Automating Data Validation on SQL Server Using R and the Machine Learning package

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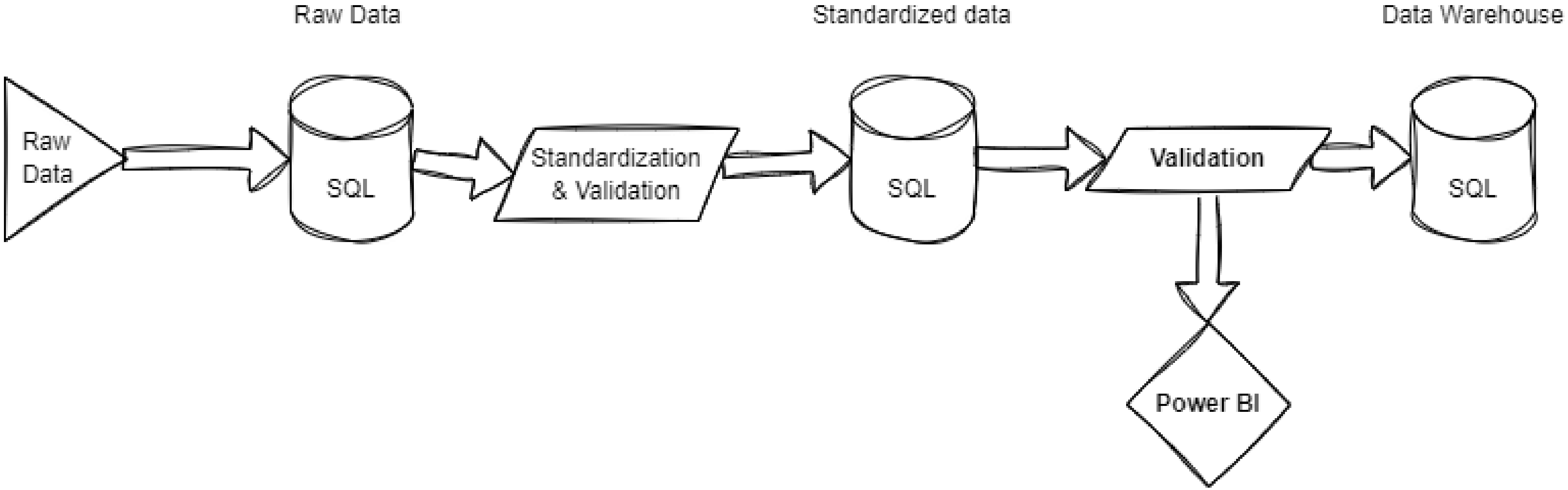
Automated data validation within dataflow on SQL Server

Fully automated data flow in SQL Stored Procedures



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Automated data validation within dataflow on SQL Server

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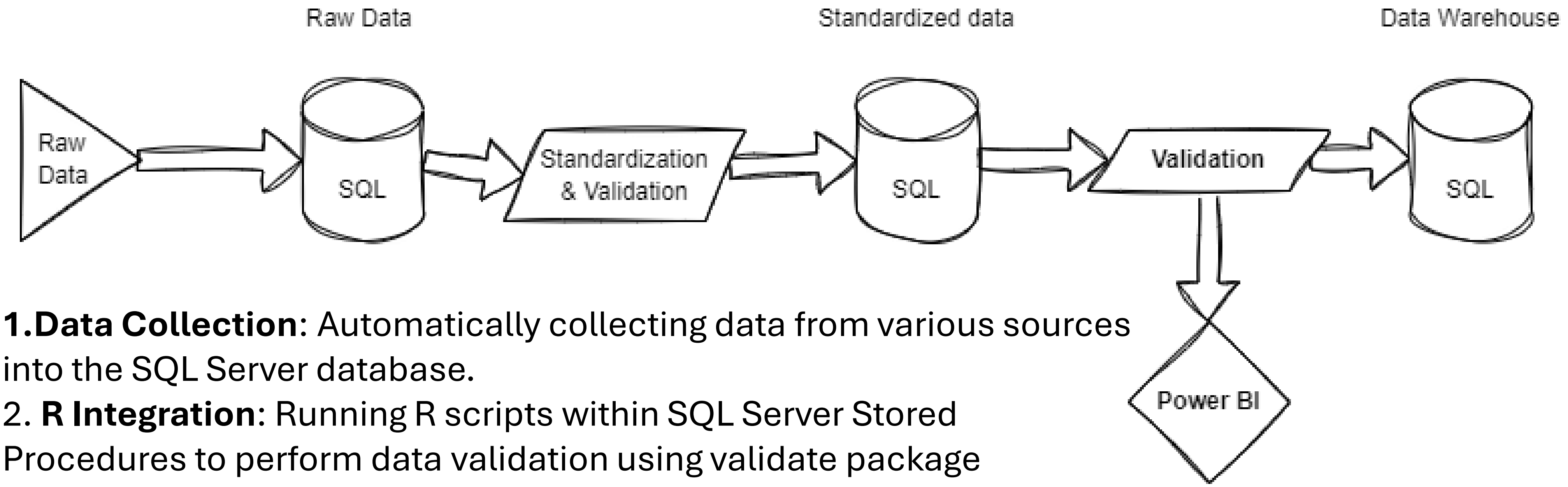
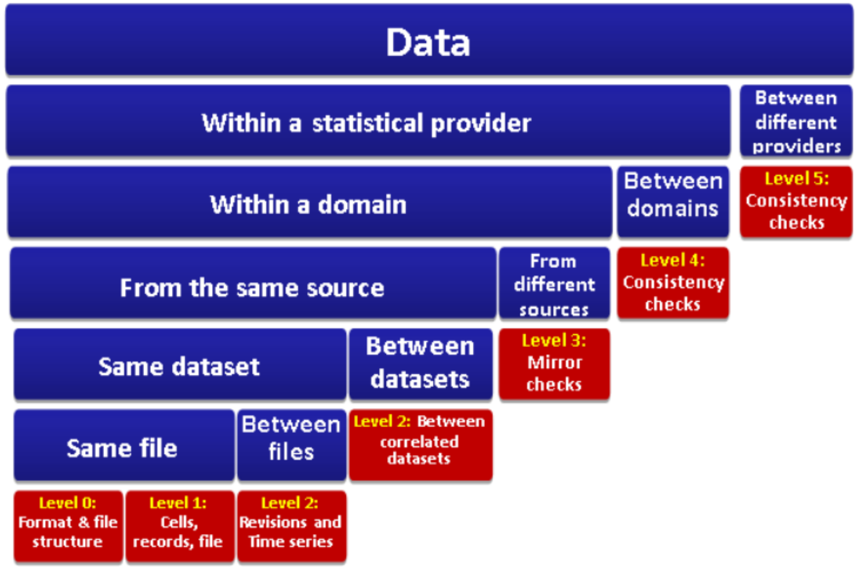


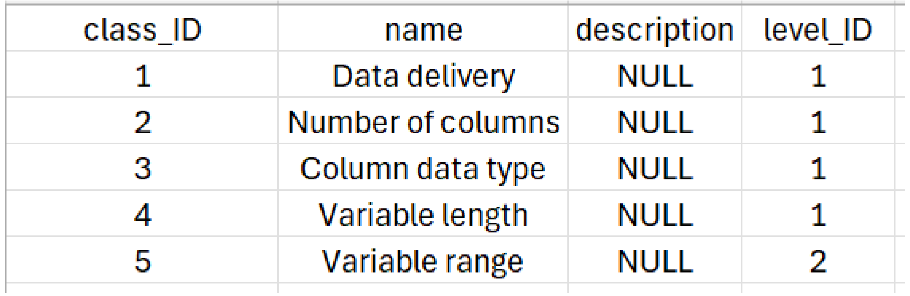
1.Data Collection: Automatically collecting data from various sources into the SQL Server database.
2. **R Integration**: Running R scripts within SQL Server Stored Procedures to perform data validation using validate package
3. **Scheduling**: Setting up SQL Server Agent jobs to automate the execution of Stored Procedures at defined intervals.

Developement of the process:
1 Validation rules in [rules]

- R code directly saved in SQL Server table for every rule
- Validation rules according to validation classes, e.g. Cellular, within data set, against other files, data sets,….
- In collaboration with the (end)users

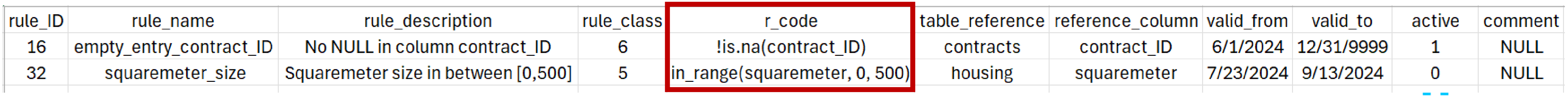

Data
Within a statistical provider
Between different providers
Within a domain
Between domains
Level 5: Consistency checks
From the same source
From different sources
Level 4: Consistency checks
Same dataset
Between datasets
Level 3: Mirror checks
Same file
Between files
Level 2: Between correlated datasets
Level 0: Format & file structure
Level 1: Cells, records, file
Level 2: Revisions and Time series

[validation].[classes]



class_ID	name	description	level_ID
1	Data delivery	NULL	1
2	Number of columns	NULL	1
3	Column data type	NULL	1
4	Variable length	NULL	1
5	Variable range	NULL	2

[validation].[rules]

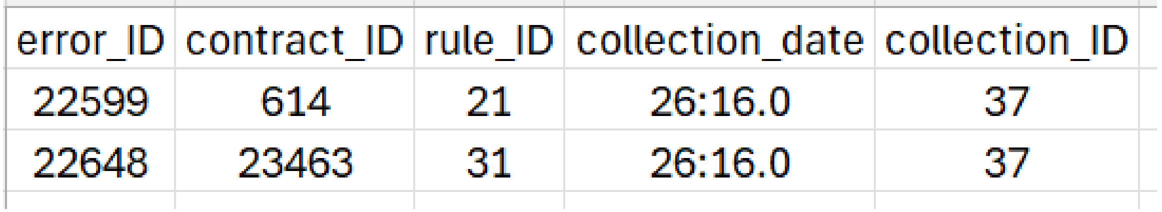


rule_ID	rule_name	rule_description	rule_class	r_code	table_reference	reference_column	valid_from	valid_to	active	comment
16	empty_entry_contract_ID	No NULL in column contract_ID	6	!is.na(contract_ID)	contracts	contract_ID	6/1/2024	12/31/9999	1	NULL
32	squaremeter_size	Squaremeter size in between [0,500]	5	in_range(squaremeter, 0, 500)	housing	squaremeter	7/23/2024	9/13/2024	0	NULL

Developement of the process:
2 Validation in R

- Development of the R code in R Studio
- Collection of data and validation rules from SQL tables
- Select which data to validate by collection_IDs
- Validation
- Extraction of results into excel / SQL table

[validation].[errors]



error_ID	contract_ID	rule_ID	collection_date	collection_ID
22599	614	21	26:16.0	37
22648	23463	31	26:16.0	37

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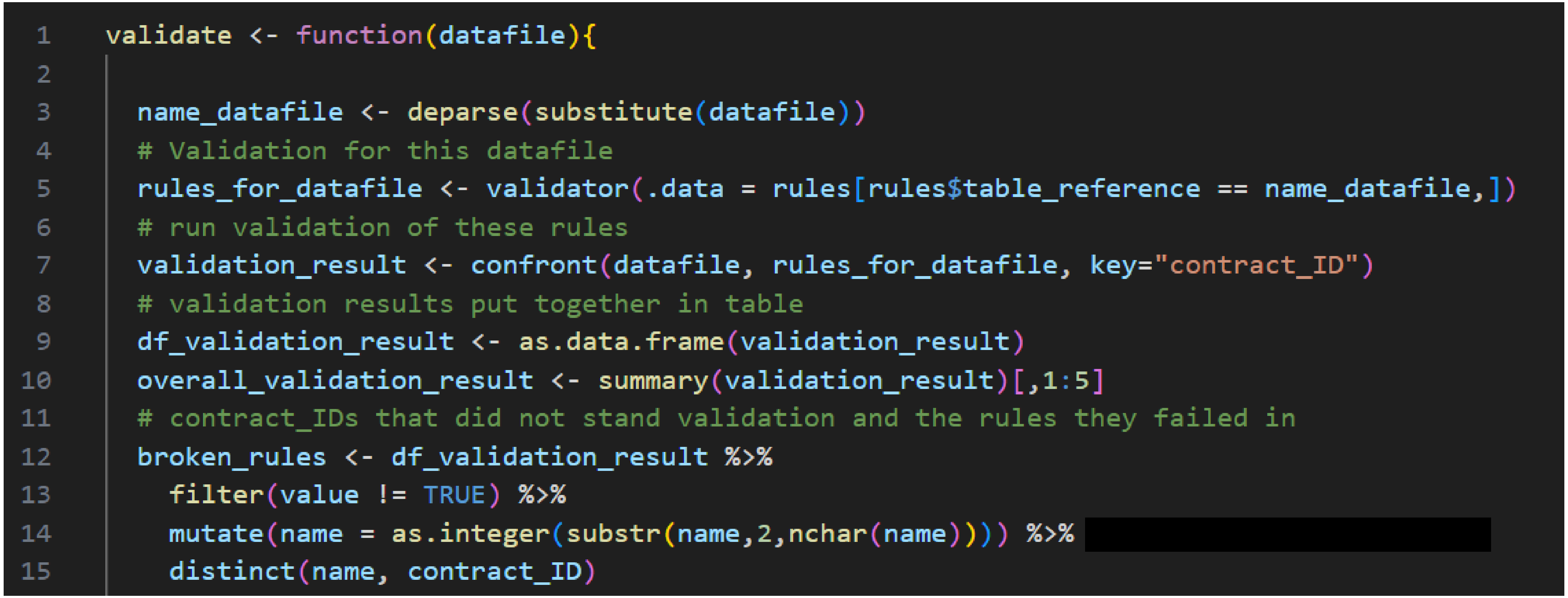
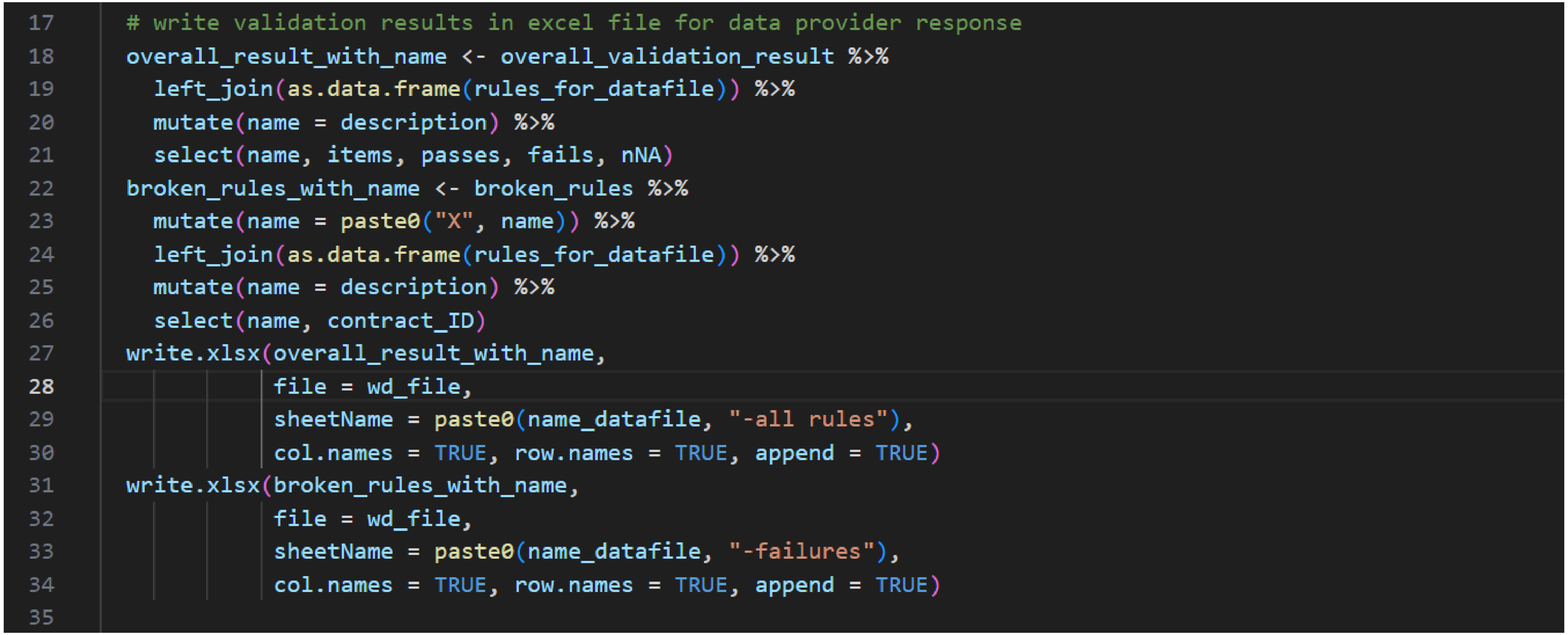
Developement of the process:
2 Validation in R



```r
validate <- function(datafile){

  name_datafile <- deparse(substitute(datafile))
  # Validation for this datafile
  rules_for_datafile <- validator(.data = rules[rules$table_reference == name_datafile,])
  # run validation of these rules
  validation_result <- confront(datafile, rules_for_datafile, key="contract_ID")
  # validation results put together in table
  df_validation_result <- as.data.frame(validation_result)
  overall_validation_result <- summary(validation_result)[,1:5]
  # contract_IDs that did not stand validation and the rules they failed in
  broken_rules <- df_validation_result %>%
    filter(value != TRUE) %>%
    mutate(name = as.integer(substr(name,2,nchar(name)))) %>% [redacted]
    distinct(name, contract_ID)
```

Developement of the process:
3 Writing validation results into excel (Dataprovider)



```r
# write validation results in excel file for data provider response
overall_result_with_name <- overall_validation_result %>%
  left_join(as.data.frame(rules_for_datafile)) %>%
  mutate(name = description) %>%
  select(name, items, passes, fails, nNA)
broken_rules_with_name <- broken_rules %>%
  mutate(name = paste0("X", name)) %>%
  left_join(as.data.frame(rules_for_datafile)) %>%
  mutate(name = description) %>%
  select(name, contract_ID)
write.xlsx(overall_result_with_name,
           file = wd_file,
           sheetName = paste0(name_datafile, "-all rules"),
           col.names = TRUE, row.names = TRUE, append = TRUE)
write.xlsx(broken_rules_with_name,
           file = wd_file,
           sheetName = paste0(name_datafile, "-failures"),
           col.names = TRUE, row.names = TRUE, append = TRUE)

```

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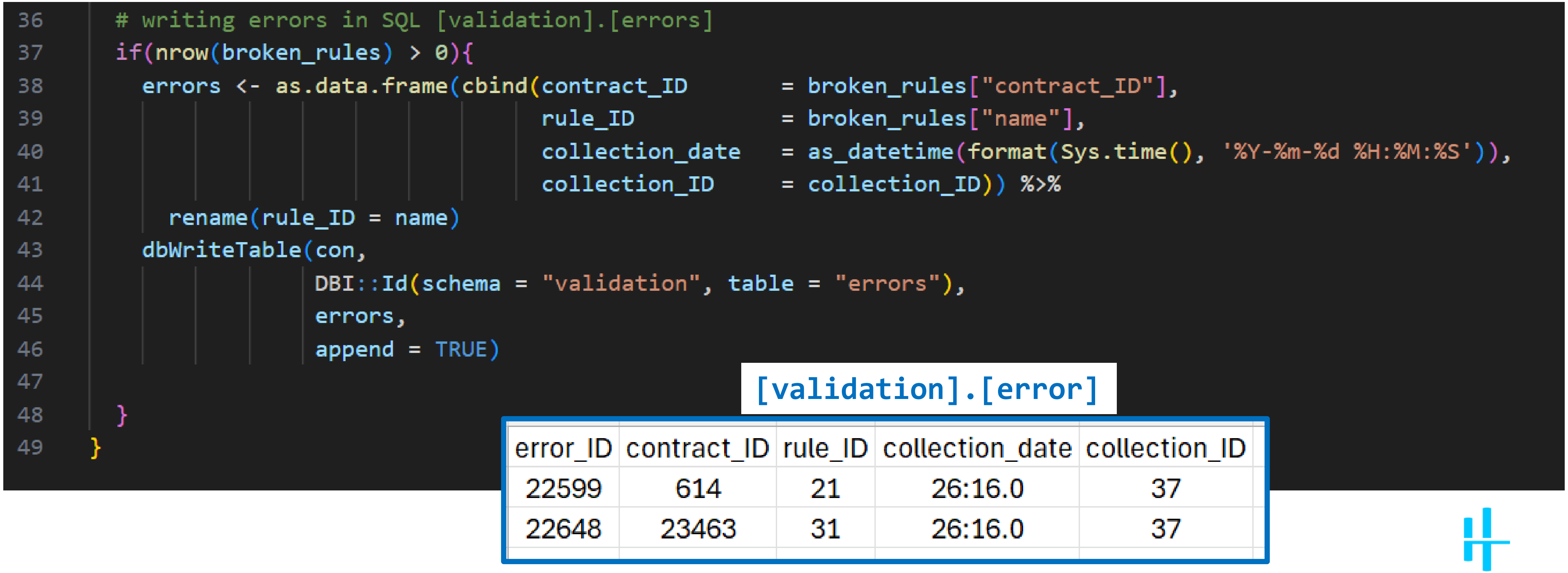
Developement of the process:
4 Writing validation results into SQL tables



```
  # writing errors in SQL [validation].[errors]
  if(nrow(broken_rules) > 0){
    errors <- as.data.frame(cbind(contract_ID       = broken_rules["contract_ID"],
                                  rule_ID           = broken_rules["name"],
                                  collection_date   = as_datetime(format(Sys.time(), '%Y-%m-%d %H:%M:%S')),
                                  collection_ID     = collection_ID)) %>%
      rename(rule_ID = name)
    dbWriteTable(con,
                 DBI::Id(schema = "validation", table = "errors"),
                 errors,
                 append = TRUE)

  }
}
```

[validation].[error]

error_ID	contract_ID	rule_ID	collection_date	collection_ID
22599	614	21	26:16.0	37
22648	23463	31	26:16.0	37

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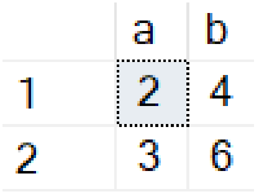
Transfer to SQL Stored Procedure, basic example

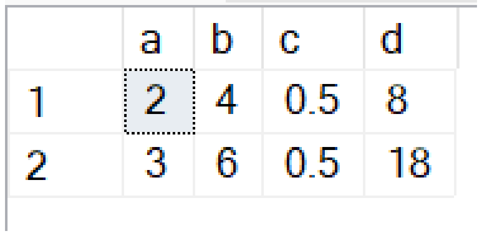
```
CREATE PROCEDURE [dbo].[CalculateValues]
AS
BEGIN
    EXEC sp_execute_external_script
         @language = N'R‘,
         @script = N‘ #library()
            a <- InputDataSet$a
            b <- InputDataSet$b
            c <- a / b
            d <- a * b
            OutputDataSet <- data.frame(a, b, c, d)',
        @input_data_1 = N'SELECT * FROM [dbo].[example];',
        @output_data_1_name = N'OutputDataSet'
    WITH RESULT SETS ((a FLOAT, b FLOAT, c FLOAT, d FLOAT));
END;

EXEC [dbo].[CalculateValues]
```

[dbo].[example]



	a	b
1	2	4
2	3	6

OutputDataSet



	a	b	c	d
1	2	4	0.5	8
2	3	6	0.5	18

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Obstacles

- R version control

  (SQL Server 2022 Machine Learning package : R 4.2.0)

- R package management

- Language issues (Icelandic letters in the data, utf-8) on SQL Server 2019 (R 3.5.2)

- Loading in more than one SQL table per Stored Procedure – in progress

- Resource management

Pros/Cons of automation directly on SQL Server using R code within ML package

Pro

- Resssource **efficient**: Processing ressources and time
- Data is processed where it is stored
- User/Machine independent automation
- Perfect addition to fully automized data flow process
- Standardized way of data validation (reusable)
- Comparability between process qualities
- Continous data quality insurance
- Implementing of additional validation checks
- Improved accuracy in detecting data anomalies and inconsistencies
- Successful **scheduling** of validation tasks
- Potential for **Machine Learning / AI** implementation

Con

- Need for Machine Learning package on SQL Server
- Recommended from SQL Microsoft Server 2022 onwards (otherwise language issues)
- Learning threshold to implement R code into Stored Procedures
- Only one SQL table can be read in in per Stored Procedure at a time
- Installation of R packages (IT support) within ML package

THANK YOU

Do you have any questions?

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Used R packages

- Validate[1]: for validation cran.r-project.org/web/packages/validate/
  - declare rules
  - apply them on dataset

- xlsx[2]: production of validation files to return to data providers, only if applicable cran.r-project.org/web/packages/xlsx/

- DBI [3] / odbc[4] for read in of SQL tables / writing results into SQL tables , only if not run on SQL Server cran.r-project.org/web/packages/DBI/ / cran.r-project.org/web/packages/odbc/