RQ1: Can we quantify interest of TD at the functional level? How much is the interest? (Version 2)

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What did we revise?

- We divide one whole dataset into three projects (jruby, Ant and jmeter)
- To calcuate interest, we use the ratio of metrics value of v2 in it of v1. The positive value means we may need to spend additional cost.
  - For division, we exclude the technical debt that has 0 in v1. We show the number of the excluded technical debt.
  - Previous report measured the interest by substracting the metric value of v2 - the metric value v1.
- We use only one of duplicate technical debt that has same function name and same introducing version

Data Overview

```
data <- read.csv("/Users/kamei/Research/techdebt/msr16_td_interest/datasets/CSV/technical_debt_summary.
fc <- factor(data$Project)

data = cbind(year = (as.Date(data$v2_date) - as.Date(data$v1_date)) / 365, data)

# the number of technical debt at the method-level
tapply(data$Project, fc, length)
```

```
##    apache-ant apache-jmeter         jruby
##            97           234           506
```

```
# choose one of duplicated method and version name
method_and_version_name <- paste(data$Method_Signature, data$v1, sep="")
sum(duplicated(method_and_version_name))
```

```
## [1] 140
```

```
data <- data[!duplicated(method_and_version_name), ]
fc <- factor(data$Project)
tapply(data$Project, fc, length)
```

```
##    apache-ant apache-jmeter         jruby
##            84           180           433
```

```
# any correlation?
cor(data[,c("CountInput_v1","CountOutput_v1","CountLine_v1","Cyclomatic_v1","MaxNesting_v1")],method="sp
```

```
##                CountInput_v1 CountOutput_v1 CountLine_v1 Cyclomatic_v1
## CountInput_v1      1.0000000      0.7709514    0.7739577     0.7863770
## CountOutput_v1     0.7709514      1.0000000    0.8908325     0.8452407
## CountLine_v1       0.7739577      0.8908325    1.0000000     0.8907939
## Cyclomatic_v1      0.7863770      0.8452407    0.8907939     1.0000000
## MaxNesting_v1      0.7361987      0.7938156    0.8305780     0.9371390
##                MaxNesting_v1
## CountInput_v1      0.7361987
## CountOutput_v1     0.7938156
## CountLine_v1       0.8305780
## Cyclomatic_v1      0.9371390
## MaxNesting_v1      1.0000000
```

```
cor(data[,c("CountInput_v2","CountOutput_v2","CountLine_v2","Cyclomatic_v2","MaxNesting_v2")],method="sp
```

```
##                CountInput_v2 CountOutput_v2 CountLine_v2 Cyclomatic_v2
## CountInput_v2      1.0000000      0.6985802    0.7197771     0.7191144
## CountOutput_v2     0.6985802      1.0000000    0.8717805     0.8219677
## CountLine_v2       0.7197771      0.8717805    1.0000000     0.8857751
## Cyclomatic_v2      0.7191144      0.8219677    0.8857751     1.0000000
## MaxNesting_v2      0.6749945      0.7753973    0.8135089     0.9286364
##                MaxNesting_v2
## CountInput_v2      0.6749945
## CountOutput_v2     0.7753973
## CountLine_v2       0.8135089
## Cyclomatic_v2      0.9286364
## MaxNesting_v2      1.0000000
```

Observation

- 140 technical debt is removed due to duplication
- apache-ant has 84 technical debt. The number may be small.
- The following pairs have more than 0.8 correlation value
  - (CountOutput, CountLine), (CountOutput, Cyclomatic), (CountLine, Cyclomatic), (CountLine, MaxNesting), (Cyclomatic, MaxNesting)
  - So we report the results of fanin and countline.

How many technical debt can we map between a metrics file and Everton's summary file?

*_v1 means the version that introduces technical debt and *_v2 means the last version that technical debt was found.

```
# the number of technical debt that cannot be mapped between a metrics file
#and Everton's summary file
tapply(data$version_name, fc, function(x){sum(x == -1) })
```

```
##    apache-ant apache-jmeter         jruby
##             3             0             4
```

```
tapply(data$CountInput_v1, fc, function(x){sum(x == -1) })
```

```
##    apache-ant apache-jmeter         jruby
##            17             9           114
```

```
tapply(data$CountInput_v2, fc, function(x){sum(x == -1) })
```

```
##    apache-ant apache-jmeter         jruby
##             4             3            82
```

```
# the number of technical debt that have metrics in both versions
# of introduction and last_found
a <- data[(data[, "CountInput_v1"] != -1 & data[, "CountInput_v2"] != -1), ]
fc.a <- factor(a$Project)
tapply(a$version_name, fc.a, length)
```

```
##    apache-ant apache-jmeter         jruby
##            67           169           268
```

Observation

- jruby misses 114 technical debt in v1 and 82 in v2.
- 67 (ant), 169(jmeter) and 268(jruby) technical debt has metrics in both versions of introduction and last_found.
- We need to discuss how to solve such missed technical debt.

How much is the interest?

We target 67 (ant), 169(jmeter) and 268(jruby) technical debt in this analysis. For each technical debt, we measure the ratio of metrics value of v2 in it of v1. We use 5 metrics as interest.

CountInput (fanin)

```
# interest of CountInput (fanin)
idx <- a[,"CountInput_v1"] == 0
sum(idx)
```

```
## [1] 17
```

```
b <- a[!idx, ]
fc.b <- factor(b$Project)
interest <- (b[,"CountInput_v2"] ) / (b[,"CountInput_v1"])

# summary of interest for all technical debt
tapply(interest, fc.b, summary)
```

```
## $`apache-ant`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.4615  1.0000  1.0000  1.0520  1.0190  2.5000
##
## $`apache-jmeter`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.900   1.000   1.000   1.041   1.000   2.000
##
## $jruby
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.3125  1.0000  1.0000  1.1610  1.0830  9.0000
```

```
# the number of the percenage of positive interest, same interest, positive interest, negative interest
tapply(interest, fc.b, function(x){c( round((sum(x > 1)/ length(x) * 100)), sum(x==1), sum(x > 1), sum(
```

```
## $`apache-ant`
## [1] 25 36 16 12
##
## $`apache-jmeter`
## [1]  22 122  35   2
##
## $jruby
## [1]  27 153  70  41
```

```
# summary of interest for only technical debt that has positive / negative value.
tapply(interest, fc.b, function(x){summary(subset(x, x !=1))} )
```

```
## $`apache-ant`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.4615  0.7500  1.0830  1.1200  1.2710  2.5000
##
## $`apache-jmeter`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.900   1.083   1.133   1.178   1.222   2.000
##
## $jruby
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.3125  0.8167  1.1670  1.3820  1.5000  9.0000
```

CountLine

```
# interest of CountLine (LOC)
idx <- a[,"CountLine_v1"] == 0
sum(idx)
```

```
## [1] 0
```

```
b <- a[!idx, ]
fc.b <- factor(b$Project)
interest <- (b[,"CountLine_v2"] ) / (b[,"CountLine_v1"])
```

```
# summary of interest for all technical debt
tapply(interest, fc.b, summary)
```

```
## $`apache-ant`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##  0.1500  1.0000  1.0000  0.9944  1.0600  1.5710 
## 
## $`apache-jmeter`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##  0.2951  1.0000  1.0000  1.0260  1.0000  2.1940 
## 
## $jruby
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
## 0.03409 1.00000 1.00000 1.01800 1.04100 4.62500
```

```
# the number of the percenage of positive interest, same interest, positive interest, negative interest
tapply(interest, fc.b, function(x){c( round((sum(x > 1)/ length(x) * 100)), sum(x==1), sum(x > 1), sum(
```

```
## $`apache-ant`
## [1] 36 30 24 13
## 
## $`apache-jmeter`
## [1]  22 120  38  11
## 
## $jruby
## [1]  28 130  74  64
```

```
# summary of interest for only technical debt that has positive / negative value.
tapply(interest, fc.b, function(x){summary(subset(x, x !=1))} )
```

```
## $`apache-ant`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##  0.1500  0.8977  1.0530  0.9899  1.1050  1.5710 
## 
## $`apache-jmeter`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##  0.2951  1.0110  1.0570  1.0910  1.1560  2.1940 
## 
## $jruby
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
## 0.03409 0.83330 1.03500 1.03400 1.20000 4.62500
```

Observation

- 22%-36% of technical debt has positive interest.
- If we focus on technical debt that has more than 1 interest
    - the number of technical debt that have positive interest is more than negative interest one

```
# the top interest tech debt?
met_v1 <- "CountInput_v1"
met_v2 <- "CountInput_v2"

data.CountInput <- data[,c("Project", "Method_Signature", met_v1, met_v2)]
data.CountInput <- data.CountInput[(data.CountInput[, met_v1] != -1 & data.CountInput[, met_v2] != -1),
idx <- order(data.CountInput[,met_v2] - data.CountInput[,met_v1], decreasing = T)
head(data.CountInput[idx,])
```

```
##     Project
## 797   jruby
## 805   jruby
## 419   jruby
## 227   jruby
## 816   jruby
## 649   jruby
##                                                              Method_Signature
## 797                                                               getObject()
## 805                             newIOErrorFromException(java.io.IOException)
## 419                                               inspect(org.jruby.ast.Node)
## 227                                               inspect(org.jruby.ast.Node)
## 816  format(java.util.Date, java.lang.StringBuffer, java.text.FieldPosition)
## 649 unpack(org.jruby.Ruby, org.jruby.util.ByteList, org.jruby.util.ByteList)
##     CountInput_v1 CountInput_v2
## 797            19            65
## 805            25            65
## 419           113           144
## 227           114           142
## 816            26            48
## 649            10            21
```

Observation

- [Discuss] if technical debt has same version and same method siguniture, should we remove one of them?
  - We soloved the above point.

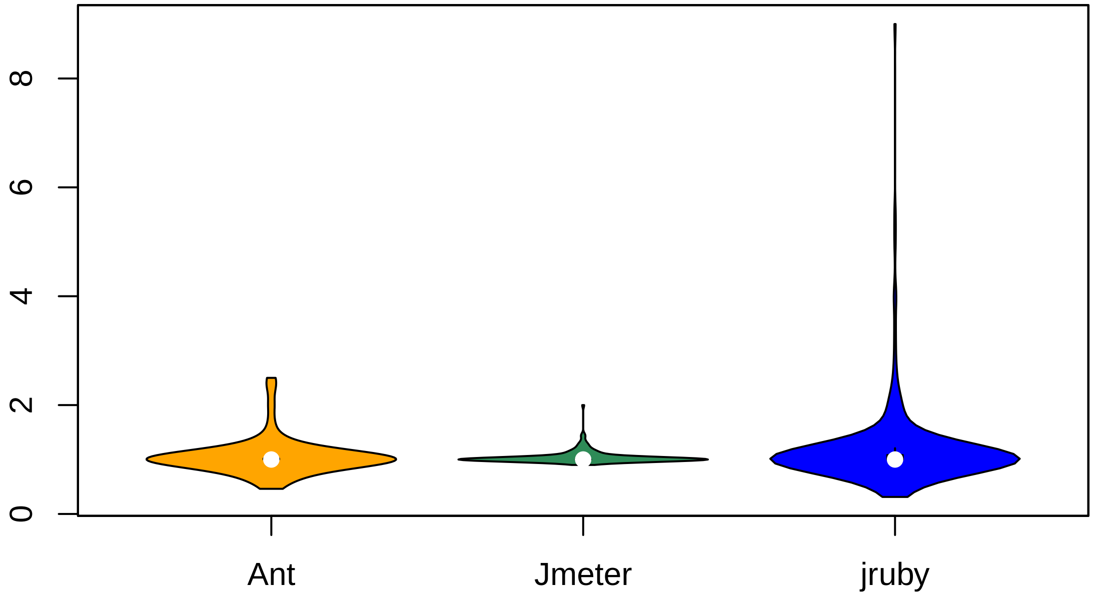
[Emad] I think one thing to measure is the metric value in v-1/metric value in v-2. Of course we can only do this for non-zero differences.

```
data.CountInput = subset(data.CountInput, data.CountInput$CountInput_v1 !=0)

library(vioplot)
```

```
## Loading required package: sm
```

```
## Package 'sm', version 2.2-5.4: type help(sm) for summary information
```

```
idx.ant <- data.CountInput[,"Project"] == "apache-ant"
idx.jmeter <- data.CountInput[,"Project"] == "apache-jmeter"
idx.jruby <- data.CountInput[,"Project"] == "jruby"

ant <- data.CountInput[idx.ant,met_v2]/data.CountInput[idx.ant,met_v1]
jmeter <- data.CountInput[idx.jmeter,met_v2]/data.CountInput[idx.jmeter,met_v1]
jruby <- data.CountInput[idx.jruby,met_v2]/data.CountInput[idx.jruby,met_v1]

plot(0, 0, type = "n", xlab = "", ylab = "", axes = FALSE,
     xlim = c(0.5, 3.5), ylim = range(c(ant, jmeter, jruby)))

axis(side = 1, at = 1:3, labels = c("Ant", "Jmeter", "jruby"))
axis(side = 2)

vioplot(ant, at = 1, col = "orange", add = TRUE)
vioplot(jmeter, at = 2, col = "seagreen", add = TRUE)
vioplot(jruby, at = 3, col = "blue", add = TRUE)
```



```
# How much percentage does technical debt has double interest?
sum(ant >= 2)
```

```
## [1] 3
```

```
sum(jmeter >= 2)
```

```
## [1] 1
```

```
sum(jruby >= 2)
```

```
## [1] 17
```

Observation

- There are several technical debt of which the ratio is more than 2. This means that the dependency of technical debt becomes double before being removed.

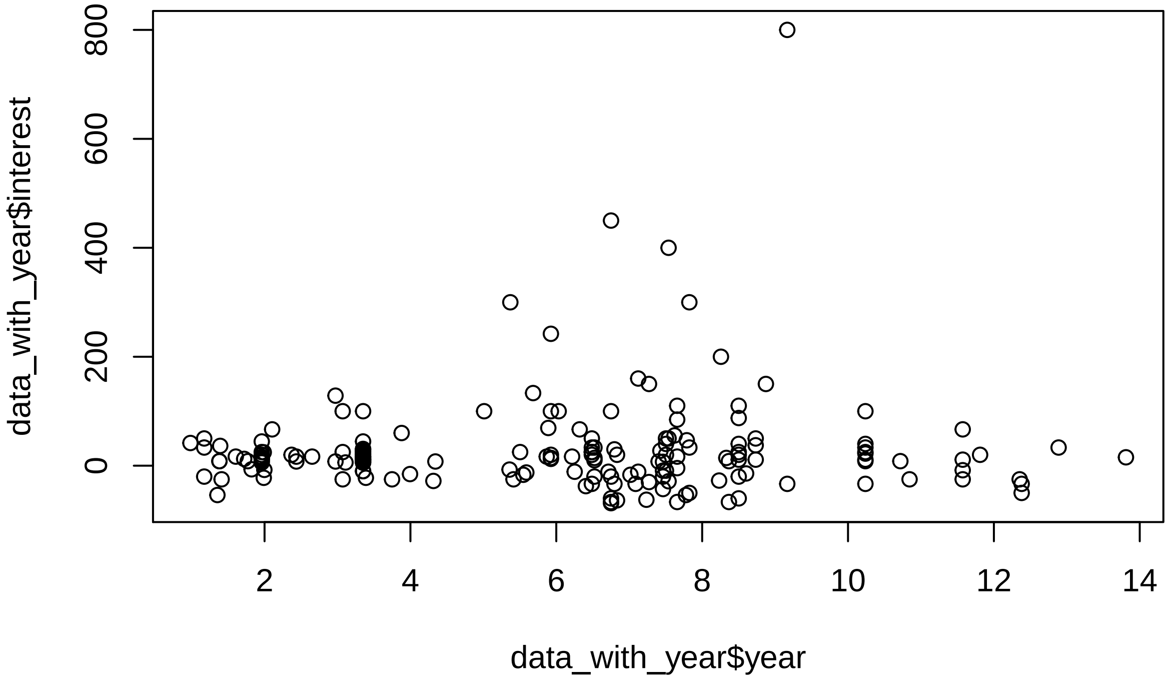
period

CountInput (fanin)

```
# interest of CountInput (fanin)
idx <- a[,"CountInput_v1"] == 0
b <- a[!idx, ]
interest <- ((b[,"CountInput_v2"] ) - (b[,"CountInput_v1"]))  / (b[,"CountInput_v1"]) * 100
year <- b[,"year"]

summary(as.double(year))
```

```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max. 
##  0.00274  2.99900  5.86800  5.19700  7.17800 13.95000
```

```
# we focus on technical debt that has non 0 interest.
d <- interest != 0

data_with_year = data.frame(year=as.double(year[d]), interest=interest[d], project=b[d,"Project"])
fc.d <- factor(data_with_year$project)

plot(data_with_year$year, data_with_year$interest)
```



```
summary(data_with_year$interest/data_with_year$year)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## -39.790  -2.179   2.963   5.720   7.523  87.270
```

```
tapply(data_with_year$interest/data_with_year$year, fc.d, summary)
```

```
## $`apache-ant`
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
## -39.79000  -2.40200   0.88700  -0.08328   2.47800  23.47000
##
## $`apache-jmeter`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  -2.984   3.158   5.969   6.986   8.049  29.840
##
## $jruby
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## -17.060  -3.035   2.681   6.763   9.366  87.270
```

Observation

- per year, 0.8%-5.9% interest happens as median.