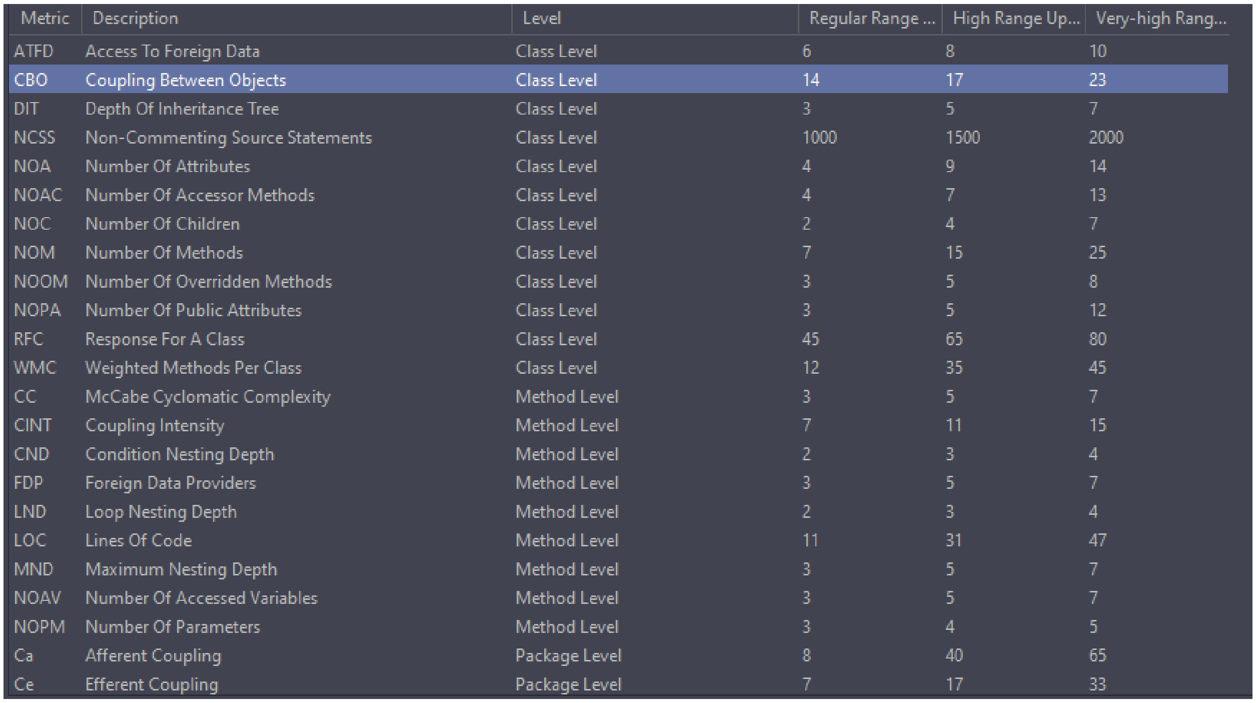
Assignment 2: Refactoring

In order to calculate our code metrics we used the intellij plugin called MetricsTree. We ran the plugin and identified several areas of our project that could be improved.

The metrics provided by MetricsTree are split into two categories:

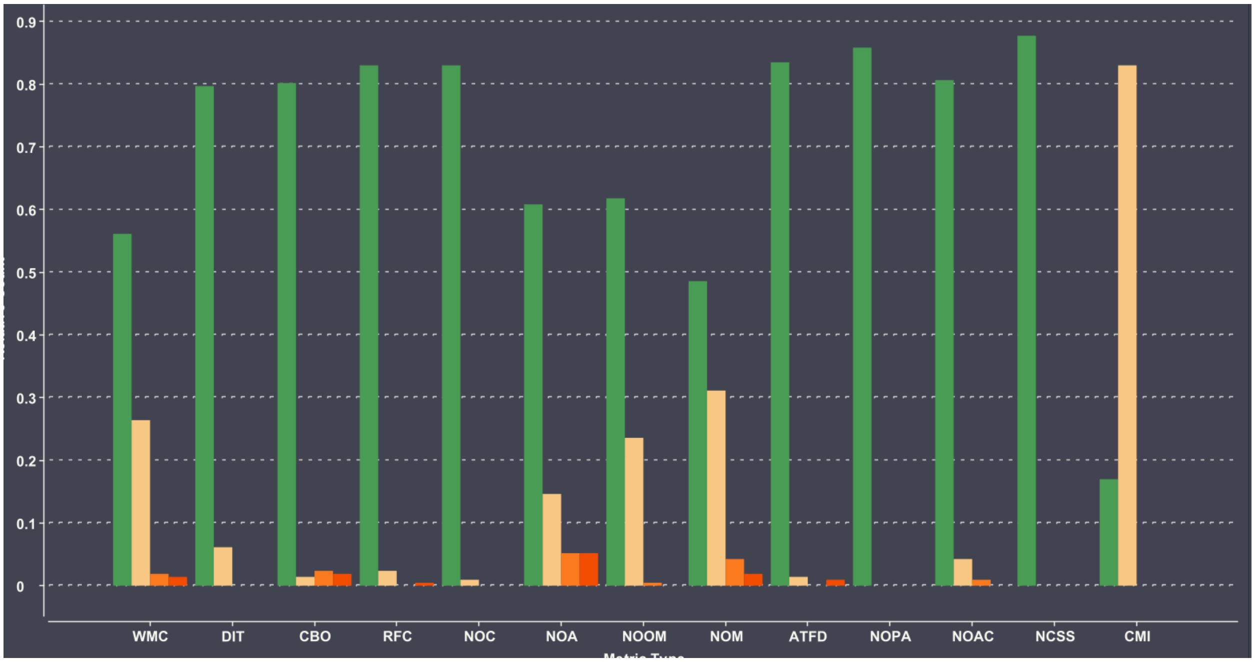
1. Class level metrics
2. Method level metrics

We decided to use the default metric thresholds given by the metricsTree plugin as we find them reasonable and well researched. More exactly the thresholds we decided to go with are the following:



Metric	Description	Level	Regular Range ...	High Range Up...	Very-high Rang...
ATFD	Access To Foreign Data	Class Level	6	8	10
CBO	Coupling Between Objects	Class Level	14	17	23
DIT	Depth Of Inheritance Tree	Class Level	3	5	7
NCSS	Non-Commenting Source Statements	Class Level	1000	1500	2000
NOA	Number Of Attributes	Class Level	4	9	14
NOAC	Number Of Accessor Methods	Class Level	4	7	13
NOC	Number Of Children	Class Level	2	4	7
NOM	Number Of Methods	Class Level	7	15	25
NOOM	Number Of Overridden Methods	Class Level	3	5	8
NOPA	Number Of Public Attributes	Class Level	3	5	12
RFC	Response For A Class	Class Level	45	65	80
WMC	Weighted Methods Per Class	Class Level	12	35	45
CC	McCabe Cyclomatic Complexity	Method Level	3	5	7
CINT	Coupling Intensity	Method Level	7	11	15
CND	Condition Nesting Depth	Method Level	2	3	4
FDP	Foreign Data Providers	Method Level	3	5	7
LND	Loop Nesting Depth	Method Level	2	3	4
LOC	Lines Of Code	Method Level	11	31	47
MND	Maximum Nesting Depth	Method Level	3	5	7
NOAV	Number Of Accessed Variables	Method Level	3	5	7
NOPM	Number Of Parameters	Method Level	3	4	5
Ca	Afferent Coupling	Package Level	8	40	65
Ce	Efferent Coupling	Package Level	7	17	33

As they produce graphs that seem alright to all of us:



We have decided to choose 5 classes to refactor in order to improve their class metrics and 5 different methods.

The classes that we chose are the following:

1. UserController - a controller that lets the user perform all the required actions related to their personal account.
2. MatchmakingService - handles a lot of the logic of users finding activities and managing their applications.
3. NotificationsServiceImpl - ensures that the notifications are sent as emails to their corresponding users
4. ActivityController - a controller that exposes a lot of different management endpoints related to activities.
5. MatchmakingController - a controller that is part of the gateway microservice that handles connecting users to activities.

The methods that we chose are the following:

1. AddUser in UserService, which is responsible for input validation before adding the user (email and username should already exist) and then saving the user in the database.
2. sendNotification() in NotificationServiceImpl - a method that sends an email to the user to notify them about things related to an activity they are in.
3. determineFeasibility() and checkBoatAvailability() - methods used to choose boatRoles possible for a given user to select.
4. getCompetitionById() in ActivityService - main method to access competitions from the database.

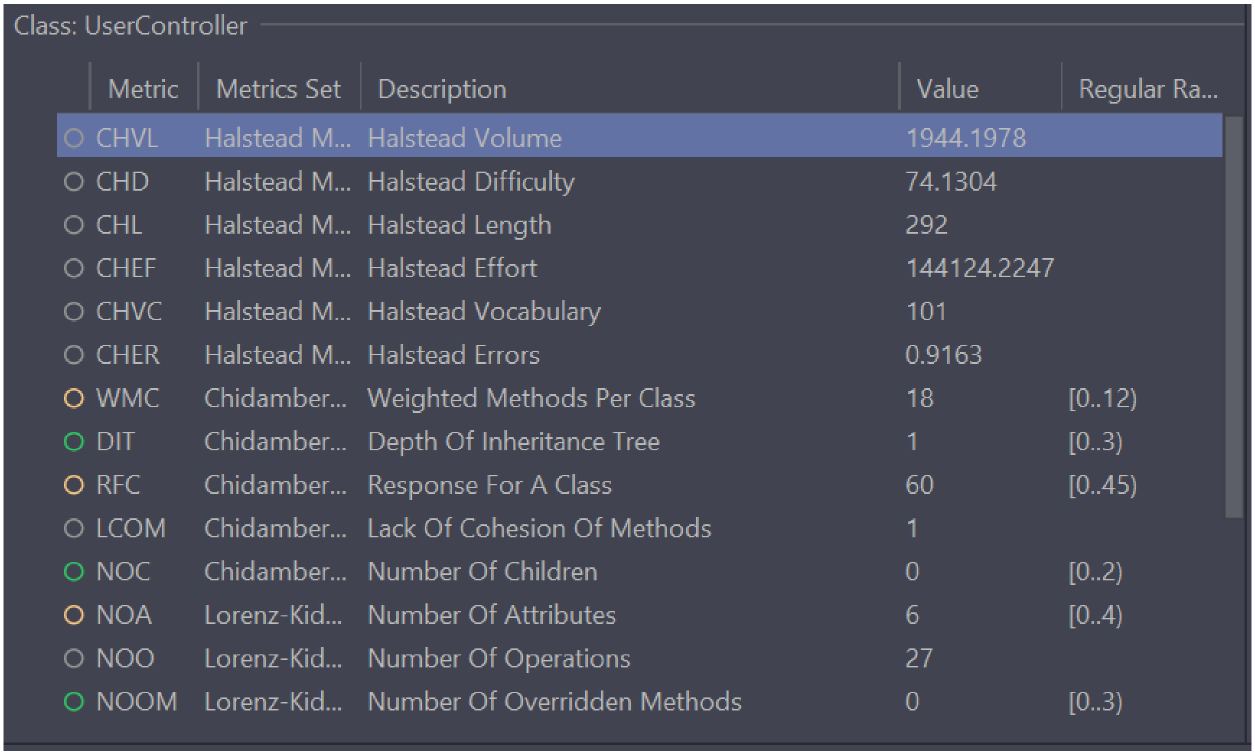
5. getTrainingById() in ActivityService - similarly to the previous method, important for accessing training activities

The Refactoring

Class 1: UserController

The user controller had several metrics in relatively high areas. We decided to improve this controller in particular as it is used extensively and will be a hot path for the user as it handles all account management.

The metrics from before the refactoring can be seen in the picture below.



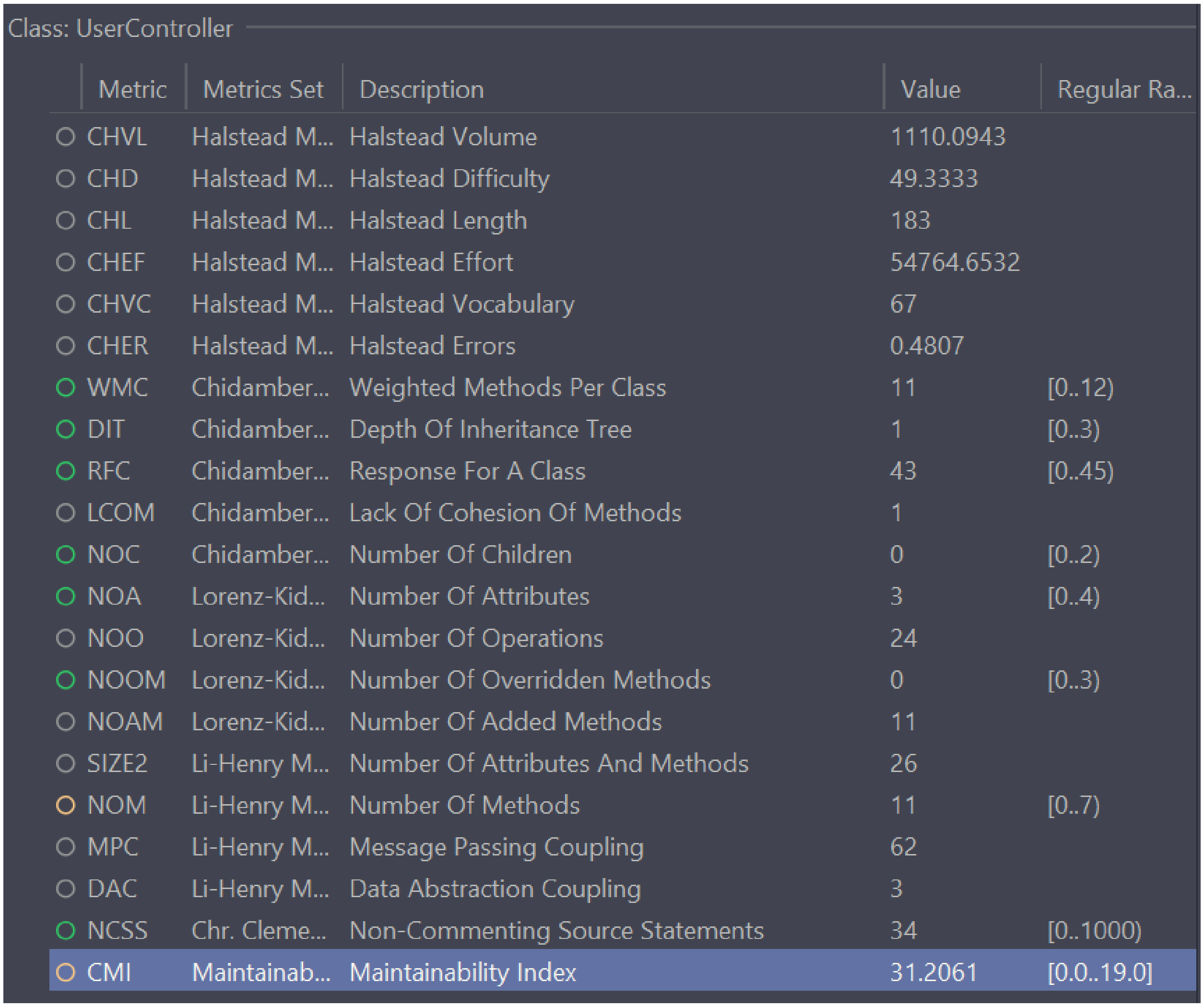
Class: UserController

Metric	Metrics Set	Description	Value	Regular Ra...
○ CHVL	Halstead M...	Halstead Volume	1944.1978	
○ CHD	Halstead M...	Halstead Difficulty	74.1304	
○ CHL	Halstead M...	Halstead Length	292	
○ CHEF	Halstead M...	Halstead Effort	144124.2247	
○ CHVC	Halstead M...	Halstead Vocabulary	101	
○ CHER	Halstead M...	Halstead Errors	0.9163	
○ WMC	Chidamber...	Weighted Methods Per Class	18	[0..12)
○ DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○ RFC	Chidamber...	Response For A Class	60	[0..45)
○ LCOM	Chidamber...	Lack Of Cohesion Of Methods	1	
○ NOC	Chidamber...	Number Of Children	0	[0..2)
○ NOA	Lorenz-Kid...	Number Of Attributes	6	[0..4)
○ NOO	Lorenz-Kid...	Number Of Operations	27	
○ NOOM	Lorenz-Kid...	Number Of Overridden Methods	0	[0..3)

The metrics which we aim to improve are the **Weighted methods per class** and the **number of attributes**.

In order to improve these metrics we opted for splitting the class into UserController and UserCertificateController. The new controller handles the connection between certificates and users which was previously handled in the controller.

The image below shows the new metric values after the refactor. We managed to significantly improve the class metrics.



Class: UserController

	Metric	Metrics Set	Description	Value	Regular Ra...
○	CHVL	Halstead M...	Halstead Volume	1110.0943	
○	CHD	Halstead M...	Halstead Difficulty	49.3333	
○	CHL	Halstead M...	Halstead Length	183	
○	CHEF	Halstead M...	Halstead Effort	54764.6532	
○	CHVC	Halstead M...	Halstead Vocabulary	67	
○	CHER	Halstead M...	Halstead Errors	0.4807	
○	WMC	Chidamber...	Weighted Methods Per Class	11	[0..12)
○	DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber...	Response For A Class	43	[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	24	
○	NOOM	Lorenz-Kid...	Number Of Overridden Methods	0	[0..3)
○	NOAM	Lorenz-Kid...	Number Of Added Methods	11	
○	SIZE2	Li-Henry M...	Number Of Attributes And Methods	26	
○	NOM	Li-Henry M...	Number Of Methods	11	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	62	
○	DAC	Li-Henry M...	Data Abstraction Coupling	3	
○	NCSS	Chr. Cleme...	Non-Commenting Source Statements	34	[0..1000)
○	CMI	Maintainab...	Maintainability Index	31.2061	[0.0..19.0]

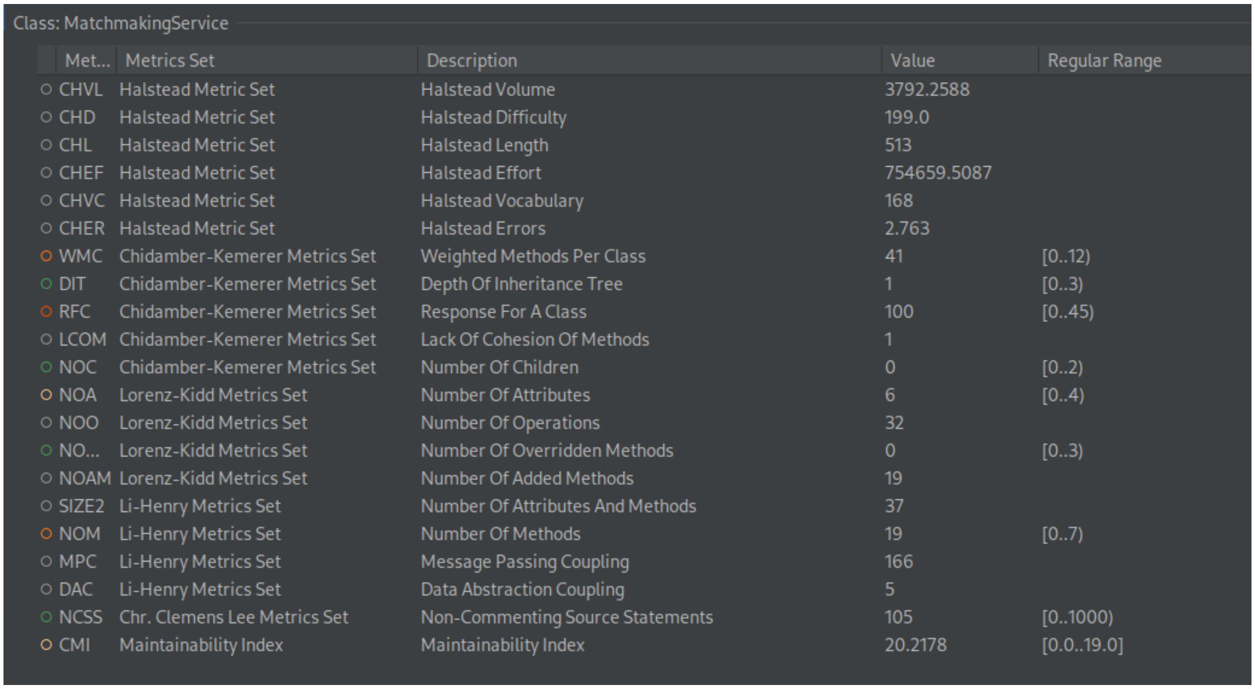
Class 2: MatchmakingService

In the matchmaking service we identified the number of methods to be the root cause for poor metrics also in other categories. MatchmakingService was an example of God class code smell. The class has too much functionality crammed into it. Thus we decided to split it off into another service by logically dividing the class functionality.

We decided that the MatchmakingService should stay in charge of controlling the signup for activities, browsing and other administrative tasks. To complement it we created a new service which will be responsible for doing sanity checks such as whether the user is eligible to join an activity.

After the refactoring the methods were split between the 2 classes (and slightly refactored). That resulted in the decrease of the NOM metric from 19 to 11 and 7 per class. The refactor further improved metrics such as WMC and RFC, which are strongly correlated with the God class code smell.

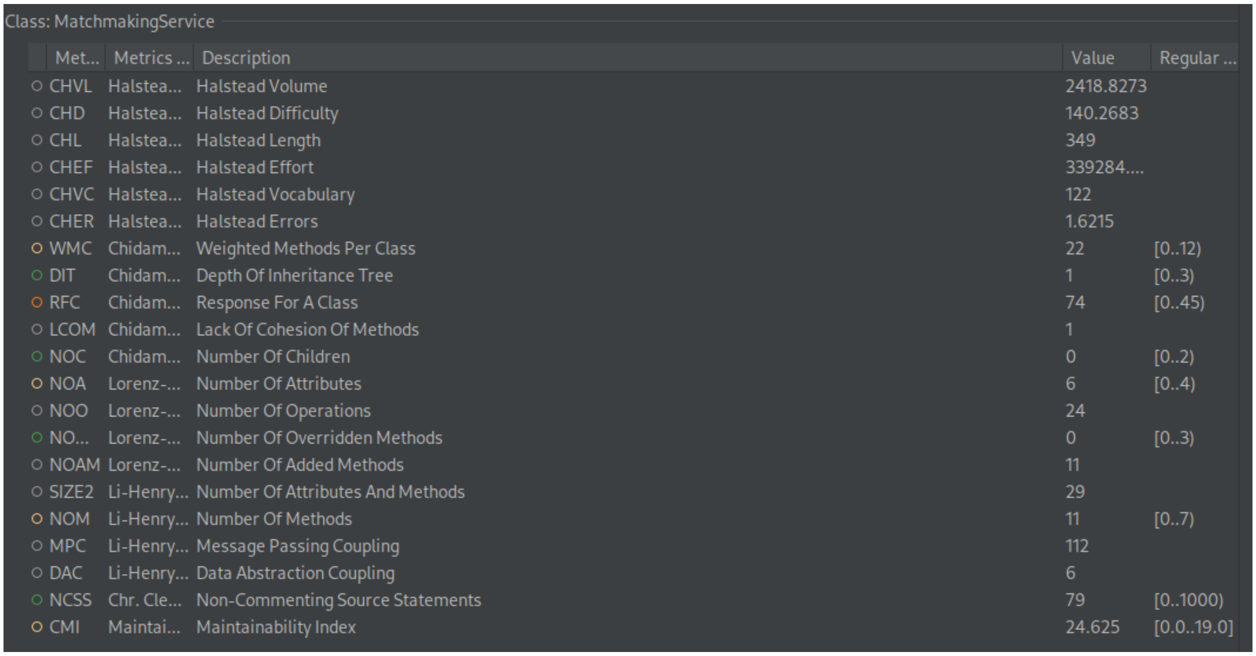
Before:



Class: MatchmakingService

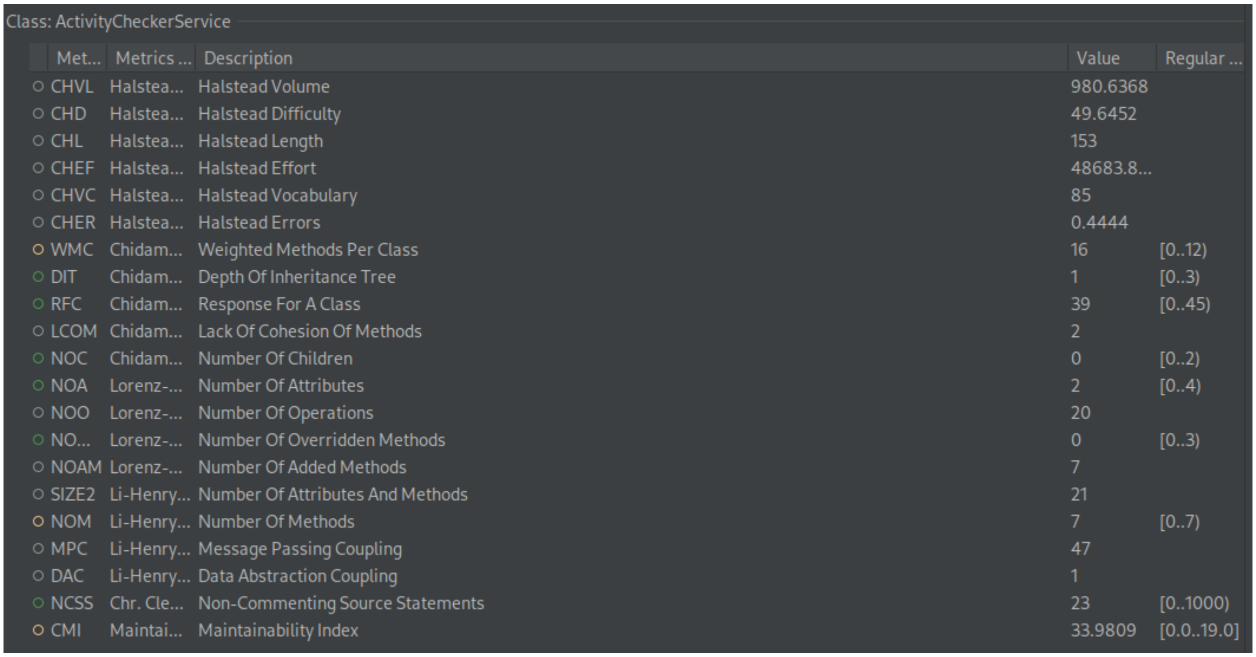
Met...	Metrics Set	Description	Value	Regular Range
○ CHVL	Halstead Metric Set	Halstead Volume	3792.2588	
○ CHD	Halstead Metric Set	Halstead Difficulty	199.0	
○ CHL	Halstead Metric Set	Halstead Length	513	
○ CHEF	Halstead Metric Set	Halstead Effort	754659.5087	
○ CHVC	Halstead Metric Set	Halstead Vocabulary	168	
○ CHER	Halstead Metric Set	Halstead Errors	2.763	
○ WMC	Chidamber-Kemerer Metrics Set	Weighted Methods Per Class	41	[0..12)
○ DIT	Chidamber-Kemerer Metrics Set	Depth Of Inheritance Tree	1	[0..3)
○ RFC	Chidamber-Kemerer Metrics Set	Response For A Class	100	[0..45)
○ LCOM	Chidamber-Kemerer Metrics Set	Lack Of Cohesion Of Methods	1	
○ NOC	Chidamber-Kemerer Metrics Set	Number Of Children	0	[0..2)
○ NOA	Lorenz-Kidd Metrics Set	Number Of Attributes	6	[0..4)
○ NOO	Lorenz-Kidd Metrics Set	Number Of Operations	32	
○ NO...	Lorenz-Kidd Metrics Set	Number Of Overridden Methods	0	[0..3)
○ NOAM	Lorenz-Kidd Metrics Set	Number Of Added Methods	19	
○ SIZE2	Li-Henry Metrics Set	Number Of Attributes And Methods	37	
○ NOM	Li-Henry Metrics Set	Number Of Methods	19	[0..7)
○ MPC	Li-Henry Metrics Set	Message Passing Coupling	166	
○ DAC	Li-Henry Metrics Set	Data Abstraction Coupling	5	
○ NCSS	Chr. Clemens Lee Metrics Set	Non-Commenting Source Statements	105	[0..1000)
○ CMI	Maintainability Index	Maintainability Index	20.2178	[0.0..19.0]

After:



Class: MatchmakingService

Met...	Metrics ...	Description	Value	Regular ...
○ CHVL	Halstea...	Halstead Volume	2418.8273	
○ CHD	Halstea...	Halstead Difficulty	140.2683	
○ CHL	Halstea...	Halstead Length	349	
○ CHEF	Halstea...	Halstead Effort	339284....	
○ CHVC	Halstea...	Halstead Vocabulary	122	
○ CHER	Halstea...	Halstead Errors	1.6215	
○ WMC	Chidam...	Weighted Methods Per Class	22	[0..12)
○ DIT	Chidam...	Depth Of Inheritance Tree	1	[0..3)
○ RFC	Chidam...	Response For A Class	74	[0..45)
○ LCOM	Chidam...	Lack Of Cohesion Of Methods	1	
○ NOC	Chidam...	Number Of Children	0	[0..2)
○ NOA	Lorenz-...	Number Of Attributes	6	[0..4)
○ NOO	Lorenz-...	Number Of Operations	24	
○ NO...	Lorenz-...	Number Of Overridden Methods	0	[0..3)
○ NOAM	Lorenz-...	Number Of Added Methods	11	
○ SIZE2	Li-Henry...	Number Of Attributes And Methods	29	
○ NOM	Li-Henry...	Number Of Methods	11	[0..7)
○ MPC	Li-Henry...	Message Passing Coupling	112	
○ DAC	Li-Henry...	Data Abstraction Coupling	6	
○ NCSS	Chr. Cle...	Non-Commenting Source Statements	79	[0..1000)
○ CMI	Maintai...	Maintainability Index	24.625	[0.0..19.0]



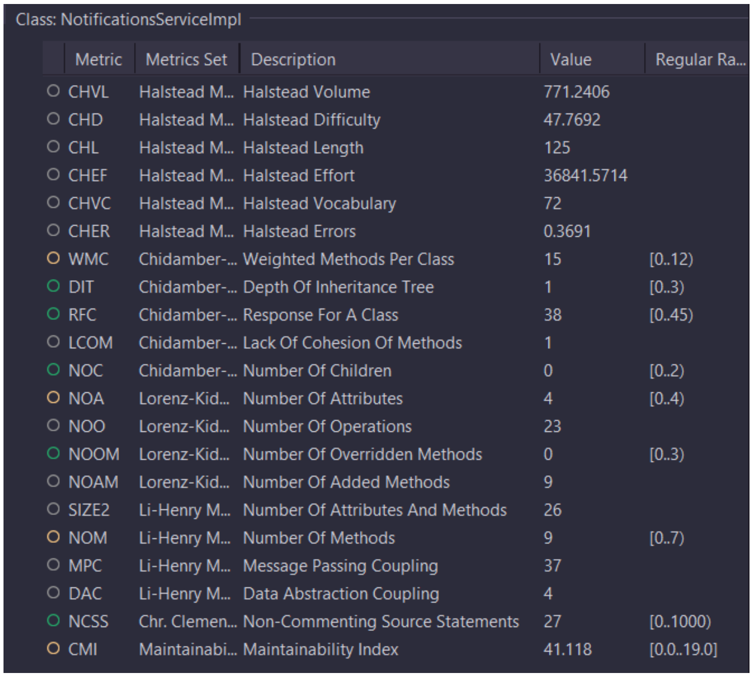
Class: ActivityCheckerService

Met...	Metrics ...	Description	Value	Regular ...
○ CHVL	Halstea...	Halstead Volume	980.6368	
○ CHD	Halstea...	Halstead Difficulty	49.6452	
○ CHL	Halstea...	Halstead Length	153	
○ CHEF	Halstea...	Halstead Effort	48683.8...	
○ CHVC	Halstea...	Halstead Vocabulary	85	
○ CHER	Halstea...	Halstead Errors	0.4444	
○ WMC	Chidam...	Weighted Methods Per Class	16	[0..12)
○ DIT	Chidam...	Depth Of Inheritance Tree	1	[0..3)
○ RFC	Chidam...	Response For A Class	39	[0..45)
○ LCOM	Chidam...	Lack Of Cohesion Of Methods	2	
○ NOC	Chidam...	Number Of Children	0	[0..2)
○ NOA	Lorenz-...	Number Of Attributes	2	[0..4)
○ NOO	Lorenz-...	Number Of Operations	20	
○ NO...	Lorenz-...	Number Of Overridden Methods	0	[0..3)
○ NOAM	Lorenz-...	Number Of Added Methods	7	
○ SIZE2	Li-Henry...	Number Of Attributes And Methods	21	
○ NOM	Li-Henry...	Number Of Methods	7	[0..7)
○ MPC	Li-Henry...	Message Passing Coupling	47	
○ DAC	Li-Henry...	Data Abstraction Coupling	1	
○ NCSS	Chr. Cle...	Non-Commenting Source Statements	23	[0..1000)
○ CMI	Maintai...	Maintainability Index	33.9809	[0.0..19.0]

Class 3: NotificationsServiceImpl

The main metrics that have been improved within this class were the **Weighted Methods Per Class**, **Number Of Attributes** and **Number Of Methods**. We decided to refactor the class as the notification sending aspect of the platform would be an often used feature. Thus, we would like to avoid any future performance bottlenecks and/or maintainability issues.

These were the initial metrics of the class:



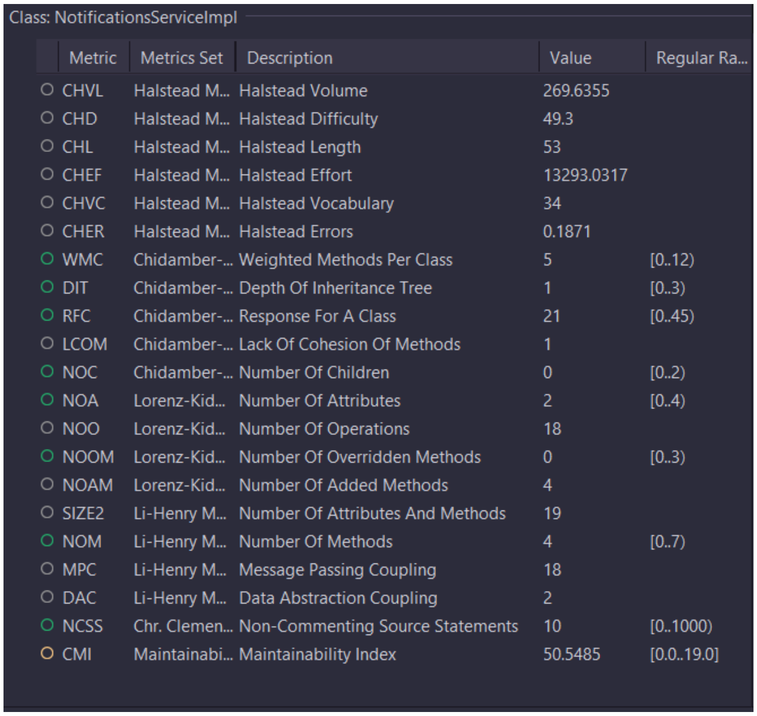
Class: NotificationsServiceImpl

	Metric	Metrics Set	Description	Value	Regular Ra...
○	CHVL	Halstead M...	Halstead Volume	771.2406	
○	CHD	Halstead M...	Halstead Difficulty	47.7692	
○	CHL	Halstead M...	Halstead Length	125	
○	CHEF	Halstead M...	Halstead Effort	36841.5714	
○	CHVC	Halstead M...	Halstead Vocabulary	72	
○	CHER	Halstead M...	Halstead Errors	0.3691	
○	WMC	Chidamber-...	Weighted Methods Per Class	15	[0..12)
○	DIT	Chidamber-...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber-...	Response For A Class	38	[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	23	
○	NOOM	Lorenz-Kid...	Number Of Overridden Methods	0	[0..3)
○	NOAM	Lorenz-Kid...	Number Of Added Methods	9	
○	SIZE2	Li-Henry M...	Number Of Attributes And Methods	26	
○	NOM	Li-Henry M...	Number Of Methods	9	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	37	
○	DAC	Li-Henry M...	Data Abstraction Coupling	4	
○	NCSS	Chr. Clemen...	Non-Commenting Source Statements	27	[0..1000)
○	CMI	Maintainabi...	Maintainability Index	41.118	[0.0..19.0]

We decided that, within the **NotificationsServiceImpl** class, only functionality aspects that have to do with the actual sending of the emails should exist and helper methods used for things such as message formatting should be moved into another separate class.

Thus, we refactored the class by splitting it into two classes, in order to reduce the number of methods and attributes: **NotificationsServiceImpl** and **common/notifications/Util**. Thus, functionality that only had to do with message formatting was moved to the utility class. We have also removed unnecessary setter methods.

These are the metrics after the refactoring:



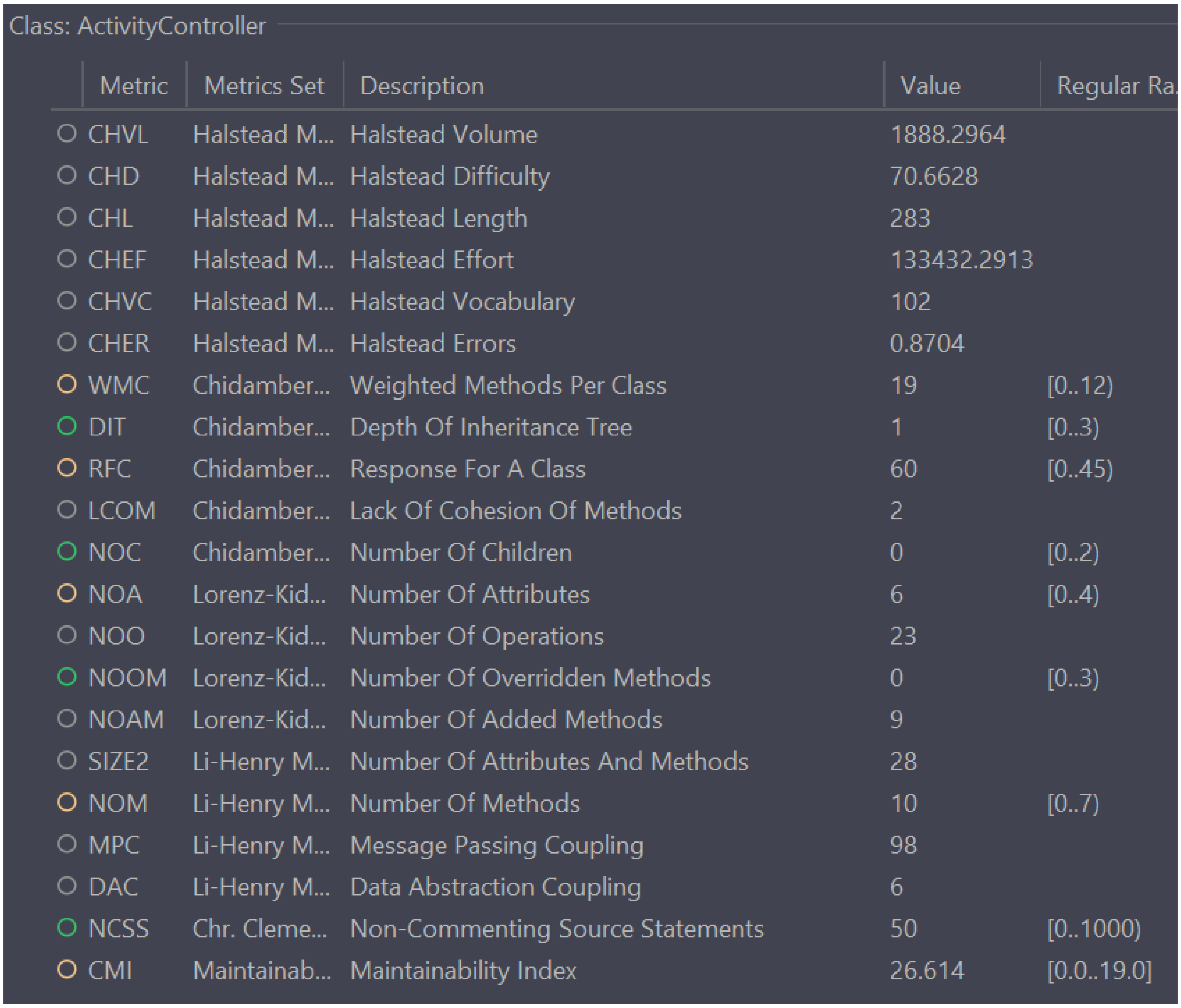
Class: NotificationsServiceImpl

	Metric	Metrics Set	Description	Value	Regular Ra...
○	CHVL	Halstead M...	Halstead Volume	269.6355	
○	CHD	Halstead M...	Halstead Difficulty	49.3	
○	CHL	Halstead M...	Halstead Length	53	
○	CHEF	Halstead M...	Halstead Effort	13293.0317	
○	CHVC	Halstead M...	Halstead Vocabulary	34	
○	CHER	Halstead M...	Halstead Errors	0.1871	
○	WMC	Chidamber-...	Weighted Methods Per Class	5	[0..12)
○	DIT	Chidamber-...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber-...	Response For A Class	21	[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	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	19	
○	NOM	Li-Henry M...	Number Of Methods	4	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	18	
○	DAC	Li-Henry M...	Data Abstraction Coupling	2	
○	NCSS	Chr. Clemen...	Non-Commenting Source Statements	10	[0..1000)
○	CMI	Maintainabi...	Maintainability Index	50.5485	[0.0..19.0]

Class 4: ActivityController

We decided to refactor this class as it had yellow scores in many categories and we aim to improve it as much as we can. This function is the controller for activities that is part of the gateway microservice.

Below are the initial metrics of the class.

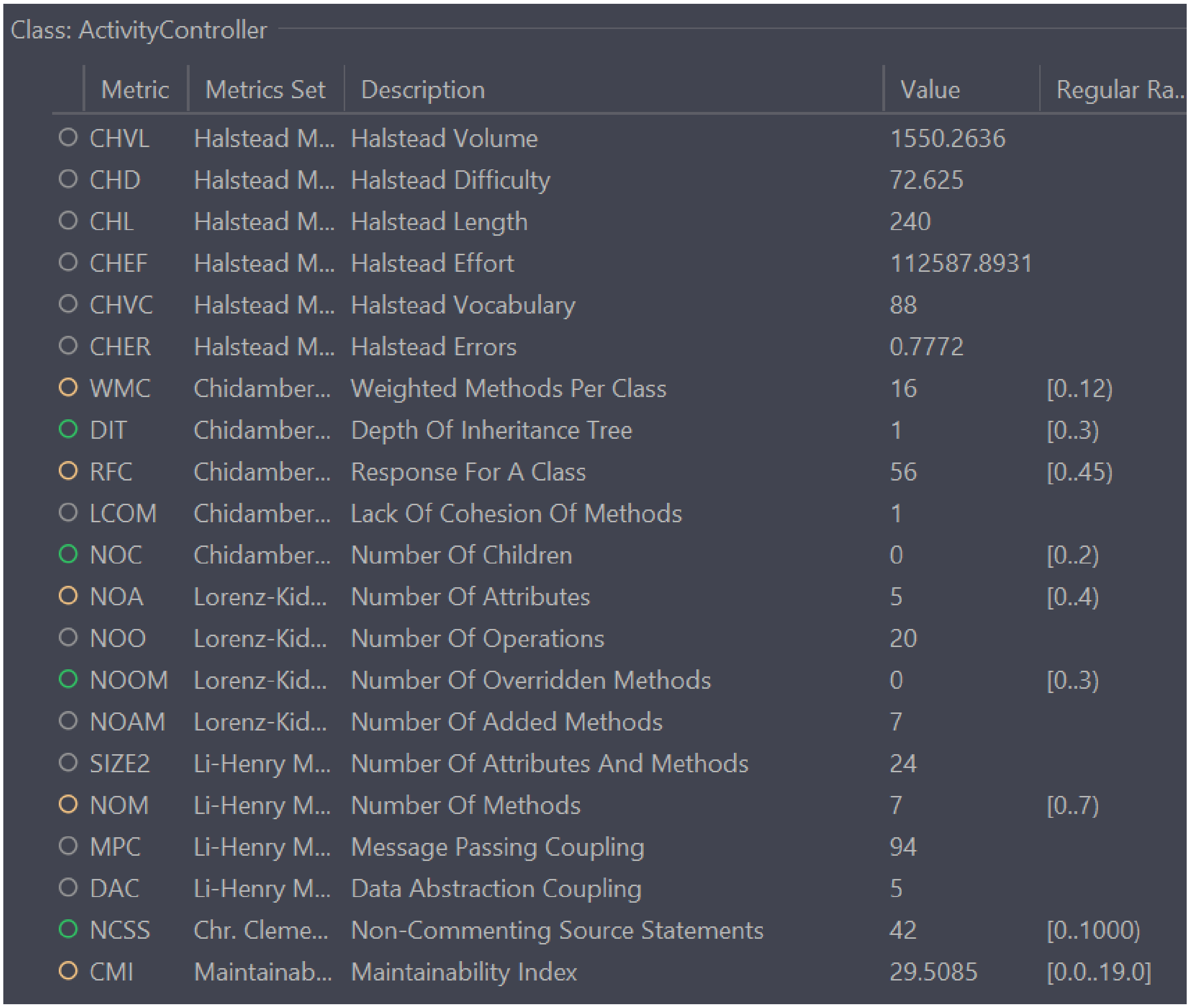


Class: ActivityController

	Metric	Metrics Set	Description	Value	Regular Ra
○	CHVL	Halstead M...	Halstead Volume	1888.2964	
○	CHD	Halstead M...	Halstead Difficulty	70.6628	
○	CHL	Halstead M...	Halstead Length	283	
○	CHEF	Halstead M...	Halstead Effort	133432.2913	
○	CHVC	Halstead M...	Halstead Vocabulary	102	
○	CHER	Halstead M...	Halstead Errors	0.8704	
○	WMC	Chidamber...	Weighted Methods Per Class	19	[0..12)
○	DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber...	Response For A Class	60	[0..45)
○	LCOM	Chidamber...	Lack Of Cohesion Of Methods	2	
○	NOC	Chidamber...	Number Of Children	0	[0..2)
○	NOA	Lorenz-Kid...	Number Of Attributes	6	[0..4)
○	NOO	Lorenz-Kid...	Number Of Operations	23	
○	NOOM	Lorenz-Kid...	Number Of Overridden Methods	0	[0..3)
○	NOAM	Lorenz-Kid...	Number Of Added Methods	9	
○	SIZE2	Li-Henry M...	Number Of Attributes And Methods	28	
○	NOM	Li-Henry M...	Number Of Methods	10	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	98	
○	DAC	Li-Henry M...	Data Abstraction Coupling	6	
○	NCSS	Chr. Cleme...	Non-Commenting Source Statements	50	[0..1000)
○	CMI	Maintainab...	Maintainability Index	26.614	[0.0..19.0]

We aim to improve the Weighted Methods Per Class score, the number of attributes and the number of methods. We did this by splitting this class into two controllers. The new class is called ActivityRegistrationController and has only two methods which handle the waiting room and the participants of an activity.

The image below shows the new metrics for the class. We managed to improve the number of methods, the number of attributes and also the Weighted Method Per Class score.



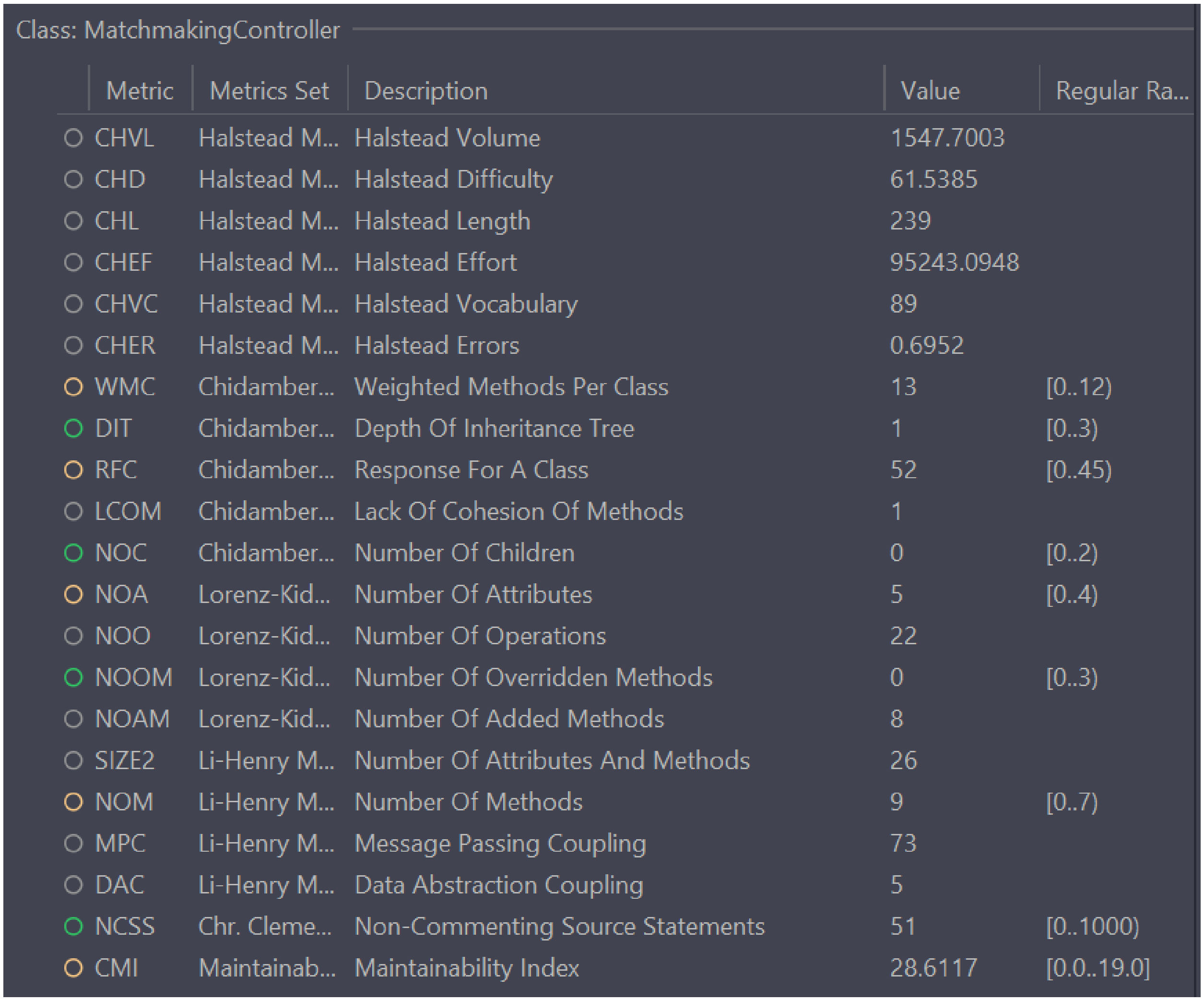
Class: ActivityController

	Metric	Metrics Set	Description	Value	Regular Ra...
○	CHVL	Halstead M...	Halstead Volume	1550.2636	
○	CHD	Halstead M...	Halstead Difficulty	72.625	
○	CHL	Halstead M...	Halstead Length	240	
○	CHEF	Halstead M...	Halstead Effort	112587.8931	
○	CHVC	Halstead M...	Halstead Vocabulary	88	
○	CHER	Halstead M...	Halstead Errors	0.7772	
○	WMC	Chidamber...	Weighted Methods Per Class	16	[0..12)
○	DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber...	Response For A Class	56	[0..45)
○	LCOM	Chidamber...	Lack Of Cohesion Of Methods	1	
○	NOC	Chidamber...	Number Of Children	0	[0..2)
○	NOA	Lorenz-Kid...	Number Of Attributes	5	[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	24	
○	NOM	Li-Henry M...	Number Of Methods	7	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	94	
○	DAC	Li-Henry M...	Data Abstraction Coupling	5	
○	NCSS	Chr. Cleme...	Non-Commenting Source Statements	42	[0..1000)
○	CMI	Maintainab...	Maintainability Index	29.5085	[0.0..19.0]

Class 5: MatchmakingController

We decided to improve the metrics of this class as it can be easily improved by splitting it into a new class. We decided to take some of the endpoints present in this controller into the previously newly created class called ActivityRegistrationController as they logically made more sense to be part of this new controller. This improved class metrics and coherence of our classes and endpoints.

Below are the class metrics from before the refactoring was applied.

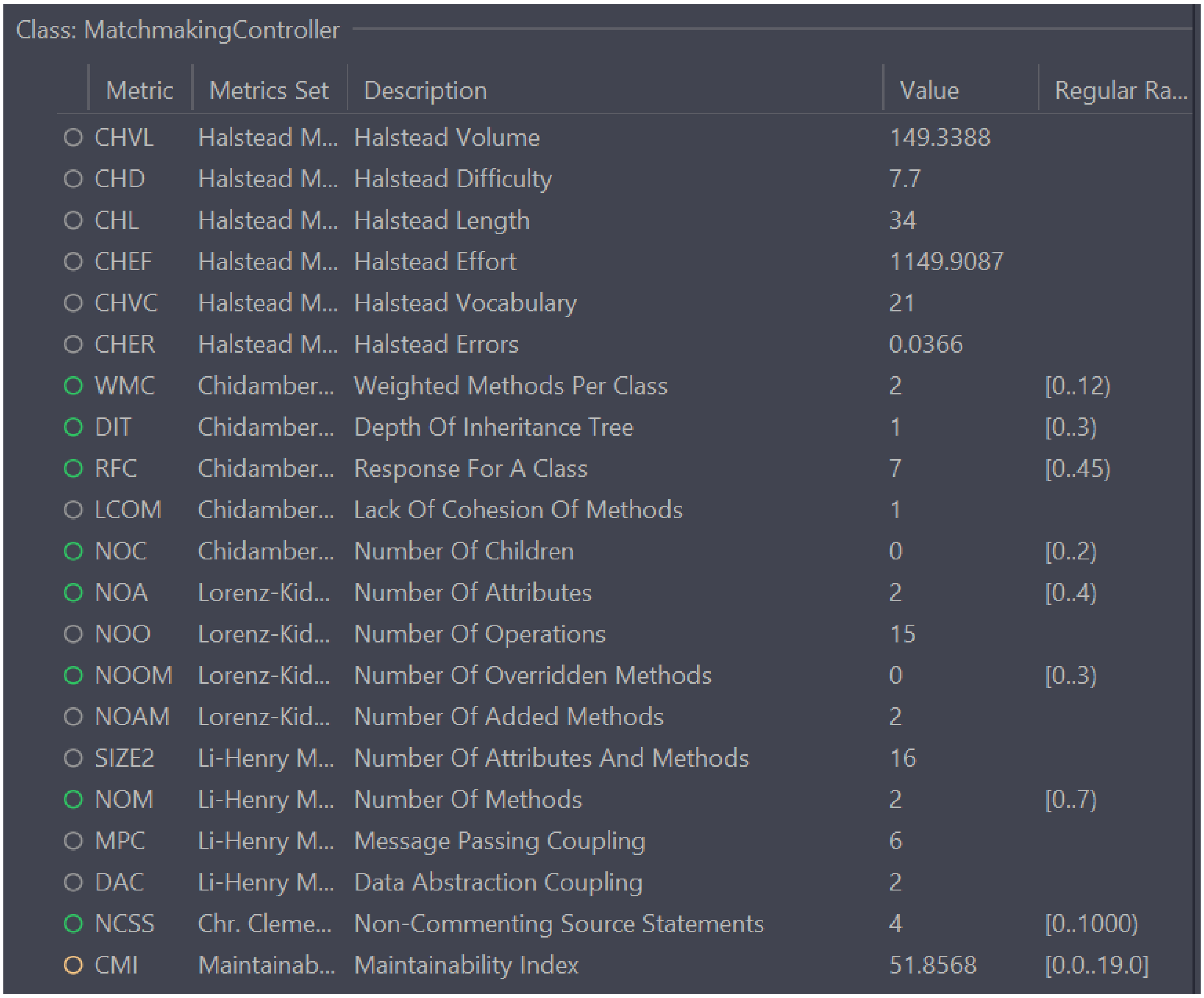


Class: MatchmakingController

	Metric	Metrics Set	Description	Value	Regular Ra...
○	CHVL	Halstead M...	Halstead Volume	1547.7003	
○	CHD	Halstead M...	Halstead Difficulty	61.5385	
○	CHL	Halstead M...	Halstead Length	239	
○	CHEF	Halstead M...	Halstead Effort	95243.0948	
○	CHVC	Halstead M...	Halstead Vocabulary	89	
○	CHER	Halstead M...	Halstead Errors	0.6952	
○	WMC	Chidamber...	Weighted Methods Per Class	13	[0..12)
○	DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber...	Response For A Class	52	[0..45)
○	LCOM	Chidamber...	Lack Of Cohesion Of Methods	1	
○	NOC	Chidamber...	Number Of Children	0	[0..2)
○	NOA	Lorenz-Kid...	Number Of Attributes	5	[0..4)
○	NOO	Lorenz-Kid...	Number Of Operations	22	
○	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	26	
○	NOM	Li-Henry M...	Number Of Methods	9	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	73	
○	DAC	Li-Henry M...	Data Abstraction Coupling	5	
○	NCSS	Chr. Cleme...	Non-Commenting Source Statements	51	[0..1000)
○	CMI	Maintainab...	Maintainability Index	28.6117	[0.0..19.0]

We decided to improve the number of attributes, the weighted method per class score, the RFC score and the number of methods.

Below are the new metric values. The new ones are all green(besides maintainability index)!

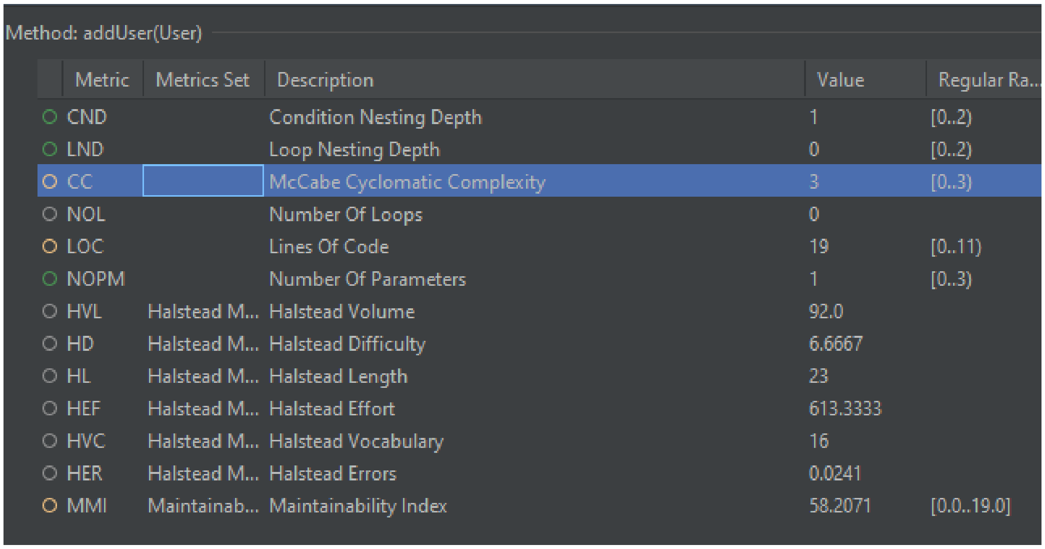


Class: MatchmakingController

	Metric	Metrics Set	Description	Value	Regular Ra...
○	CHVL	Halstead M...	Halstead Volume	149.3388	
○	CHD	Halstead M...	Halstead Difficulty	7.7	
○	CHL	Halstead M...	Halstead Length	34	
○	CHEF	Halstead M...	Halstead Effort	1149.9087	
○	CHVC	Halstead M...	Halstead Vocabulary	21	
○	CHER	Halstead M...	Halstead Errors	0.0366	
○	WMC	Chidamber...	Weighted Methods Per Class	2	[0..12)
○	DIT	Chidamber...	Depth Of Inheritance Tree	1	[0..3)
○	RFC	Chidamber...	Response For A Class	7	[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	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	16	
○	NOM	Li-Henry M...	Number Of Methods	2	[0..7)
○	MPC	Li-Henry M...	Message Passing Coupling	6	
○	DAC	Li-Henry M...	Data Abstraction Coupling	2	
○	NCSS	Chr. Cleme...	Non-Commenting Source Statements	4	[0..1000)
○	CMI	Maintainab...	Maintainability Index	51.8568	[0.0..19.0]

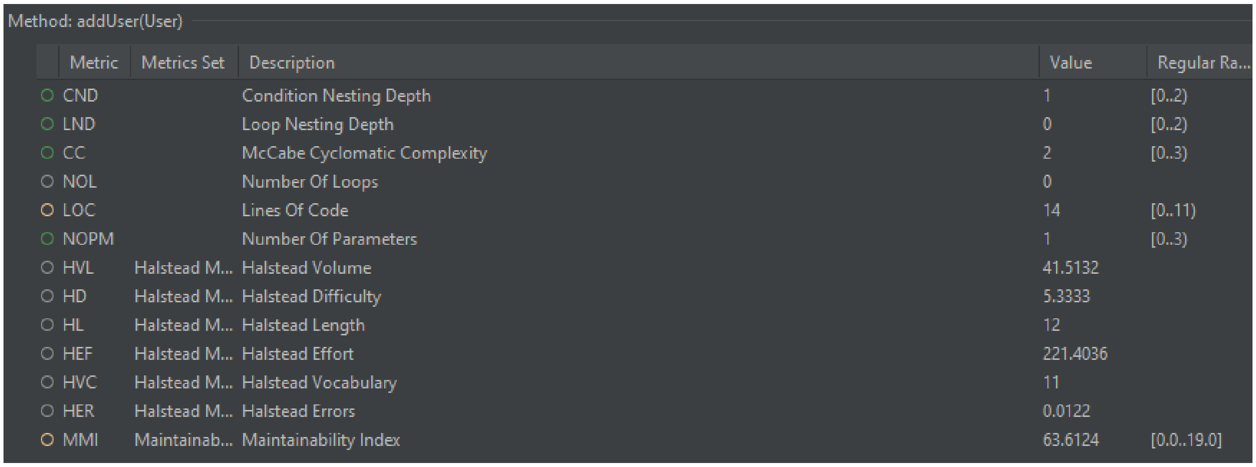
Method 1: AddUser

For this method, we aimed to improve its cyclomatic complexity, which was relatively high. We think this is an important method that would be crucial to our user data integrity, so we need to make sure it is as maintainable as possible. In order to achieve the cyclomatic complexity improvement, we delegated the responsibility of the existence checks to another method. By doing this, we also managed to improve the lines of code metric, reducing the lines method lines of code a bit. We attached a photo of the metric before and after the refactoring.



Method: addUser(User)

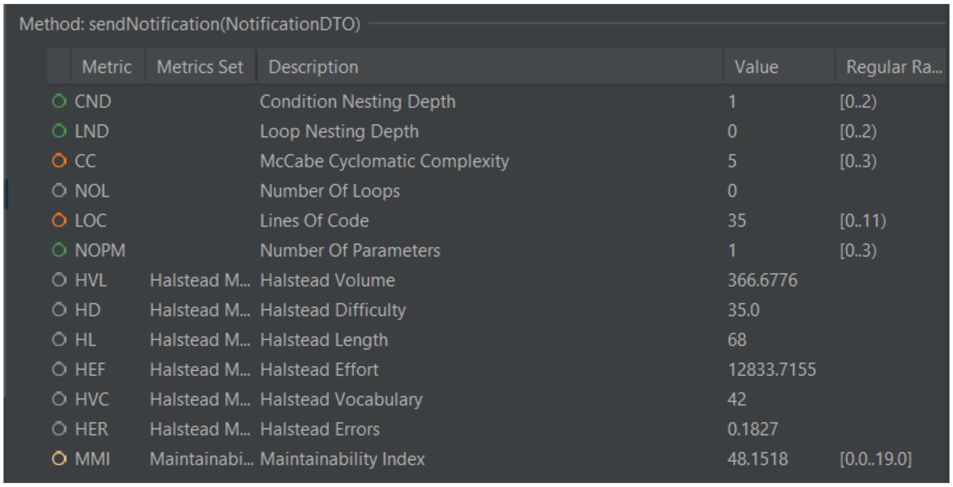
Metric	Metrics Set	Description	Value	Regular Ra...
CND		Condition Nesting Depth	1	[0..2)
LND		Loop Nesting Depth	0	[0..2)
CC		McCabe Cyclomatic Complexity	3	[0..3)
NOL		Number Of Loops	0	
LOC		Lines Of Code	19	[0..11)
NOPM		Number Of Parameters	1	[0..3)
HVL	Halstead M...	Halstead Volume	92.0	
HD	Halstead M...	Halstead Difficulty	6.6667	
HL	Halstead M...	Halstead Length	23	
HEF	Halstead M...	Halstead Effort	613.3333	
HVC	Halstead M...	Halstead Vocabulary	16	
HER	Halstead M...	Halstead Errors	0.0241	
MMI	Maintainab...	Maintainability Index	58.2071	[0.0..19.0]



Method: addUser(User)

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	2	[0..3)
NOL		Number Of Loops	0	
LOC		Lines Of Code	14	[0..11)
NOPM		Number Of Parameters	1	[0..3)
HVL	Halstead M...	Halstead Volume	41.5132	
HD	Halstead M...	Halstead Difficulty	5.3333	
HL	Halstead M...	Halstead Length	12	
HEF	Halstead M...	Halstead Effort	221.4036	
HVC	Halstead M...	Halstead Vocabulary	11	
HER	Halstead M...	Halstead Errors	0.0122	
MMI	Maintainab...	Maintainability Index	63.6124	[0.0..19.0]

Method 2: sendNotification() in NotificationServiceImpl



Method: sendNotification(NotificationDTO)

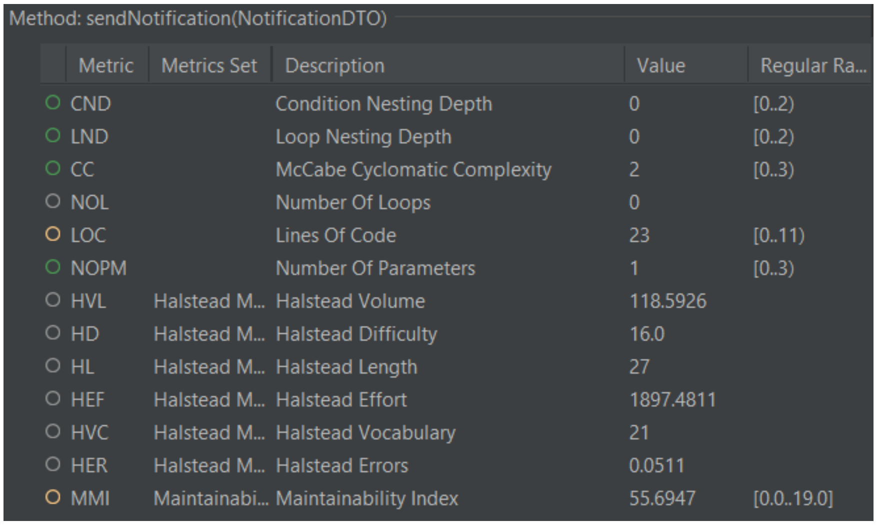
	Metric	Metrics Set	Description	Value	Regular Ra...
○	CND		Condition Nesting Depth	1	[0..2)
○	LND		Loop Nesting Depth	0	[0..2)
○	CC		McCabe Cyclomatic Complexity	5	[0..3)
○	NOL		Number Of Loops	0	
○	LOC		Lines Of Code	35	[0..11)
○	NOPM		Number Of Parameters	1	[0..3)
○	HVL	Halstead M...	Halstead Volume	366.6776	
○	HD	Halstead M...	Halstead Difficulty	35.0	
○	HL	Halstead M...	Halstead Length	68	
○	HEF	Halstead M...	Halstead Effort	12833.7155	
○	HVC	Halstead M...	Halstead Vocabulary	42	
○	HER	Halstead M...	Halstead Errors	0.1827	
○	MMI	Maintainabi...	Maintainability Index	48.1518	[0.0..19.0]

For this method, we aimed to improve its **Cyclomatic Complexity** and the **Lines Of Code** used, as these were the main areas that - we identified - could negatively impact the overall maintainability of the method and its containing class.

We did this by grouping parts of code that did one task into separate methods, specifically **addMessageDetails()**, which sets the “to”, “from”, and “subject” fields of the email, and **formatActivityDetailsMessage()**, which has been moved to the utility class. In this way, we have also removed “if-else” paths that unnecessarily increased the cyclomatic complexity.

Furthermore, in order to ensure that we haven’t just moved the code rot to another place, the **formatActivityDetailsMessage()** method has itself been refactored: we concluded it would be best if we split it into two more methods, the second one being **addActivityInfo()**.

These are metrics after the refactoring:



Method: sendNotification(NotificationDTO)

	Metric	Metrics Set	Description	Value	Regular Ra...
○	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	23	[0..11)
○	NOPM		Number Of Parameters	1	[0..3)
○	HVL	Halstead M...	Halstead Volume	118.5926	
○	HD	Halstead M...	Halstead Difficulty	16.0	
○	HL	Halstead M...	Halstead Length	27	
○	HEF	Halstead M...	Halstead Effort	1897.4811	
○	HVC	Halstead M...	Halstead Vocabulary	21	
○	HER	Halstead M...	Halstead Errors	0.0511	
○	MMI	Maintainabi...	Maintainability Index	55.6947	[0.0..19.0]

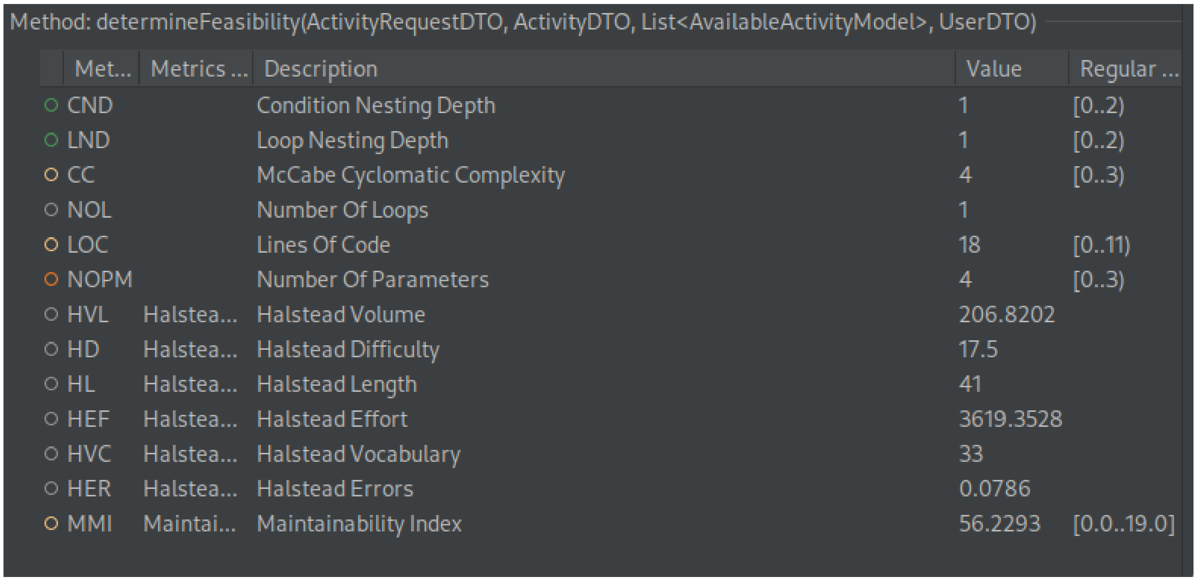
Method 3: determineFeasibility() and checkBoatAvailability() into generateSuitableActivities()

For these two methods below we mainly aimed to reduce the number of parameters passed. Additionally the methods were refactored to improve readability and make functionality clearer.

We decided that the number of parameters the methods were using, was way above the threshold of 3 parameters we decided for.
It turned out that a lot of the parameters were redundant - were superseded by other arguments of the method. Further reduction in the NOPM metrics was achieved by merging the 2 methods above into one.
However, after that the method got considerably longer. This obfuscated readability and lowered maintainability of the method. Therefore, we created a couple of helper methods to logically extract small parts of the functionality. And thus we kept the methods' LOC under our chosen threshold of 40 lines.

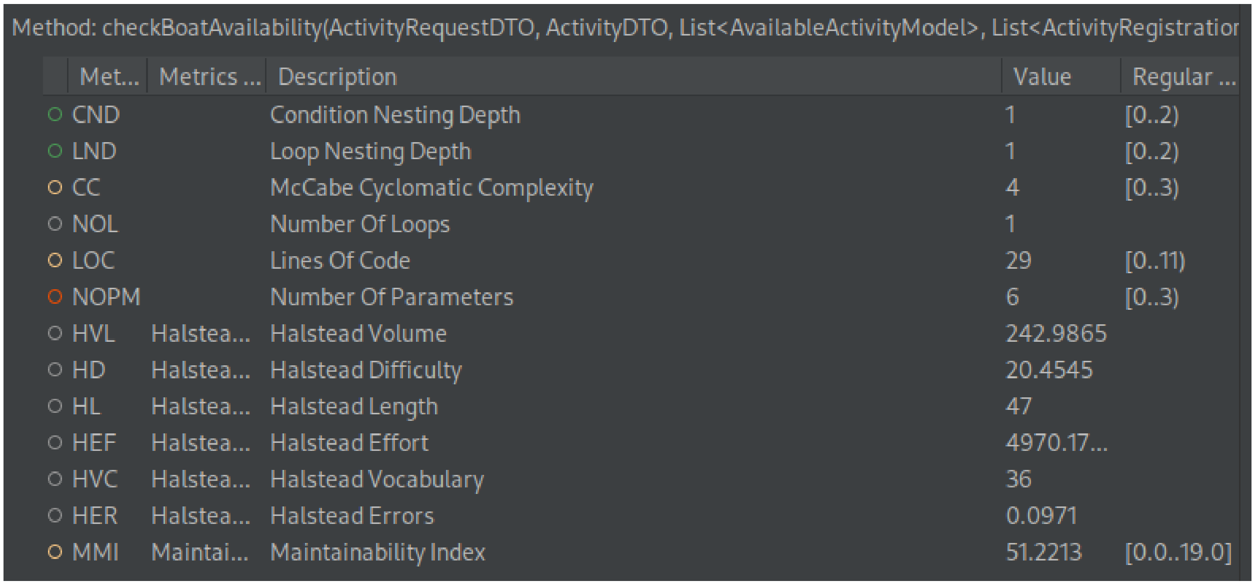
One other big factor why we decided to refactor these methods, that is not reflected in the metrics, is the readability and ability to understand the code. Previously the method would not have a return value. Instead of it it would populate a list that was passed by a parameter. With missing javadocs and complicated structure it was very difficult to understand its innerworkings. After the refactorings, the method returns a list instead and the readability was improved by using the Stream API with filters.

This method received further changes after the class level refactoring of the Matchmaking service. This was to accommodate a different split of functionalities required by the changes. Therefore the current state of code is not a direct representation of this refactoring.



Method: determineFeasibility(ActivityRequestDTO, ActivityDTO, List<AvailableActivityModel>, UserDTO)

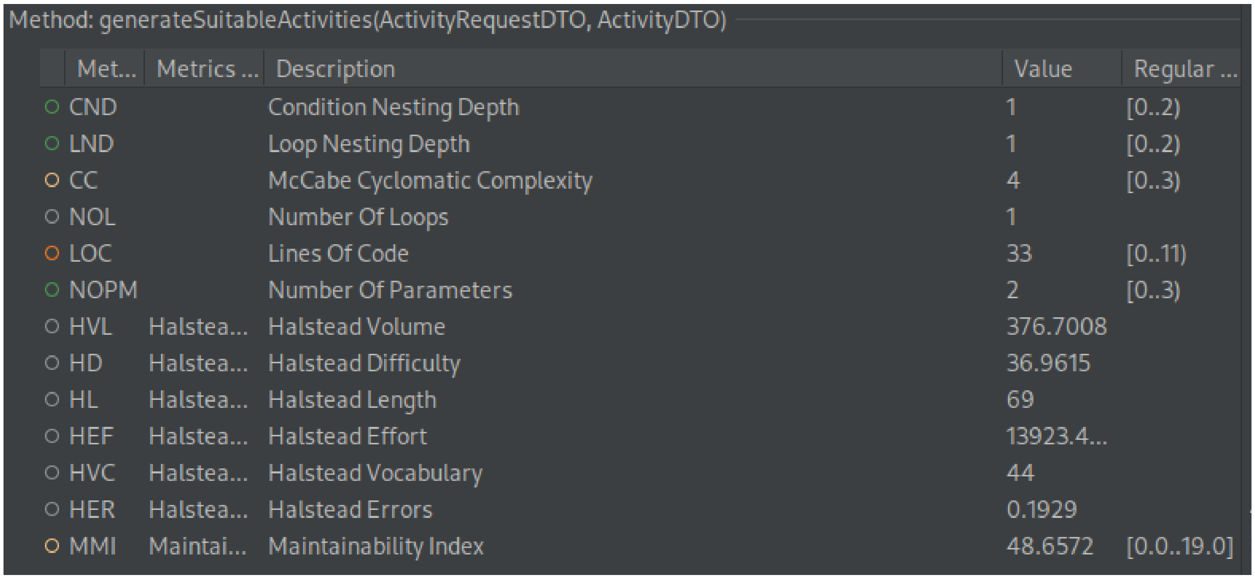
Met...	Metrics ...	Description	Value	Regular ...
○ CND		Condition Nesting Depth	1	[0..2)
○ LND		Loop Nesting Depth	1	[0..2)
○ CC		McCabe Cyclomatic Complexity	4	[0..3)
○ NOL		Number Of Loops	1	
○ LOC		Lines Of Code	18	[0..11)
○ NOPM		Number Of Parameters	4	[0..3)
○ HVL	Halstea...	Halstead Volume	206.8202	
○ HD	Halstea...	Halstead Difficulty	17.5	
○ HL	Halstea...	Halstead Length	41	
○ HEF	Halstea...	Halstead Effort	3619.3528	
○ HVC	Halstea...	Halstead Vocabulary	33	
○ HER	Halstea...	Halstead Errors	0.0786	
○ MMI	Maintai...	Maintainability Index	56.2293	[0.0..19.0]



Method: checkBoatAvailability(ActivityRequestDTO, ActivityDTO, List<AvailableActivityModel>, List<ActivityRegistratio

Met...	Metrics ...	Description	Value	Regular ...
○ CND		Condition Nesting Depth	1	[0..2)
○ LND		Loop Nesting Depth	1	[0..2)
○ CC		McCabe Cyclomatic Complexity	4	[0..3)
○ NOL		Number Of Loops	1	
○ LOC		Lines Of Code	29	[0..11)
○ NOPM		Number Of Parameters	6	[0..3)
○ HVL	Halstea...	Halstead Volume	242.9865	
○ HD	Halstea...	Halstead Difficulty	20.4545	
○ HL	Halstea...	Halstead Length	47	
○ HEF	Halstea...	Halstead Effort	4970.17...	
○ HVC	Halstea...	Halstead Vocabulary	36	
○ HER	Halstea...	Halstead Errors	0.0971	
○ MMI	Maintai...	Maintainability Index	51.2213	[0.0..19.0]

After:



Method: generateSuitableActivities(ActivityRequestDTO, ActivityDTO)

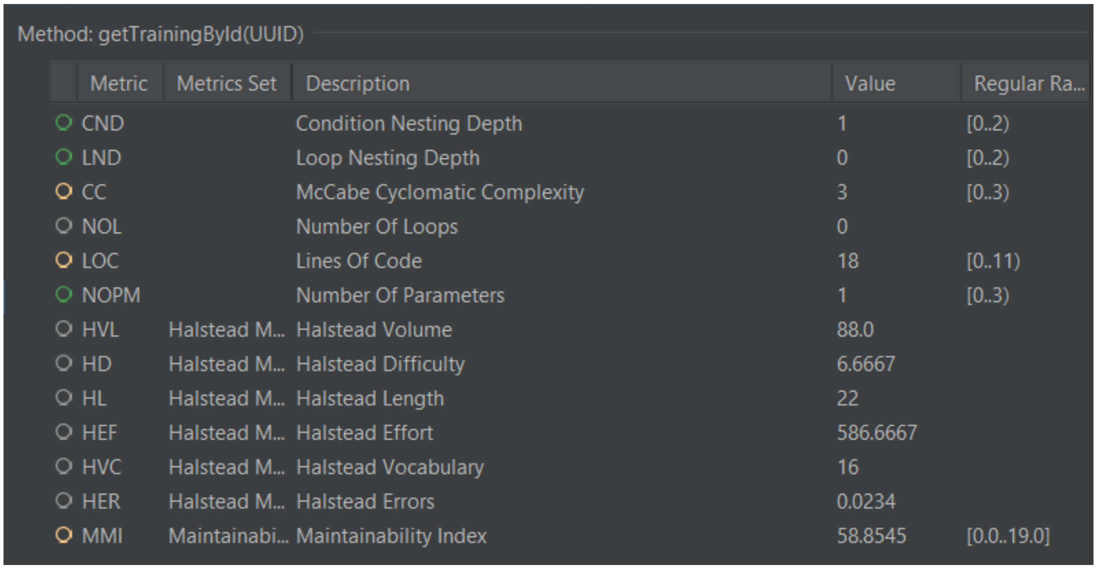
Met...	Metrics ...	Description	Value	Regular ...
○ CND		Condition Nesting Depth	1	[0..2)
○ LND		Loop Nesting Depth	1	[0..2)
○ CC		McCabe Cyclomatic Complexity	4	[0..3)
○ NOL		Number Of Loops	1	
○ LOC		Lines Of Code	33	[0..11)
○ NOPM		Number Of Parameters	2	[0..3)
○ HVL	Halstea...	Halstead Volume	376.7008	
○ HD	Halstea...	Halstead Difficulty	36.9615	
○ HL	Halstea...	Halstead Length	69	
○ HEF	Halstea...	Halstead Effort	13923.4...	
○ HVC	Halstea...	Halstead Vocabulary	44	
○ HER	Halstea...	Halstead Errors	0.1929	
○ MMI	Maintai...	Maintainability Index	48.6572	[0.0..19.0]

Method 4: getTrainingById() in ActivityService

For this method we primarily aim to reduce the cyclomatic complexity and also reduce the number of lines of code.

We believe this is a crucial method to the system, because it’s one of the two main points to access activities. By reducing the cyclomatic complexity and the lines of code, we can improve the maintainability and clarity of the method.

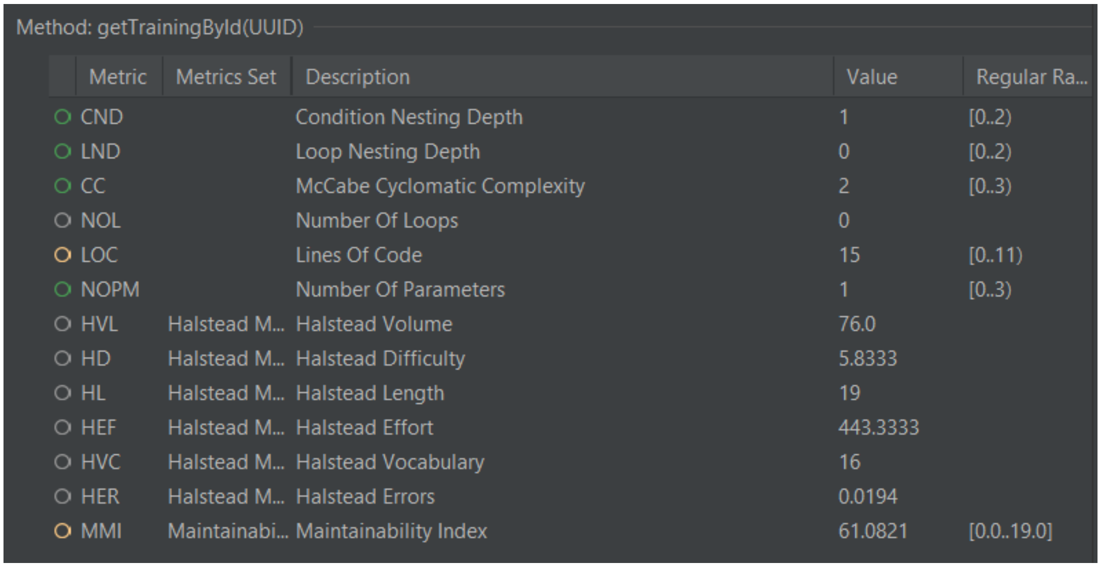
Before:



Method: getTrainingById(UUID)

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	18	[0..11)
○ NOPM		Number Of Parameters	1	[0..3)
○ HVL	Halstead M...	Halstead Volume	88.0	
○ HD	Halstead M...	Halstead Difficulty	6.6667	
○ HL	Halstead M...	Halstead Length	22	
○ HEF	Halstead M...	Halstead Effort	586.6667	
○ HVC	Halstead M...	Halstead Vocabulary	16	
○ HER	Halstead M...	Halstead Errors	0.0234	
○ MMI	Maintainabi...	Maintainability Index	58.8545	[0.0..19.0]

After:



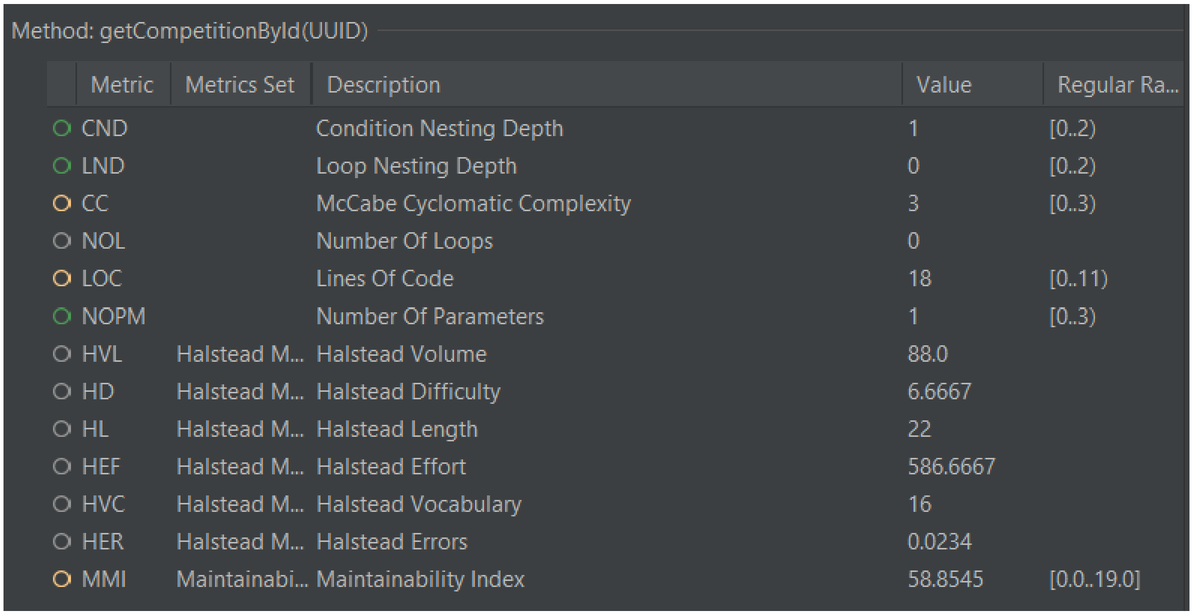
Method: getTrainingById(UUID)

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	2	[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	76.0	
○ HD	Halstead M...	Halstead Difficulty	5.8333	
○ HL	Halstead M...	Halstead Length	19	
○ HEF	Halstead M...	Halstead Effort	443.3333	
○ HVC	Halstead M...	Halstead Vocabulary	16	
○ HER	Halstead M...	Halstead Errors	0.0194	
○ MMI	Maintainabi...	Maintainability Index	61.0821	[0.0..19.0]

Method 5: getCompetitionById() in ActivityService

Similarly to the previous method, this one is also of big importance to the system to access activities. For the same reasons here we also try to reduce the cyclomatic complexity and number of lines of code.

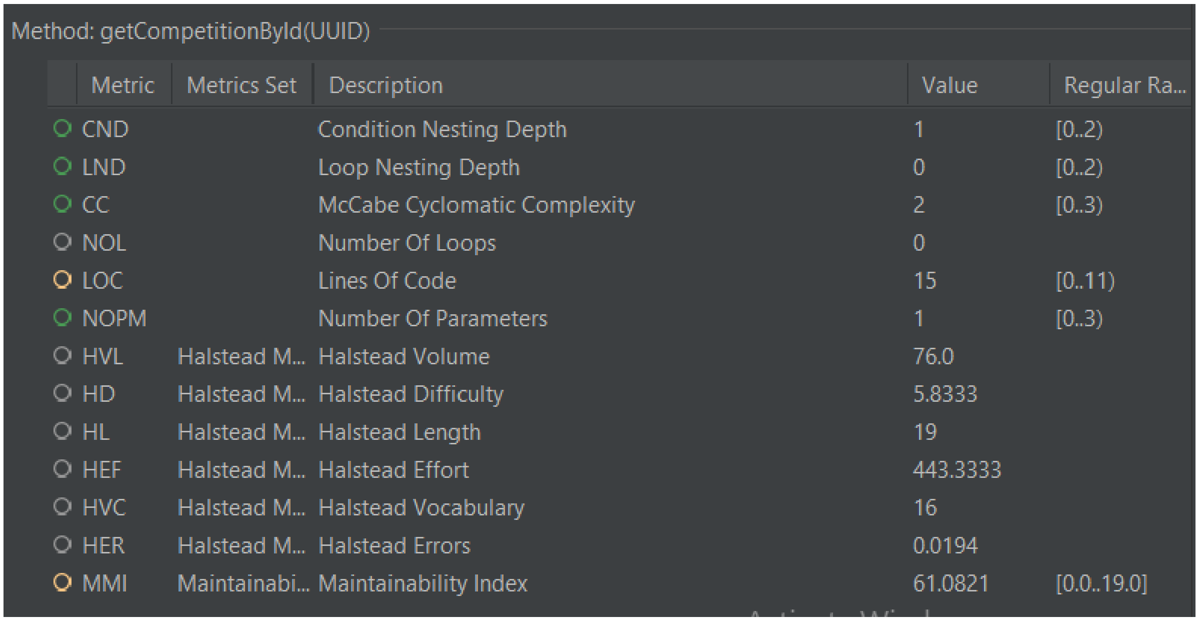
Before:



Method: getCompetitionById(UUID)

	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	18	[0..11)
○	NOPM		Number Of Parameters	1	[0..3)
○	HVL	Halstead M...	Halstead Volume	88.0	
○	HD	Halstead M...	Halstead Difficulty	6.6667	
○	HL	Halstead M...	Halstead Length	22	
○	HEF	Halstead M...	Halstead Effort	586.6667	
○	HVC	Halstead M...	Halstead Vocabulary	16	
○	HER	Halstead M...	Halstead Errors	0.0234	
○	MMI	Maintainabi...	Maintainability Index	58.8545	[0.0..19.0]

After:



Method: getCompetitionById(UUID)

	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	2	[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	76.0	
○	HD	Halstead M...	Halstead Difficulty	5.8333	
○	HL	Halstead M...	Halstead Length	19	
○	HEF	Halstead M...	Halstead Effort	443.3333	
○	HVC	Halstead M...	Halstead Vocabulary	16	
○	HER	Halstead M...	Halstead Errors	0.0194	
○	MMI	Maintainabi...	Maintainability Index	61.0821	[0.0..19.0]