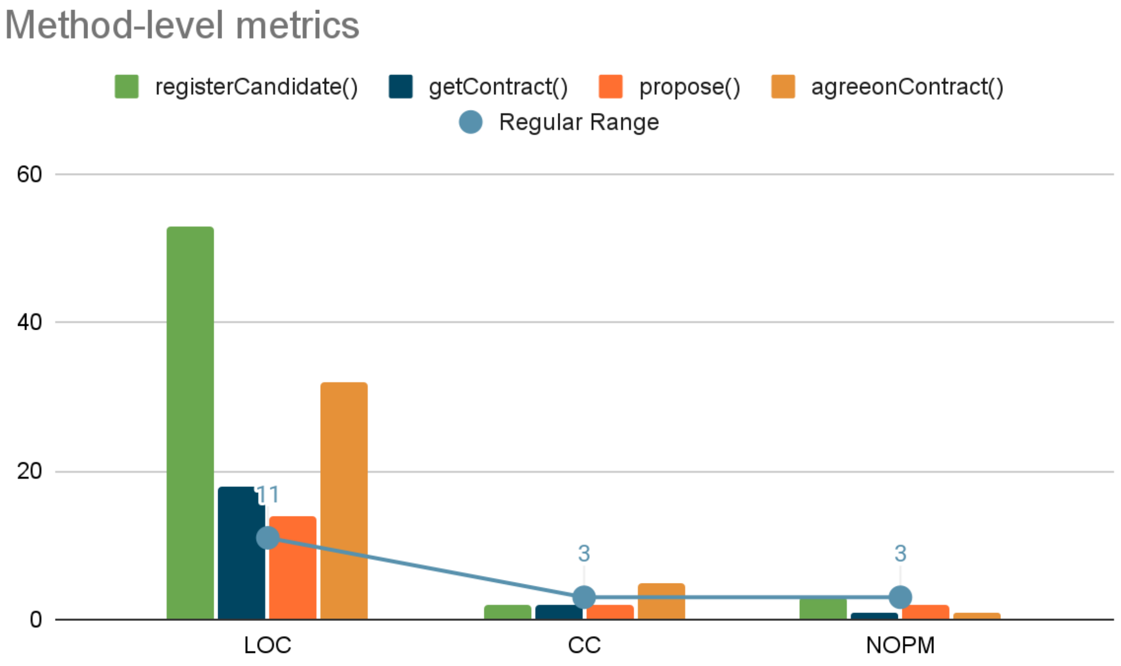
Task 1

For this assignment we have decided to use the MetricsTree IntelliJ plugin. To exemplify our thought process, we will use data from the User microservice.



Graph 1. Class-level metrics for the User microservice



Graph 2. Method-level metrics for the User microservice

In the graphs above, each class' and methods' metrics are represented by bars, and the line represents the Regular Range. The numbers shown indicate the Regular Range value.

Class-level refactoring

From Graph 1, we can see that for all classes the CMI (Class Maintainability Index) is higher than the regular range. The MPC (Message Passing Coupling) in the UserContractController class has a value of 20. Although there is no specific threshold, lowering the MPC would result in better separation of the functionality, improved readability, maintainability and testability.

Method-level refactoring

From Graph 2, we can see that the registerCandidate() method has almost more than 5 times the recommended LOC and the agreeOnContract() method has 3 times as many LOC and a CC of 5, while the threshold is 3. Given the analysis of our code metrics, we have identified that the registerCandidate() and agreeOnContract() methods in the UserContractController class exceeds our established threshold for lines of code per method.

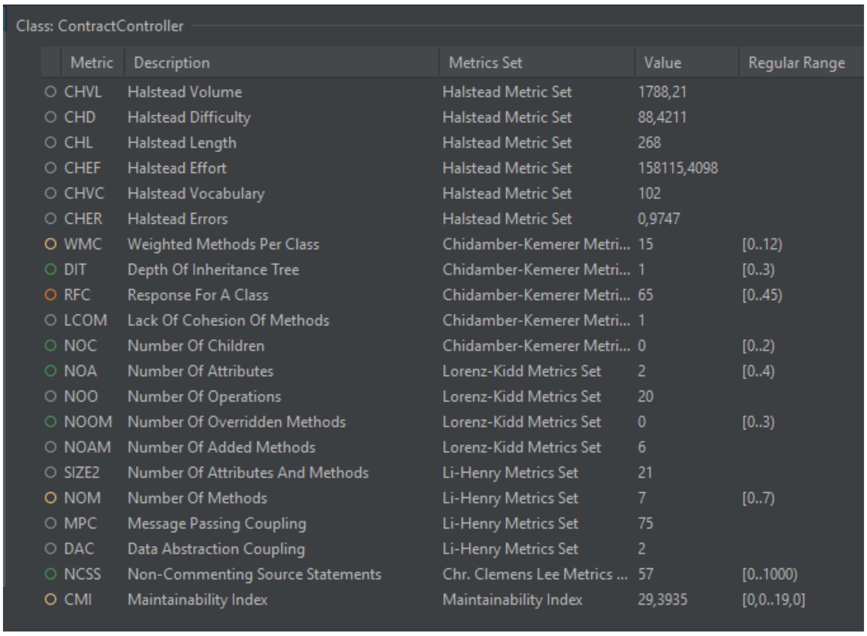
Using this thought process, we have identified 6 classes and 6 methods to improve. Each one has a more detailed explanation of the steps taken below.

Task 2

Class Refactoring

1. ContractController class:

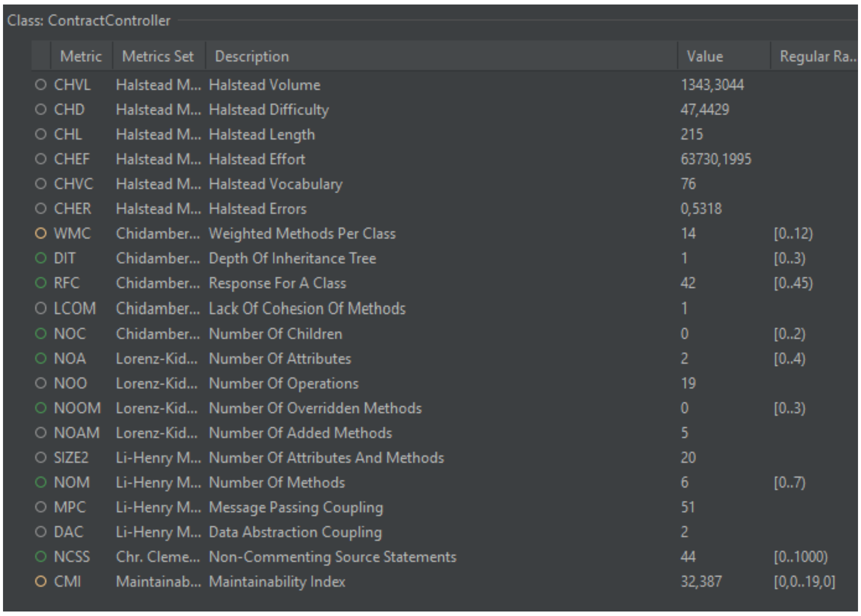
For the ContractController class we improved the Response For A Class metric by creating a proper toString method for the contract class instead of using a bunch of calls to getter methods to serialize contract data.
Before:



Class: ContractController

	Metric	Description	Metrics Set	Value	Regular Range
○	CHVL	Halstead Volume	Halstead Metric Set	1788,21	
○	CHD	Halstead Difficulty	Halstead Metric Set	88,4211	
○	CHL	Halstead Length	Halstead Metric Set	268	
○	CHEF	Halstead Effort	Halstead Metric Set	158115,4098	
○	CHVC	Halstead Vocabulary	Halstead Metric Set	102	
○	CHER	Halstead Errors	Halstead Metric Set	0,9747	
○	WMC	Weighted Methods Per Class	Chidamber-Kemerer Metri...	15	[0..12)
○	DIT	Depth Of Inheritance Tree	Chidamber-Kemerer Metri...	1	[0..3)
○	RFC	Response For A Class	Chidamber-Kemerer Metri...	65	[0..45)
○	LCOM	Lack Of Cohesion Of Methods	Chidamber-Kemerer Metri...	1	
○	NOC	Number Of Children	Chidamber-Kemerer Metri...	0	[0..2)
○	NOA	Number Of Attributes	Lorenz-Kidd Metrics Set	2	[0..4)
○	NOO	Number Of Operations	Lorenz-Kidd Metrics Set	20	
○	NOOM	Number Of Overridden Methods	Lorenz-Kidd Metrics Set	0	[0..3)
○	NOAM	Number Of Added Methods	Lorenz-Kidd Metrics Set	6	
○	SIZE2	Number Of Attributes And Methods	Li-Henry Metrics Set	21	
○	NOM	Number Of Methods	Li-Henry Metrics Set	7	[0..7)
○	MPC	Message Passing Coupling	Li-Henry Metrics Set	75	
○	DAC	Data Abstraction Coupling	Li-Henry Metrics Set	2	
○	NCSS	Non-Commenting Source Statements	Chr. Clemens Lee Metrics ...	57	[0..1000)
○	CMI	Maintainability Index	Maintainability Index	29,3935	[0,0..19,0]

After:



Class: ContractController

	Metric	Metrics Set	Description	Value	Regular Ra...
○	CHVL	Halstead M...	Halstead Volume	1343,3044	
○	CHD	Halstead M...	Halstead Difficulty	47,4429	
○	CHL	Halstead M...	Halstead Length	215	
○	CHEF	Halstead M...	Halstead Effort	63730,1995	
○	CHVC	Halstead M...	Halstead Vocabulary	76	
○	CHER	Halstead M...	Halstead Errors	0,5318	
○	WMC	Chidamber...	Weighted Methods Per Class	14	[0..12)
○	DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber...	Response For A Class	42	[0..45)
○	LCOM	Chidamber...	Lack Of Cohesion Of Methods	1	
○	NOC	Chidamber...	Number Of Children	0	[0..2)
○	NOA	Lorenz-Kid...	Number Of Attributes	2	[0..4)
○	NOO	Lorenz-Kid...	Number Of Operations	19	
○	NOOM	Lorenz-Kid...	Number Of Overridden Methods	0	[0..3)
○	NOAM	Lorenz-Kid...	Number Of Added Methods	5	
○	SIZE2	Li-Henry M...	Number Of Attributes And Methods	20	
○	NOM	Li-Henry M...	Number Of Methods	6	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	51	
○	DAC	Li-Henry M...	Data Abstraction Coupling	2	
○	NCSS	Chr. Cleme...	Non-Commenting Source Statements	44	[0..1000)
○	CMI	Maintainab...	Maintainability Index	32,387	[0,0..19,0]

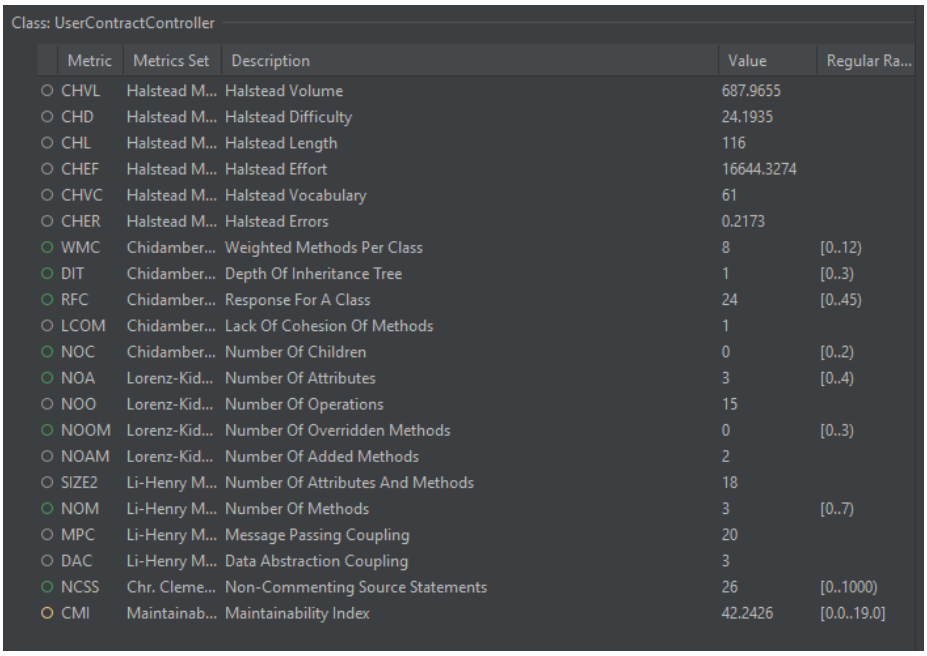
Improved metric: RFC (65 -> 42)

2. UserContractController class

The UserContractController class is the one that could be improved the most. For this we will apply the **Move Method refactoring** technique, to reduce the coupling between classes. To be specific, a new class RequestForwarder was created, which now implements two methods that were previously part of the UserContractController. Now forwarding to the Request microservice is only done in RequestForwarder, lowering the coupling of the classes.

Class-level metrics for the UserContractController:

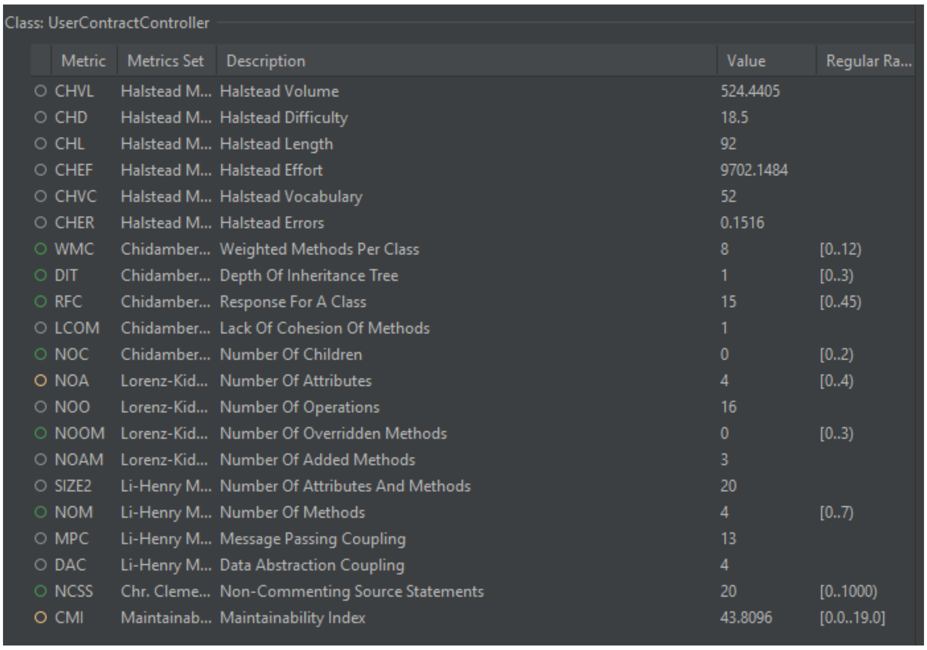
Before:



Class: UserContractController

Metric	Metrics Set	Description	Value	Regular Ra...
○ CHVL	Halstead M...	Halstead Volume	687.9655	
○ CHD	Halstead M...	Halstead Difficulty	24.1935	
○ CHL	Halstead M...	Halstead Length	116	
○ CHEF	Halstead M...	Halstead Effort	16644.3274	
○ CHVC	Halstead M...	Halstead Vocabulary	61	
○ CHER	Halstead M...	Halstead Errors	0.2173	
○ WMC	Chidamber...	Weighted Methods Per Class	8	[0..12)
○ DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○ RFC	Chidamber...	Response For A Class	24	[0..45)
○ LCOM	Chidamber...	Lack Of Cohesion Of Methods	1	
○ NOC	Chidamber...	Number Of Children	0	[0..2)
○ NOA	Lorenz-Kid...	Number Of Attributes	3	[0..4)
○ NOO	Lorenz-Kid...	Number Of Operations	15	
○ NOOM	Lorenz-Kid...	Number Of Overridden Methods	0	[0..3)
○ NOAM	Lorenz-Kid...	Number Of Added Methods	2	
○ SIZE2	Li-Henry M...	Number Of Attributes And Methods	18	
○ NOM	Li-Henry M...	Number Of Methods	3	[0..7)
○ MPC	Li-Henry M...	Message Passing Coupling	20	
○ DAC	Li-Henry M...	Data Abstraction Coupling	3	
○ NCSS	Chr. Cleme...	Non-Commenting Source Statements	26	[0..1000)
○ CMI	Maintainab...	Maintainability Index	42.2426	[0.0..19.0]

After:



Class: UserContractController

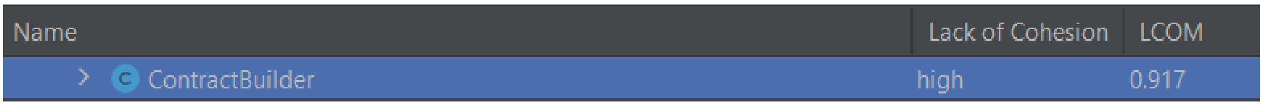
Metric	Metrics Set	Description	Value	Regular Ra...
○ CHVL	Halstead M...	Halstead Volume	524.4405	
○ CHD	Halstead M...	Halstead Difficulty	18.5	
○ CHL	Halstead M...	Halstead Length	92	
○ CHEF	Halstead M...	Halstead Effort	9702.1484	
○ CHVC	Halstead M...	Halstead Vocabulary	52	
○ CHER	Halstead M...	Halstead Errors	0.1516	
○ WMC	Chidamber...	Weighted Methods Per Class	8	[0..12)
○ DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○ RFC	Chidamber...	Response For A Class	15	[0..45)
○ LCOM	Chidamber...	Lack Of Cohesion Of Methods	1	
○ NOC	Chidamber...	Number Of Children	0	[0..2)
○ NOA	Lorenz-Kid...	Number Of Attributes	4	[0..4)
○ NOO	Lorenz-Kid...	Number Of Operations	16	
○ NOOM	Lorenz-Kid...	Number Of Overridden Methods	0	[0..3)
○ NOAM	Lorenz-Kid...	Number Of Added Methods	3	
○ SIZE2	Li-Henry M...	Number Of Attributes And Methods	20	
○ NOM	Li-Henry M...	Number Of Methods	4	[0..7)
○ MPC	Li-Henry M...	Message Passing Coupling	13	
○ DAC	Li-Henry M...	Data Abstraction Coupling	4	
○ NCSS	Chr. Cleme...	Non-Commenting Source Statements	20	[0..1000)
○ CMI	Maintainab...	Maintainability Index	43.8096	[0.0..19.0]

Improved: MPC (20 -> 13), RFC (24 -> 15)

3. ContractBuilder class

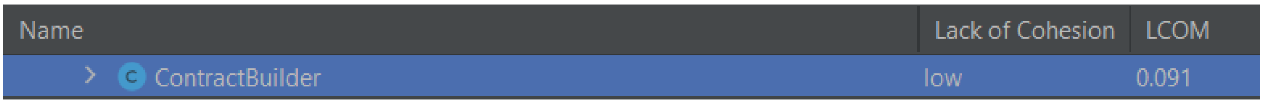
The ContractBuilder class uses the Builder design pattern to allow for future scalability, flexibility and modularity. Since there may be a need for many different types of contracts, e.g. for internships, part-time and full-time jobs, the Builder pattern is a great fit. The methods in this class all referenced a single field of the class, leading to a Lack of Cohesion Of Methods metric with a value of almost 1. To improve this, the class was rewritten so that all the necessary changes to the class' fields are done in a single method (instead of one method per field change). The new Lack of Cohesion Of Methods metric has a value of 0.091, which is considered low/negligible.

Before:



Name	Lack of Cohesion	LCOM
ContractBuilder	high	0.917

After:

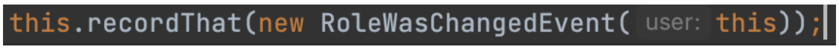


Name	Lack of Cohesion	LCOM
ContractBuilder	low	0.091

Improved: LCOM (0.917 -> 0.091)

4. AppUser class

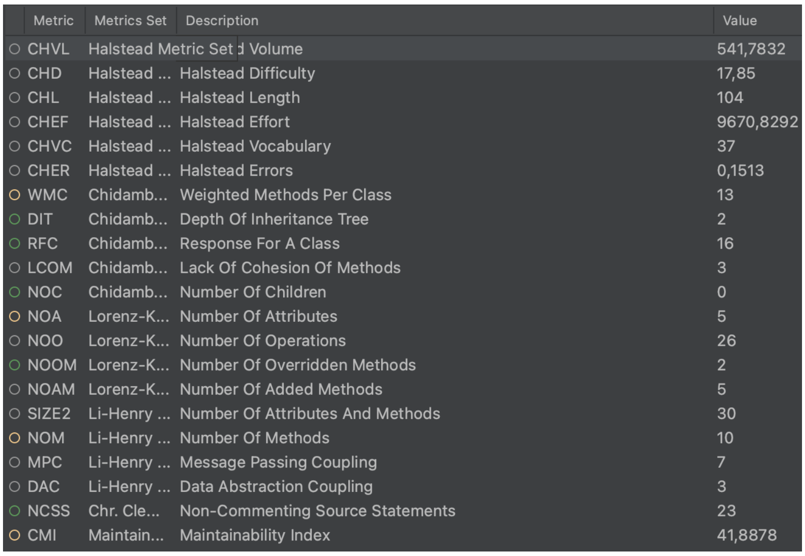
When going through this class we saw that the metrics looked good but could have been improved. There were many metrics that could have been improved by removing some unused code. The metrics that would improve are the MPC, RFC, DIT, NOA, and NOO In particular the line below.



```
this.recordThat(new RoleWasChangedEvent( user: this));
```

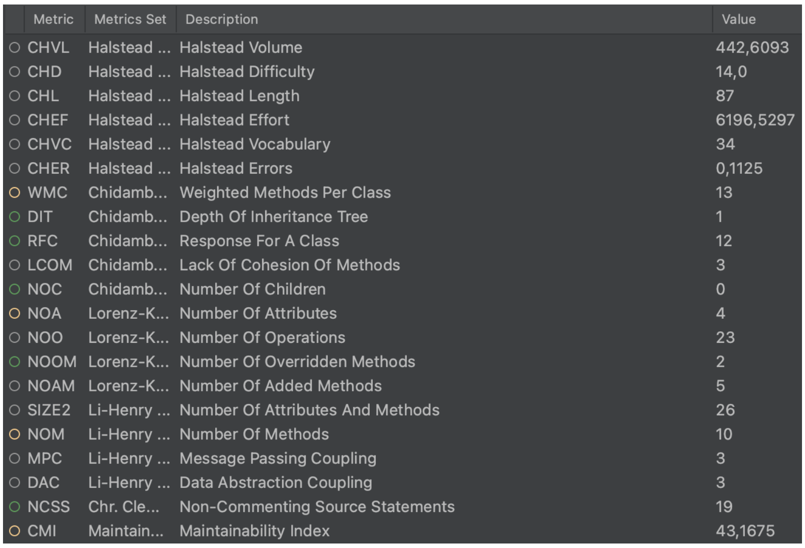
Since this line of code was not used in the application it was easily removed. Due to this line we also needed to create an inheritance tree with another class HasEvents. Since this class was not used we can also remove it from the application. Therefore, in order to decrease the metric stated above we removed the lines of unused code. This resulted in the changes seen below.

Before:



Metric	Metrics Set	Description	Value
○ CHVL	Halstead Metric Set	d Volume	541,7832
○ CHD	Halstead ...	Halstead Difficulty	17,85
○ CHL	Halstead ...	Halstead Length	104
○ CHEF	Halstead ...	Halstead Effort	9670,8292
○ CHVC	Halstead ...	Halstead Vocabulary	37
○ CHER	Halstead ...	Halstead Errors	0,1513
○ WMC	Chidamb...	Weighted Methods Per Class	13
○ DIT	Chidamb...	Depth Of Inheritance Tree	2
○ RFC	Chidamb...	Response For A Class	16
○ LCOM	Chidamb...	Lack Of Cohesion Of Methods	3
○ NOC	Chidamb...	Number Of Children	0
○ NOA	Lorenz-K...	Number Of Attributes	5
○ NOO	Lorenz-K...	Number Of Operations	26
○ NOOM	Lorenz-K...	Number Of Overridden Methods	2
○ NOAM	Lorenz-K...	Number Of Added Methods	5
○ SIZE2	Li-Henry ...	Number Of Attributes And Methods	30
○ NOM	Li-Henry ...	Number Of Methods	10
○ MPC	Li-Henry ...	Message Passing Coupling	7
○ DAC	Li-Henry ...	Data Abstraction Coupling	3
○ NCSS	Chr. Cle...	Non-Commenting Source Statements	23
○ CMI	Maintain...	Maintainability Index	41,8878

After:



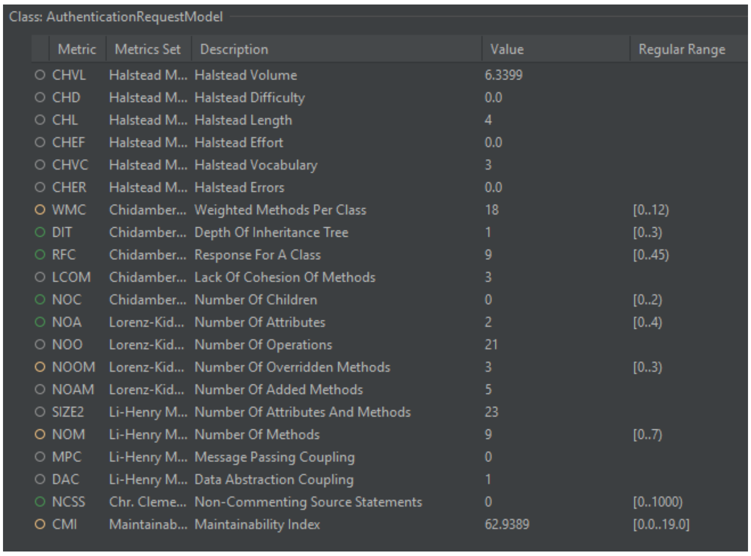
Metric	Metrics Set	Description	Value
○ CHVL	Halstead ...	Halstead Volume	442,6093
○ CHD	Halstead ...	Halstead Difficulty	14,0
○ CHL	Halstead ...	Halstead Length	87
○ CHEF	Halstead ...	Halstead Effort	6196,5297
○ CHVC	Halstead ...	Halstead Vocabulary	34
○ CHER	Halstead ...	Halstead Errors	0,1125
○ WMC	Chidamb...	Weighted Methods Per Class	13
○ DIT	Chidamb...	Depth Of Inheritance Tree	1
○ RFC	Chidamb...	Response For A Class	12
○ LCOM	Chidamb...	Lack Of Cohesion Of Methods	3
○ NOC	Chidamb...	Number Of Children	0
○ NOA	Lorenz-K...	Number Of Attributes	4
○ NOO	Lorenz-K...	Number Of Operations	23
○ NOOM	Lorenz-K...	Number Of Overridden Methods	2
○ NOAM	Lorenz-K...	Number Of Added Methods	5
○ SIZE2	Li-Henry ...	Number Of Attributes And Methods	26
○ NOM	Li-Henry ...	Number Of Methods	10
○ MPC	Li-Henry ...	Message Passing Coupling	3
○ DAC	Li-Henry ...	Data Abstraction Coupling	3
○ NCSS	Chr. Cle...	Non-Commenting Source Statements	19
○ CMI	Maintain...	Maintainability Index	43,1675

Improved: MPC(7 -> 3), RFC(16 -> 12), DIT(2 -> 1), NOA(5 -> 4), NOO(6 ->3)

5. AuthenticationRequestModel class

For the *ContractFindRequestModel* we improved LCOM, *WMC, RFC, and NOM* by selecting more specific lombok annotations which in turn improve the metrics. This could be done to other models to decrease the overall complexity of the project. Most of them use only *@Data* which contains all lombok generated boilerplate code. By picking and choosing every annotation specific to the use case we can make them even more efficient. It is also the same as the *RegistrationRequestModel* class so we can delete it because it is a Lazy Class ([*https://refactoring.guru/smells/lazy-class*](https://refactoring.guru/smells/lazy-class)) and it takes care of Code Duplication and Dead Code.

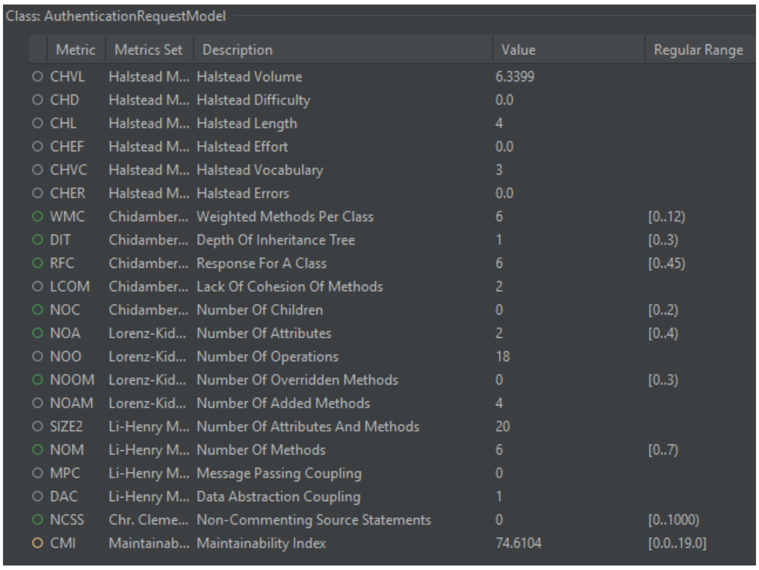
Before:



Class: AuthenticationRequestModel

	Metric	Metrics Set	Description	Value	Regular Range
○	CHVL	Halstead M...	Halstead Volume	6.3399	
○	CHD	Halstead M...	Halstead Difficulty	0.0	
○	CHL	Halstead M...	Halstead Length	4	
○	CHEF	Halstead M...	Halstead Effort	0.0	
○	CHVC	Halstead M...	Halstead Vocabulary	3	
○	CHER	Halstead M...	Halstead Errors	0.0	
○	WMC	Chidamber...	Weighted Methods Per Class	18	[0..12)
○	DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber...	Response For A Class	9	[0..45)
○	LCOM	Chidamber...	Lack Of Cohesion Of Methods	3	
○	NOC	Chidamber...	Number Of Children	0	[0..2)
○	NOA	Lorenz-Kid...	Number Of Attributes	2	[0..4)
○	NOO	Lorenz-Kid...	Number Of Operations	21	
○	NOOM	Lorenz-Kid...	Number Of Overridden Methods	3	[0..3)
○	NOAM	Lorenz-Kid...	Number Of Added Methods	5	
○	SIZE2	Li-Henry M...	Number Of Attributes And Methods	23	
○	NOM	Li-Henry M...	Number Of Methods	9	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	0	
○	DAC	Li-Henry M...	Data Abstraction Coupling	1	
○	NCSS	Chr. Cleme...	Non-Commenting Source Statements	0	[0..1000)
○	CMI	Maintainab...	Maintainability Index	62.9389	[0.0..19.0]

After:



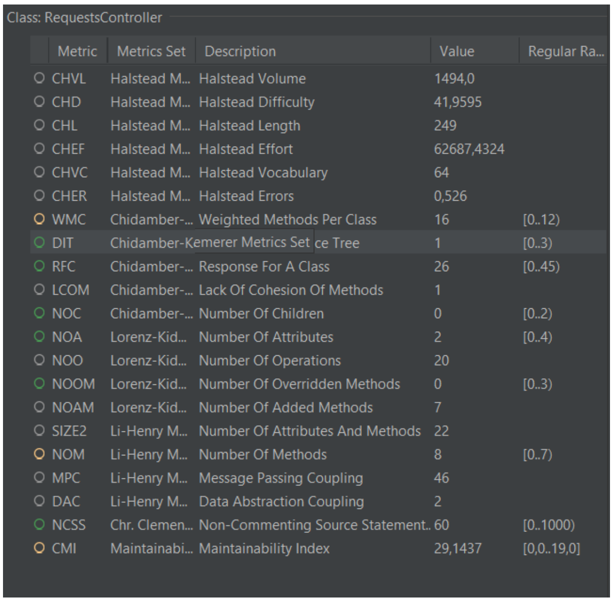
Class: AuthenticationRequestModel

	Metric	Metrics Set	Description	Value	Regular Range
○	CHVL	Halstead M...	Halstead Volume	6.3399	
○	CHD	Halstead M...	Halstead Difficulty	0.0	
○	CHL	Halstead M...	Halstead Length	4	
○	CHEF	Halstead M...	Halstead Effort	0.0	
○	CHVC	Halstead M...	Halstead Vocabulary	3	
○	CHER	Halstead M...	Halstead Errors	0.0	
○	WMC	Chidamber...	Weighted Methods Per Class	6	[0..12)
○	DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber...	Response For A Class	6	[0..45)
○	LCOM	Chidamber...	Lack Of Cohesion Of Methods	2	
○	NOC	Chidamber...	Number Of Children	0	[0..2)
○	NOA	Lorenz-Kid...	Number Of Attributes	2	[0..4)
○	NOO	Lorenz-Kid...	Number Of Operations	18	
○	NOOM	Lorenz-Kid...	Number Of Overridden Methods	0	[0..3)
○	NOAM	Lorenz-Kid...	Number Of Added Methods	4	
○	SIZE2	Li-Henry M...	Number Of Attributes And Methods	20	
○	NOM	Li-Henry M...	Number Of Methods	6	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	0	
○	DAC	Li-Henry M...	Data Abstraction Coupling	1	
○	NCSS	Chr. Cleme...	Non-Commenting Source Statements	0	[0..1000)
○	CMI	Maintainab...	Maintainability Index	74.6104	[0.0..19.0]

Improved metric: LCOM (3 -> 2), WMC (18 -> 6), RFC (9 -> 6), NOM (9 -> 6)
Removed file: *RegistrationRequestModel*

6. RequestsContoller class

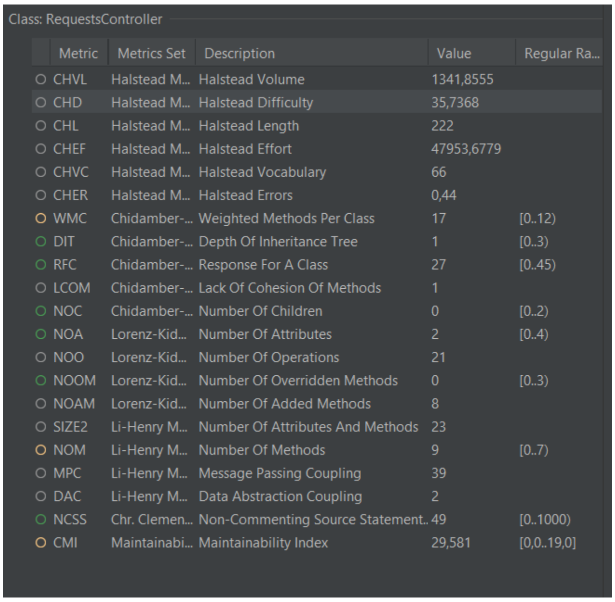
In the RequestsController class we mostly improved NCSS count and the MPC. That means we reduced the amount of actual statements and made the class more independent because it makes less calls to methods from other classes, while keeping the exact same functionality. This was done by removing duplicate code and putting it in the newly created *setHeaders* method. This method was only not used in the *sendNotification* method, because that needed a slightly different header setup and for the sake of simplicity we wanted to keep the amount of parameters in *setHeaders* to a minimal amount.



Class: RequestsController

	Metric	Metrics Set	Description	Value	Regular Ra...
○	CHVL	Halstead M...	Halstead Volume	1494,0	
○	CHD	Halstead M...	Halstead Difficulty	41,9595	
○	CHL	Halstead M...	Halstead Length	249	
○	CHEF	Halstead M...	Halstead Effort	62687,4324	
○	CHVC	Halstead M...	Halstead Vocabulary	64	
○	CHER	Halstead M...	Halstead Errors	0,526	
○	WMC	Chidamber-...	Weighted Methods Per Class	16	[0..12)
○	DIT	Chidamber-Kemerer Metrics Set	ce Tree	1	[0..3)
○	RFC	Chidamber-...	Response For A Class	26	[0..45)
○	LCOM	Chidamber-...	Lack Of Cohesion Of Methods	1	
○	NOC	Chidamber-...	Number Of Children	0	[0..2)
○	NOA	Lorenz-Kid...	Number Of Attributes	2	[0..4)
○	NOO	Lorenz-Kid...	Number Of Operations	20	
○	NOOM	Lorenz-Kid...	Number Of Overridden Methods	0	[0..3)
○	NOAM	Lorenz-Kid...	Number Of Added Methods	7	
○	SIZE2	Li-Henry M...	Number Of Attributes And Methods	22	
○	NOM	Li-Henry M...	Number Of Methods	8	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	46	
○	DAC	Li-Henry M...	Data Abstraction Coupling	2	
○	NCSS	Chr. Clemen...	Non-Commenting Source Statement..	60	[0..1000)
○	CMI	Maintainabi...	Maintainability Index	29,1437	[0,0..19,0]

Before



Class: RequestsController

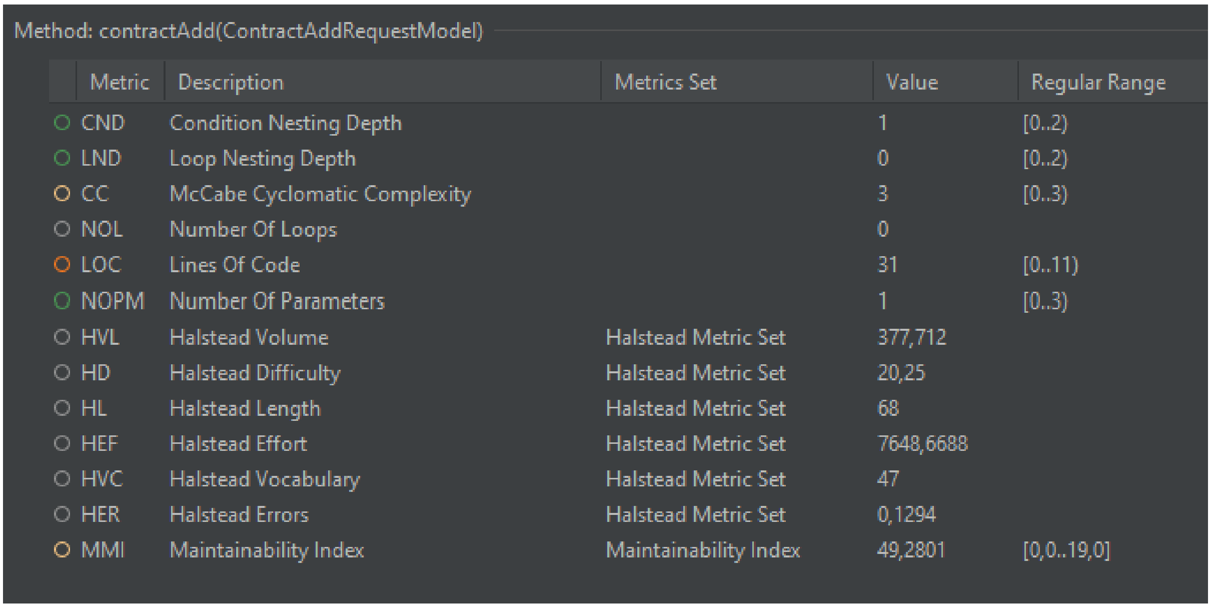
	Metric	Metrics Set	Description	Value	Regular Ra...
○	CHVL	Halstead M...	Halstead Volume	1341,8555	
○	CHD	Halstead M...	Halstead Difficulty	35,7368	
○	CHL	Halstead M...	Halstead Length	222	
○	CHEF	Halstead M...	Halstead Effort	47953,6779	
○	CHVC	Halstead M...	Halstead Vocabulary	66	
○	CHER	Halstead M...	Halstead Errors	0,44	
○	WMC	Chidamber-...	Weighted Methods Per Class	17	[0..12)
○	DIT	Chidamber-...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber-...	Response For A Class	27	[0..45)
○	LCOM	Chidamber-...	Lack Of Cohesion Of Methods	1	
○	NOC	Chidamber-...	Number Of Children	0	[0..2)
○	NOA	Lorenz-Kid...	Number Of Attributes	2	[0..4)
○	NOO	Lorenz-Kid...	Number Of Operations	21	
○	NOOM	Lorenz-Kid...	Number Of Overridden Methods	0	[0..3)
○	NOAM	Lorenz-Kid...	Number Of Added Methods	8	
○	SIZE2	Li-Henry M...	Number Of Attributes And Methods	23	
○	NOM	Li-Henry M...	Number Of Methods	9	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	39	
○	DAC	Li-Henry M...	Data Abstraction Coupling	2	
○	NCSS	Chr. Clemen...	Non-Commenting Source Statement..	49	[0..1000)
○	CMI	Maintainabi...	Maintainability Index	29,581	[0,0..19,0]

After

Method Refactoring

1. contractAdd()

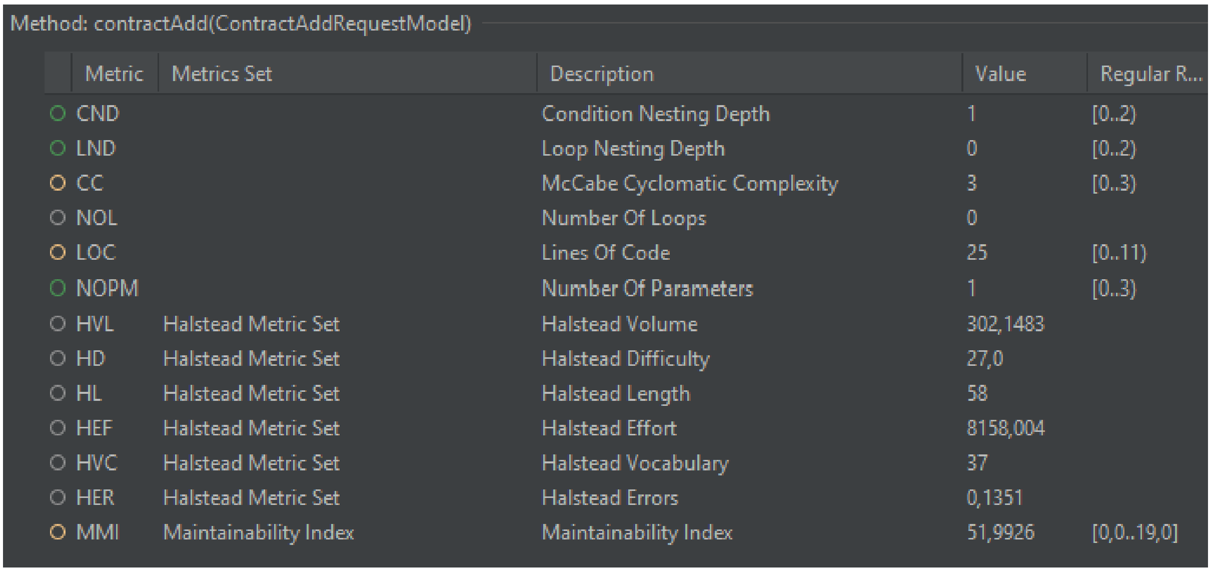
For the ContractAdd method we improved the Lines Of Code metric by removing the lines that instantiate the values for variables and instead put the values directly into the method where it gets used.
Before:



Method: contractAdd(ContractAddRequestModel)

Metric	Description	Metrics Set	Value	Regular Range
○ CND	Condition Nesting Depth		1	[0..2)
○ LND	Loop Nesting Depth		0	[0..2)
○ CC	McCabe Cyclomatic Complexity		3	[0..3)
○ NOL	Number Of Loops		0	
○ LOC	Lines Of Code		31	[0..11)
○ NOPM	Number Of Parameters		1	[0..3)
○ HVL	Halstead Volume	Halstead Metric Set	377,712	
○ HD	Halstead Difficulty	Halstead Metric Set	20,25	
○ HL	Halstead Length	Halstead Metric Set	68	
○ HEF	Halstead Effort	Halstead Metric Set	7648,6688	
○ HVC	Halstead Vocabulary	Halstead Metric Set	47	
○ HER	Halstead Errors	Halstead Metric Set	0,1294	
○ MMI	Maintainability Index	Maintainability Index	49,2801	[0,0..19,0]

After:



Method: contractAdd(ContractAddRequestModel)

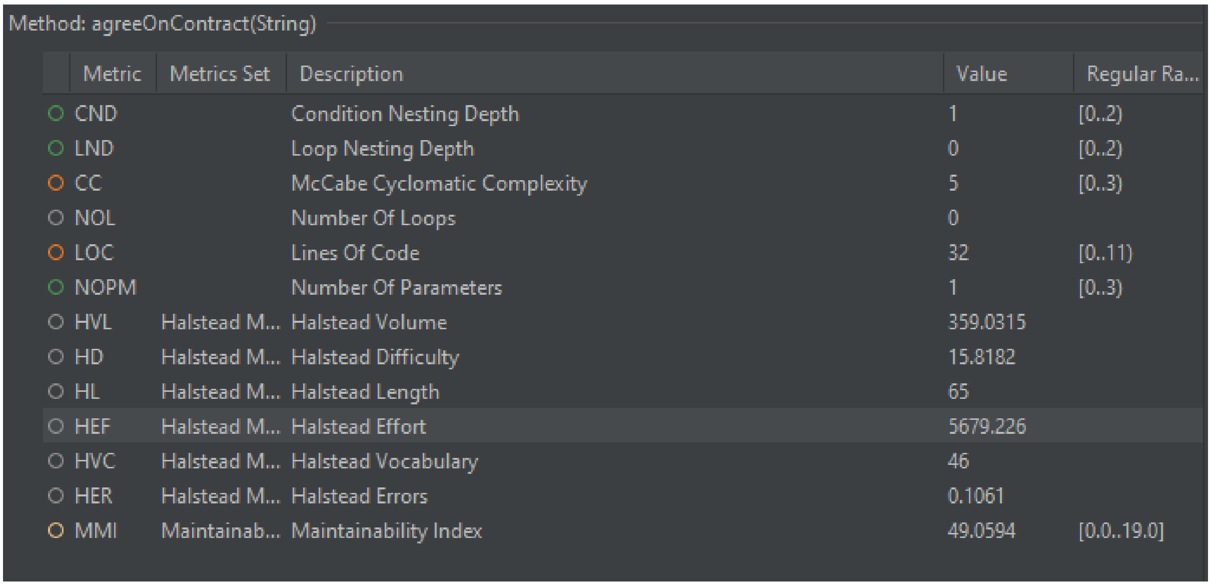
Metric	Metrics Set	Description	Value	Regular R...
○ CND		Condition Nesting Depth	1	[0..2)
○ LND		Loop Nesting Depth	0	[0..2)
○ CC		McCabe Cyclomatic Complexity	3	[0..3)
○ NOL		Number Of Loops	0	
○ LOC		Lines Of Code	25	[0..11)
○ NOPM		Number Of Parameters	1	[0..3)
○ HVL	Halstead Metric Set	Halstead Volume	302,1483	
○ HD	Halstead Metric Set	Halstead Difficulty	27,0	
○ HL	Halstead Metric Set	Halstead Length	58	
○ HEF	Halstead Metric Set	Halstead Effort	8158,004	
○ HVC	Halstead Metric Set	Halstead Vocabulary	37	
○ HER	Halstead Metric Set	Halstead Errors	0,1351	
○ MMI	Maintainability Index	Maintainability Index	51,9926	[0,0..19,0]

Improved metric: LOC (31 -> 25)

2. agreeOnContract()

To improve the maintainability and understandability of this method, we will implement the **Extract Method refactoring** technique. This involves breaking down the agreeOnContract() method into smaller, more focused methods that handle specific tasks, thus reducing the overall lines of code in the method. Additionally, we will also move code that can be grouped together to other methods. With this refactoring, we aim to improve the readability, ease of maintenance and scalability of our codebase. To be more specific, a new method getCandidateName was created, which takes the netId of the user and returns the full name of the candidate. Furthermore, the forwarding of the request was also split into another method.

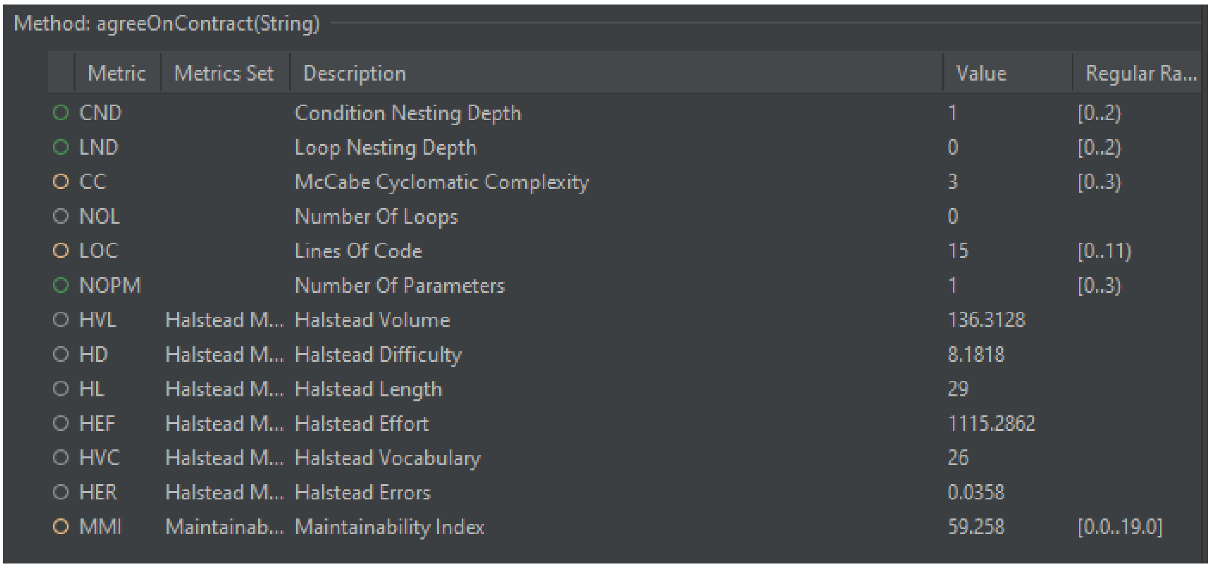
Before:



Method: agreeOnContract(String)

Metric	Metrics Set	Description	Value	Regular Ra...
○ CND		Condition Nesting Depth	1	[0..2)
○ LND		Loop Nesting Depth	0	[0..2)
○ CC		McCabe Cyclomatic Complexity	5	[0..3)
○ NOL		Number Of Loops	0	
○ LOC		Lines Of Code	32	[0..11)
○ NOPM		Number Of Parameters	1	[0..3)
○ HVL	Halstead M...	Halstead Volume	359.0315	
○ HD	Halstead M...	Halstead Difficulty	15.8182	
○ HL	Halstead M...	Halstead Length	65	
○ HEF	Halstead M...	Halstead Effort	5679.226	
○ HVC	Halstead M...	Halstead Vocabulary	46	
○ HER	Halstead M...	Halstead Errors	0.1061	
○ MMI	Maintainab...	Maintainability Index	49.0594	[0.0..19.0]

After:



Method: agreeOnContract(String)

Metric	Metrics Set	Description	Value	Regular Ra...
○ CND		Condition Nesting Depth	1	[0..2)
○ LND		Loop Nesting Depth	0	[0..2)
○ CC		McCabe Cyclomatic Complexity	3	[0..3)
○ NOL		Number Of Loops	0	
○ LOC		Lines Of Code	15	[0..11)
○ NOPM		Number Of Parameters	1	[0..3)
○ HVL	Halstead M...	Halstead Volume	136.3128	
○ HD	Halstead M...	Halstead Difficulty	8.1818	
○ HL	Halstead M...	Halstead Length	29	
○ HEF	Halstead M...	Halstead Effort	1115.2862	
○ HVC	Halstead M...	Halstead Vocabulary	26	
○ HER	Halstead M...	Halstead Errors	0.0358	
○ MMI	Maintainab...	Maintainability Index	59.258	[0.0..19.0]

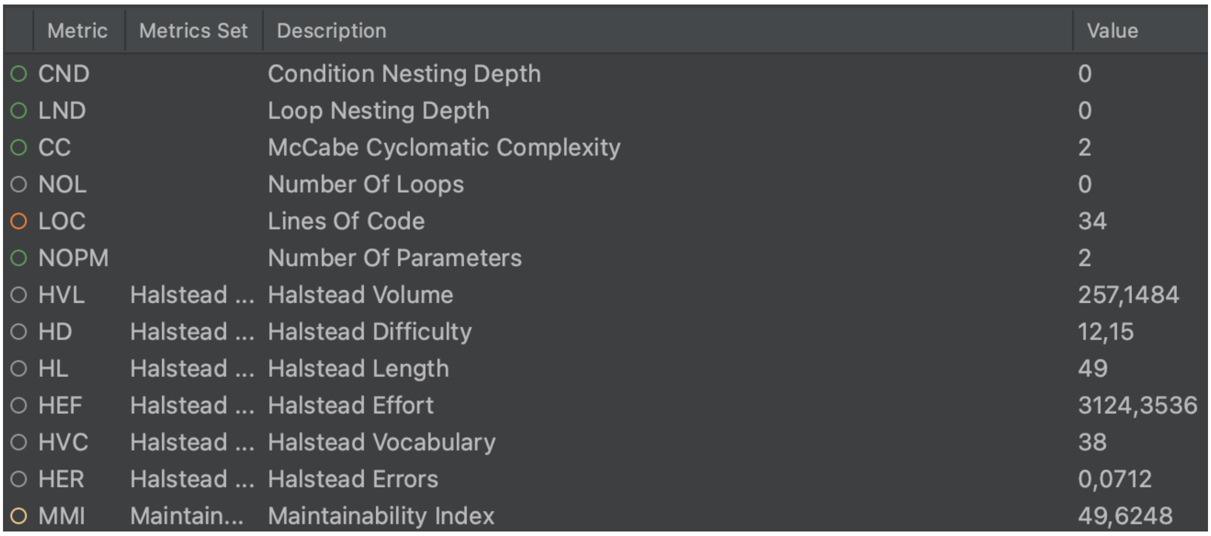
Improved: LOC (32 -> 15) and CC (5 -> 3)

3. registerCandidate()

The method that I will be refactoring is called registerCandidate() from the CandidateRegistrationController class. As seen in the figure below the LOC metric for this method is 34, which is significantly more than the desired value. The goal for this is to decrease the length of the code to 11 lines.

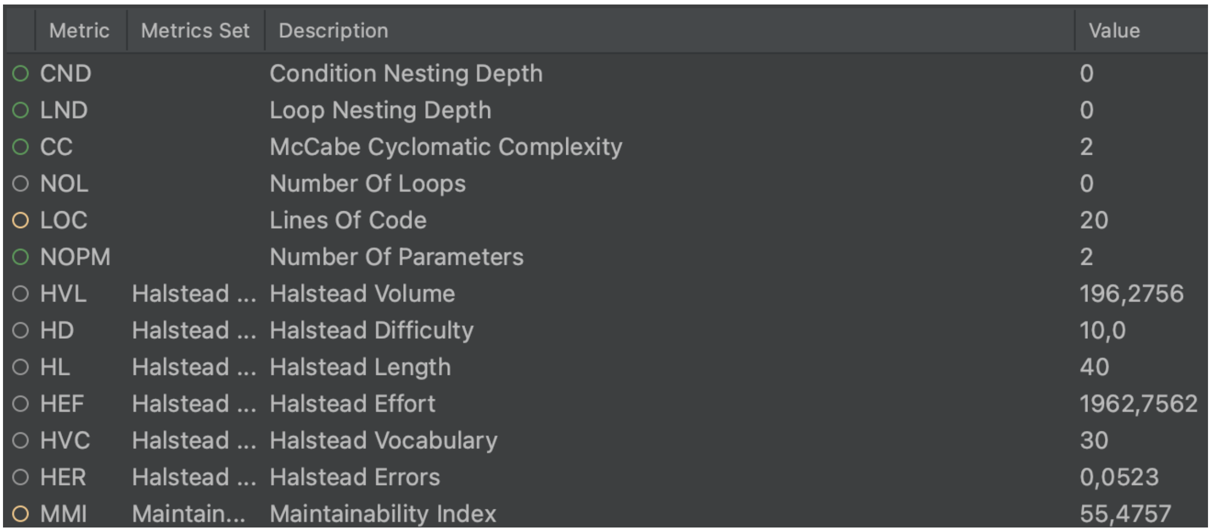
Below are the results of the refactoring. The lowest that the LOC metric could go was up to 20 lines. I managed to decrease the LOC by using extract method refactoring. I am creating new methods such as createHttpEntity() to decrease the LOC by 4. I also created another method called getNamesAndAddress() to decrease the LOC by 3. Furthermore, there were other syntax changes that I made. As seen below the final LOC value was 20, unfortunately it wasn't possible to get the LOC to 11 this is because even after using extract method refactoring this was as low as the LOC could go.

Before:



	Metric	Metrics Set	Description	Value
○	CND		Condition Nesting Depth	0
○	LND		Loop Nesting Depth	0
○	CC		McCabe Cyclomatic Complexity	2
○	NOL		Number Of Loops	0
○	LOC		Lines Of Code	34
○	NOPM		Number Of Parameters	2
○	HVL	Halstead ...	Halstead Volume	257,1484
○	HD	Halstead ...	Halstead Difficulty	12,15
○	HL	Halstead ...	Halstead Length	49
○	HEF	Halstead ...	Halstead Effort	3124,3536
○	HVC	Halstead ...	Halstead Vocabulary	38
○	HER	Halstead ...	Halstead Errors	0,0712
○	MMI	Maintain...	Maintainability Index	49,6248

After:



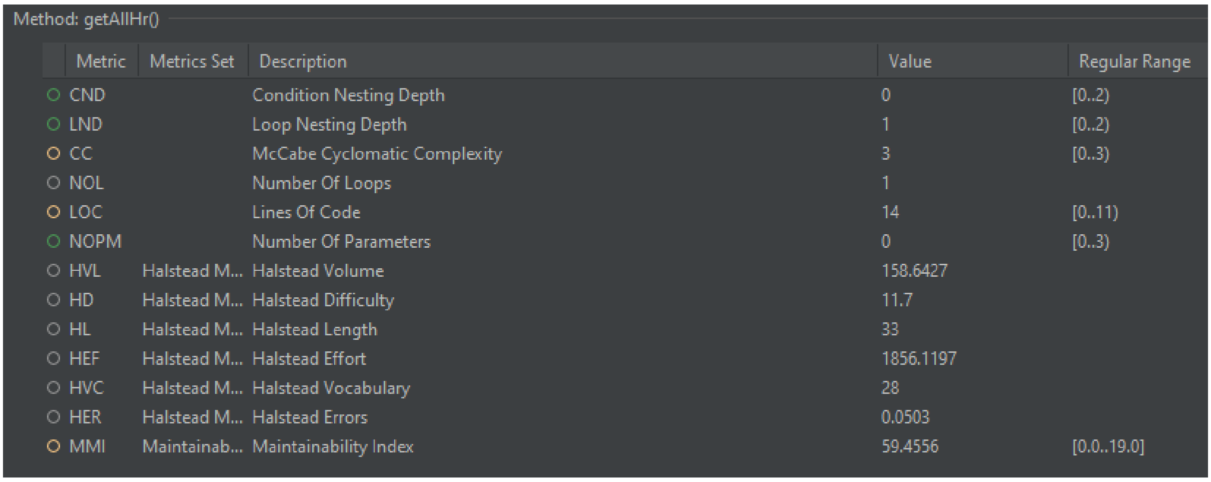
	Metric	Metrics Set	Description	Value
○	CND		Condition Nesting Depth	0
○	LND		Loop Nesting Depth	0
○	CC		McCabe Cyclomatic Complexity	2
○	NOL		Number Of Loops	0
○	LOC		Lines Of Code	20
○	NOPM		Number Of Parameters	2
○	HVL	Halstead ...	Halstead Volume	196,2756
○	HD	Halstead ...	Halstead Difficulty	10,0
○	HL	Halstead ...	Halstead Length	40
○	HEF	Halstead ...	Halstead Effort	1962,7562
○	HVC	Halstead ...	Halstead Vocabulary	30
○	HER	Halstead ...	Halstead Errors	0,0523
○	MMI	Maintain...	Maintainability Index	55,4757

Improved LOC (34 -> 20)

4. getAllHr()

For the *getAllHr()* method we improved the LOC and the CC metric by using the **Extract Method** for the statements using the user repository. We could extract that inside the Registration Service class because it also has the User Repository class already included and we can get rid of some unclear lines of code problems and also a point of cyclomatic complexity.

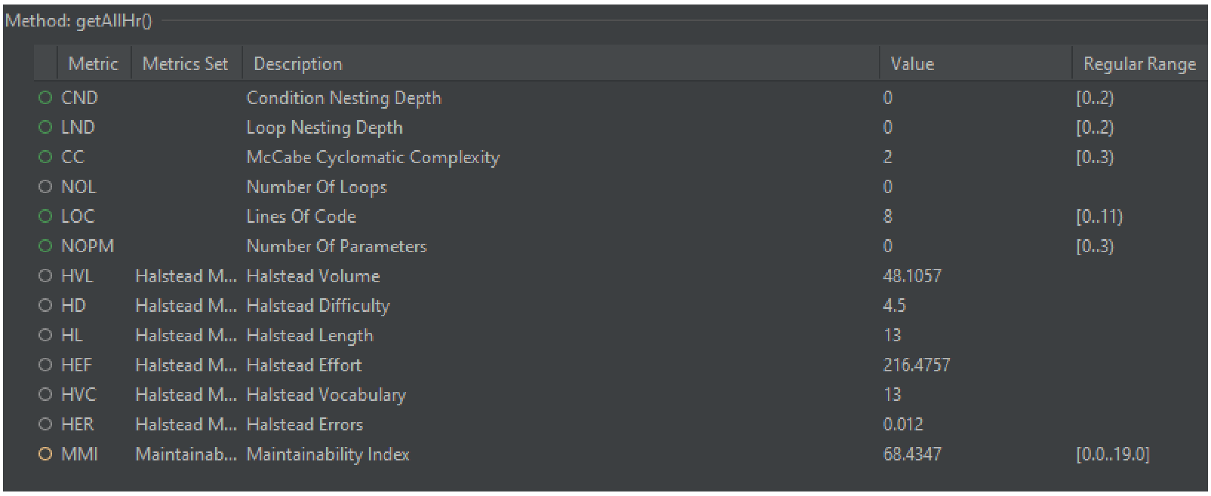
Before:



Method: getAllHr()

Metric	Metrics Set	Description	Value	Regular Range
○ CND		Condition Nesting Depth	0	[0..2)
○ LND		Loop Nesting Depth	1	[0..2)
○ CC		McCabe Cyclomatic Complexity	3	[0..3)
○ NOL		Number Of Loops	1	
○ LOC		Lines Of Code	14	[0..11)
○ NOPM		Number Of Parameters	0	[0..3)
○ HVL	Halstead M...	Halstead Volume	158.6427	
○ HD	Halstead M...	Halstead Difficulty	11.7	
○ HL	Halstead M...	Halstead Length	33	
○ HEF	Halstead M...	Halstead Effort	1856.1197	
○ HVC	Halstead M...	Halstead Vocabulary	28	
○ HER	Halstead M...	Halstead Errors	0.0503	
○ MMI	Maintainab...	Maintainability Index	59.4556	[0.0..19.0]

After:



Method: getAllHr()

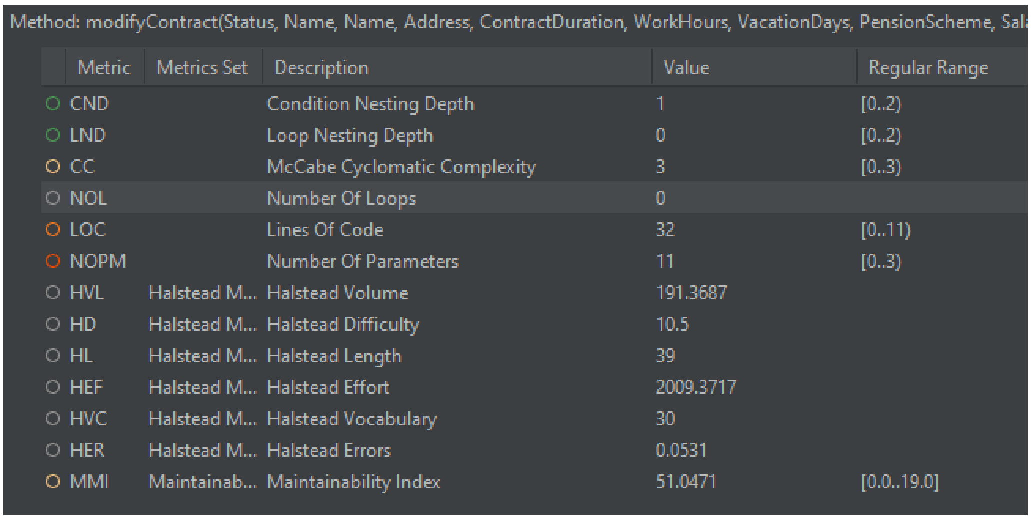
Metric	Metrics Set	Description	Value	Regular Range
○ CND		Condition Nesting Depth	0	[0..2)
○ LND		Loop Nesting Depth	0	[0..2)
○ CC		McCabe Cyclomatic Complexity	2	[0..3)
○ NOL		Number Of Loops	0	
○ LOC		Lines Of Code	8	[0..11)
○ NOPM		Number Of Parameters	0	[0..3)
○ HVL	Halstead M...	Halstead Volume	48.1057	
○ HD	Halstead M...	Halstead Difficulty	4.5	
○ HL	Halstead M...	Halstead Length	13	
○ HEF	Halstead M...	Halstead Effort	216.4757	
○ HVC	Halstead M...	Halstead Vocabulary	13	
○ HER	Halstead M...	Halstead Errors	0.012	
○ MMI	Maintainab...	Maintainability Index	68.4347	[0.0..19.0]

Improved metric: LOC (14 -> 8), CC (3 -> 2)

5. modifyContract()

A big issue with the modifyContract is that it had each parameter of the contract in the parameters list of the method. This made our code really hard to read and understand. It made it confusing. So in this case we refactored the parameters in a new Contract class to pass over instead via **Introduce Parameter Object**. This makes our Code smaller and easier to understand while reducing the metrics.

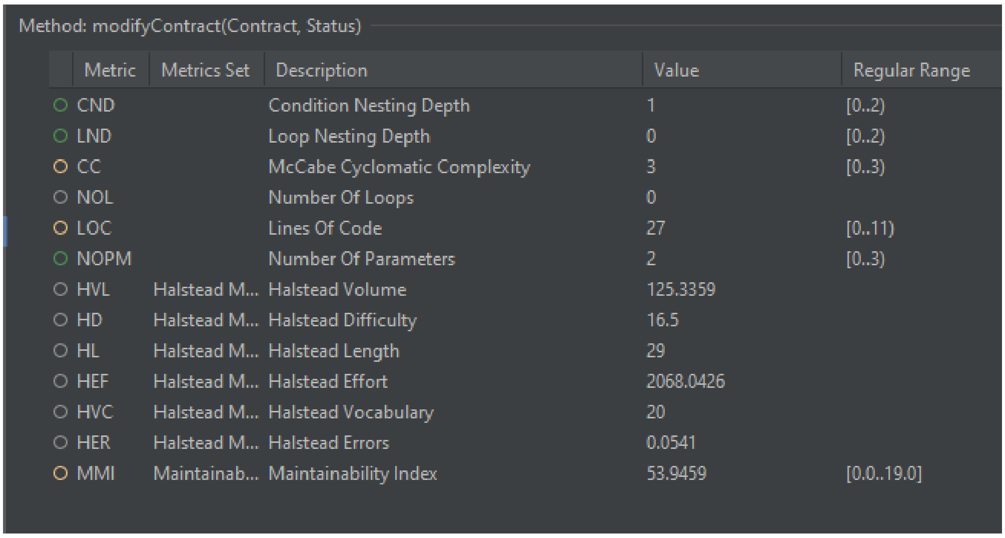
Before:



Method: modifyContract(Status, Name, Name, Address, ContractDuration, WorkHours, VacationDays, PensionScheme, Sal

Metric	Metrics Set	Description	Value	Regular Range
○ CND		Condition Nesting Depth	1	[0..2)
○ LND		Loop Nesting Depth	0	[0..2)
○ CC		McCabe Cyclomatic Complexity	3	[0..3)
○ NOL		Number Of Loops	0	
○ LOC		Lines Of Code	32	[0..11)
○ NOPM		Number Of Parameters	11	[0..3)
○ HVL	Halstead M...	Halstead Volume	191.3687	
○ HD	Halstead M...	Halstead Difficulty	10.5	
○ HL	Halstead M...	Halstead Length	39	
○ HEF	Halstead M...	Halstead Effort	2009.3717	
○ HVC	Halstead M...	Halstead Vocabulary	30	
○ HER	Halstead M...	Halstead Errors	0.0531	
○ MMI	Maintainab...	Maintainability Index	51.0471	[0.0..19.0]

After:



Method: modifyContract(Contract, Status)

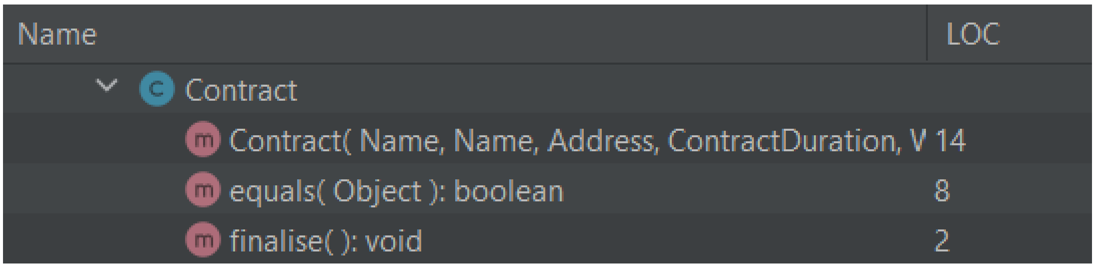
Metric	Metrics Set	Description	Value	Regular Range
○ CND		Condition Nesting Depth	1	[0..2)
○ LND		Loop Nesting Depth	0	[0..2)
○ CC		McCabe Cyclomatic Complexity	3	[0..3)
○ NOL		Number Of Loops	0	
○ LOC		Lines Of Code	27	[0..11)
○ NOPM		Number Of Parameters	2	[0..3)
○ HVL	Halstead M...	Halstead Volume	125.3359	
○ HD	Halstead M...	Halstead Difficulty	16.5	
○ HL	Halstead M...	Halstead Length	29	
○ HEF	Halstead M...	Halstead Effort	2068.0426	
○ HVC	Halstead M...	Halstead Vocabulary	20	
○ HER	Halstead M...	Halstead Errors	0.0541	
○ MMI	Maintainab...	Maintainability Index	53.9459	[0.0..19.0]

Improved: NOPM (11 -> 2), LOC(32 -> 27)

6. Contract class constructor, equals() and finalise()

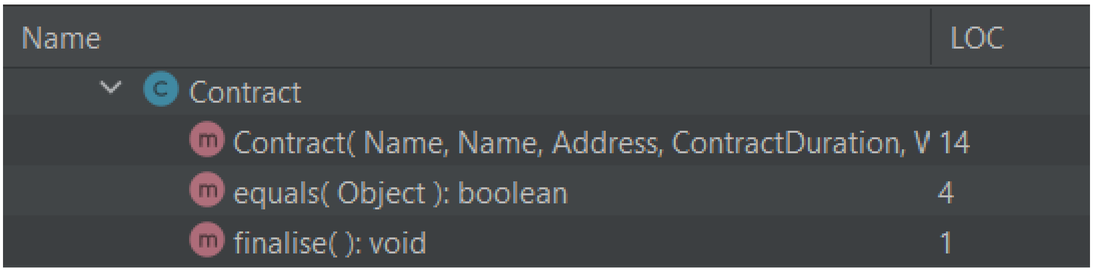
Some methods in the Contract class were written in a complicated way, which lead to many lines of code. To improve this, they were rewritten, e.g. to change the order in which logic checks were performed. Specifically, the refactoring method Consolidate Conditional Expression was used.

Before:



Name	LOC
Contract	
Contract(Name, Name, Address, ContractDuration, V	14
equals(Object): boolean	8
finalise( ): void	2

After:



Name	LOC
Contract	
Contract(Name, Name, Address, ContractDuration, V	14
equals(Object): boolean	4
finalise( ): void	1

Improved: LOC (10 -> 5)