Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Information Engineering

Master's Thesis

An Analysis Over Extendibility of Data Analytics Tools for Custom Visualizations: 9-Box Grid Development

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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DIPLOMA THESIS ASSIGNMENT

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Systems Engineering and Informatics
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Thesis title

An Analysis Over Extendibility of Data Analytics Tools for Custom Visualizations: 9-Box Grid Development

Objectives of thesis

The main objective of this thesis is to compare capabilities and extendibility of modern data visualization tools for customizations based on different needs of various companies and/or business units such as pricing, licensing, performance and custom development.

The partial goals of the thesis are to compare some aspects of tools, to create development environments and to develop at least one custom visualization.

Methodology

In the first part of this thesis a comprehensive benchmark of business intelligence and analytics tools will be performed in aspect of both data analysts (end user) and business intelligence developers with the help of public surveys, researches and public market data.

Followed by explaining data types, visualizations and their relations, second part will contain custom visualization examples and their use in various business units or dashboards and will focus a specific visualization to be developed.

In the practical part, 9-Box Grid which is a well desired visualization for talent management policies by Human Resources Departments will be developed for selected platform(s).

The proposed extent of the thesis

60 – 80 pages

Keywords

business intelligence, data analytics, data visualization, custom visualization, custom visualization development, talent management, 9 box grid, nine box grid

Recommended information sources

ECKERSON, Wayne W. Performance dashboards: measuring, monitoring, and managing your business. John Wiley & Sons, 2010.

CHAUDHURI, Surajit; DAYAL, Umeshwar; NARASAYYA, Vivek. An overview of business intelligence technology. Communications of the ACM, 2011, 54.8: 88-98.

KIMBALL, Ralph; ROSS, Margy. The data warehouse toolkit: the complete guide to dimensional modeling. John Wiley & Sons, 2011.

TYRYCHTR, J. – VASILENKO, A. Business Intelligence in Agribusiness – Fundamental Concepts and Research. Brno: KONVOJ, spol. s r. o. , 2015, 100s. ISBN 978-80-7302-170-2.

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Electronic approval: 23. 11. 2021

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Dean

Prague on 31. 03. 2022

Declaration

I declare that I have worked on my master's thesis titled “An Analysis Over Extendibility of Data Analytics Tools for Custom Visualizations: 9-Box Grid Development” by myself and I have used only the sources mentioned at the end of the thesis. As the author of the master's thesis, I declare that the thesis does not break any copyrights.

In Prague on 31.03.2022 Deniz Tuna

Acknowledgement

I would like to start by thanking my beloved family for all their support. I would like to thank my dear friend Emre Karabulut, whom I count as my big brother, for his outstanding support and mentorship. Another one that I would like to mention here for all her advice and aid is my dear friend Bilge Doğan. With their support, patience, and help, I found the strength to finish my thesis.

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I conclude by thanking my teachers, classmates, and everyone else whose name I did not mention here, for whom I have at least received support, at least something I have learned.

An Analysis Over Extendibility of Data Analytics Tools for Custom Visualization: 9-Box Grid Development

Abstract

The purpose of this thesis is to compare modern business intelligence and data analytics software and their extendibility over custom visualization and then present 9-Box Grid tool development.

In the first section, custom visualization is explored with the history of visualization and the examination of common visual types. Followed by famous and modern visualization tools, such as Excel, Power BI, and Tableau, presented with their capabilities and a summary of their provider companies.

9-Box Grid tool is explained in the continuous section with its purpose and aim of usage. Use cases of the 9-Box Grid tool exhibited with the target audience of the device. Development of a 9-Box Grid performed in the practical part of the thesis with the requirements and dependencies of development environment setup.

Keywords: business intelligence, data analytics, data visualization, custom visualization, custom visualization development, talent management, 9 box grid, nine box grid

Analýza Rozšiřitelnosti Analytických Nástrojů pro Vlastní Vizualizaci: 9 Box Grid Vývoj

Abstrakt

Cílem této diplomové práce je porovnat moderní software pro business intelligence a datové analýzy a jejich rozšiřitelnost vzhledem k vizualizačním možnostem, následně představit vývoj nástroje 9-Box Grid.

V první části práce je prozkoumána problematika vizualizace a běžných vizuálních typů. Následovaly známé a moderní vizualizační nástroje, jako je Excel, Power BI a Tableau, prezentované se svými schopnostmi a souhrnem jejich dodavatelů. V průběžné části je vysvětlen nástroj.

9-Box Grid s jeho účelem a cílem použití. Představeny jsou případové studie nástroje 9-Box Grid. V praktické části práce byl proveden vývoj 9-Box Gridu s požadavky a závislostmi nastavení vývojového prostředí.

Klíčová slova: business intelligence, datová analytika, vizualizace dat, vlastní vizualizace, vývoj vlastní vizualizace, talent management, 9 box grid, devět box grid

Table of content

1 Introduction

Before forming and communicating with words, humans recorded and transferred their stories and achievements with visuals.

Visualizing the information has had different forms through the ages, from icons and lines on the ancient cave walls that record hunts to maps of newfound lands to charts that represent numbers in shapes for easy comparison. With these improved visuals, hidden gems of the collected data can be uncovered, understood, and used in decision making, which led to survival and knowledge distribution.

These records, which will be called data, are more critical than ever in the current modern world. Now, data can be collected in massive amounts from multiple sources in a shorter time, nearly simultaneously. Humans do not need to wait for the explorer to return from the trip to learn about the newfound land's features like size, nature. This huge, live data can be collected, yet it is not very meaningful without proper analysis. This kind of analysis requires deep knowledge of statistics and analytics to gain information and appropriate visualization selection for improved data presentation. Regardless of numerous standard charts, due to the latest collectable data amount, a new custom visual is needed in analytical reports every now and then. Modern business intelligence and data analytics software tools have different approaches to this demand.

One of the main demands of today's business world is understanding employees' efficiency with their current performance and potential for future opportunities and responsibilities. That way, a business organization aims to optimize its human resource investment. An advantageous approach to analyze employee efficiency is to use a 9-Box Analyze. In this approach, all contributors can be grouped into nine main efficiency groups for further discussion.

In the scope of this thesis, modern business intelligence and data analytics tools' abilities to extend custom visuals will be analyzed by the example of desired 9-Box Grid visual.

2 Objectives and Methodology

2.1 Objectives

The main objective of this thesis is to compare the capabilities and extendibility of modern data visualization tools for customizations based on different needs of various companies or business units such as pricing, licenses, performance, and custom development.

The partial goals of the thesis are to compare some aspects of tools, create development environments, and develop at least one custom visualization.

2.2 Methodology

In the first part of this thesis, a comprehensive benchmark of business intelligence and analytics tools performs in the aspect of both data analysts (end-user) and business intelligence developers with the help of public surveys, research, and public market data.

Followed by explaining data types, visualizations, and their relations; the second part will contain custom visualization examples and their usage in various business units or dashboards and focus on a specific visualization development.

The raw data used in this thesis to show example visualizations and in the practical part created in Microsoft Excel. Each number in cells is produced by filling out with the "RANDBETWEEN" function of Excel. The randomness of the data ensures that the final output is unbiased, and there is no need for actual data for development.

In the practical part, well-desired visualization for talent management policies by decision-makers such as human resources departments or managers called 9-Box Grid will develop for the selected platform.

Deciding which application will be useful for developing custom visuals in this thesis is held by the Goal Programming (GP) method, which is a branch of Multi-Criteria Decision Analysis (MCDA). Individual features of the applications determine the output of the decision.

3 Literature Review

3.1 Data Types

3.1.1 Qualitative Data Types

Qualitative data types, also known as categorical data types, are used to define an object. Qualitative data are not countable or measurable data types. Furthermore, it is possible to separate the data into categories such as gender.

3.1.1.1 Nominal Data

Nominal data types represent the data that cannot be ordered. In the previous topic, the example was gender; it is a qualitative data type and nominal data. Female or male, it is not possible to state that the "male" gender is greater than the "female" gender; therefore, gender is an example of nominal data type.

3.1.1.2 Ordinal Data

Ordinal data types represent the data which already ordered by default. In the grading system, the best grade is "A", and let us say the next grade after "A" is "B." In this example, "A" is always accepted as a better grade than "B". This order comes from the alphabet itself and is an example of an ordinal data type. Another example comes with surveys. In the surveys, some questions expect an answer in a range that starts from 1 to 3 or 5. It is a declared range at the beginning, starting from "1 – Agree, 2 – Abstain, 3 – Disagree" or "1 – Extremely Agree, 2 – Agree, 3 – No Idea, 4 – Disagree, 5 – Extremely Disagree". It is possible to declare in the opposite order.

3.1.2 Quantitative Data Types

Quantitative data types stand for countable data types by default, such as numerical values. Any countable data is a representative of quantitative data type.

3.1.2.1 Discrete Data

Discrete data represents numeric variables that contain countable values between a beginning and an ending.

3.1.2.2 Continuous Data

Continuous data represents the numeric variables that start from a beginning to an end infinitely. A date can be an example of a continuous data type.

3.2 Visualization

Visualization is a method of creating visuals using data or information, and it is a meaning creation process with sensible data, which can be collected and transformed. It is an interpretation and making visible from an abstract one.

Visualization has found itself in various and serious real-world examples. The first known examples of visualization in history were in cartography, although it is uncertain. People visualized what they saw and then used the visuals, the knowledge for mapping, for the purpose of navigation.

The visualization field focuses on creating images that convey salient information about underlying data and processes. In the past three decades, the field has seen unprecedented growth in computational and acquisition technologies, which has resulted in an increased ability both to sense the physical world with very detailed precision and to model and simulate complex physical phenomena. (Charles D. Hansen, 2004)

3.3 Data Visualization

Humankind has been creating visual documents of its surroundings for tens of thousands of years-long before the invention of writing. Alongside naturalistic imaginary that attempts to capture what can be seen with our eyes, other visual representation methods, such as maps, were developed early in human history. (Juuso Koponen, 2019)

Data visualization is the graphical representation of information and data. Using specific methods, tools, or processes makes it possible to create visuals by collecting data or information. Created visuals can be interpreted to acquire knowledge in a variety of areas.

Data visualization is an extensive field at the crossroads of mathematics, computer science, cognitive and perception science, and engineering. Covering every discipline that shares principles with visualization, ranging from signal theory to imaging and from computer graphics to statistics, requires in itself at least one separate book. (Telea, 2015)

According to nature itself, it is not possible to see data. Data becomes possible to see, becomes achievable to interpret, and easy to understand when visualized. Therefore, the history of visualization started with cartography, extended by data visualization, and has been used in science, astronomy, analytics, statistics, economics, informatics, software development, art, marketing, medicine, etc. Nowadays, data visualization has been combined with big data. Therefore, using data visualization with Web 3.0 is possible, and it is still developing.

3.4 Data Visualization Types and Examples

There are several ways to visualize data with visualization tools. Some visualization examples are given as charts, plots, or tables with images.

A chart is a visual representation of data that is shown by shapes such as bars, circles, lines, etc. In charts, data can be categorized and represented by two different axes. Bars are a common and basic way to visualize data that can be used vertically or horizontally. Also, plots have similar usage but use dots/points. It is helpful for the detection and comparison of different numerical values in categorical form. Lines can be drawn between dots to create continuous visualization. Pie-type visualizations use a circle kind of area, and it is slightly more challenging to read than bars, still effectively categorizing data in one area separated.

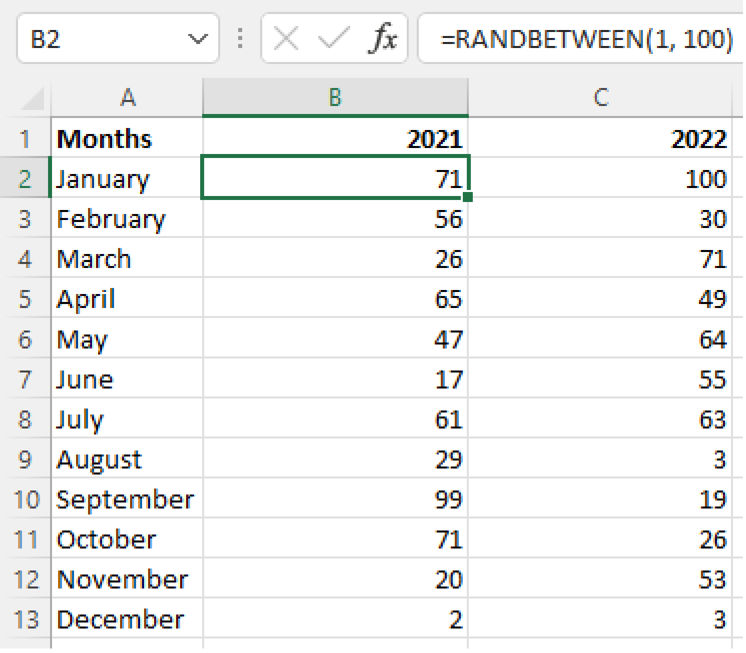
One way to visualize data and skim it is a table. It is the most common way to show data itself, usually raw. Nowadays, tables are being used to shape and prepare data itself and used as a data source.

In the following parts of the thesis, example data will be used for all graphical representations. For data preparation, Microsoft Excel365 software will be used. For graphical visualization, Microsoft Power BI will be used.

3.4.1 Creating an Example Data

Microsoft Excel365 is easy to use and create data. Later, created data will be used to visualize and show examples of commonly used visualizations. For the maintain of neutrality of the thesis, I declare that the aim of using an example(dummy) data is that there is no purpose to using actual data for showing graphical visualizations. Furthermore, the only intent of usage of Microsoft Excel and Microsoft Power BI is that I know how to use both software.

Figure 1 Creating the Example Data Table with Excel



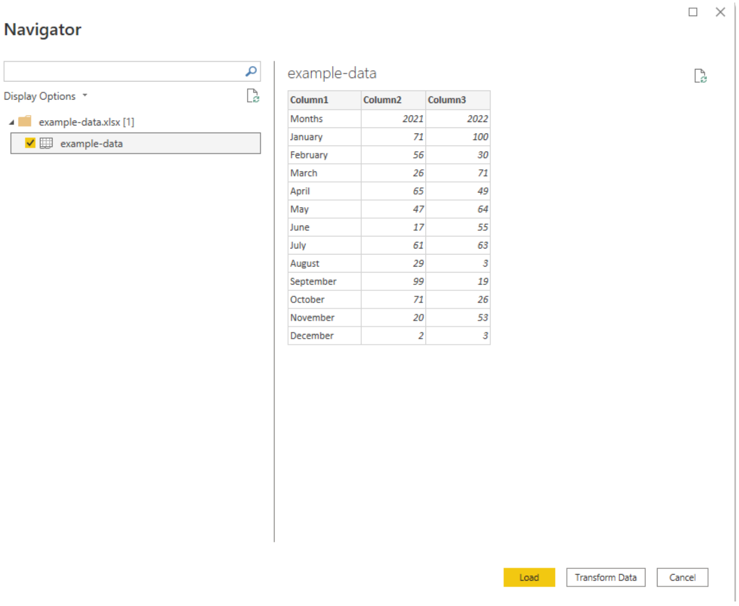
B2

=RANDBETWEEN(1, 100)

	A	B	C
1	**Months**	**2021**	**2022**
2	January	71	100
3	February	56	30
4	March	26	71
5	April	65	49
6	May	47	64
7	June	17	55
8	July	61	63
9	August	29	3
10	September	99	19
11	October	71	26
12	November	20	53
13	December	2	3

For creating a dummy dataset, I have decided to work with both text and numeric data. The primary columns are “Months”, “2021”, and “2022”. For random value columns only, numeric values are created between 1 and 100; therefore “RANDBETWEEN ()” function of Excel is used with two properties, 1 and 100. The last version of the function is: “RANDBETWEEN (1, 100)”. Actual month names are filled out with the “Months” column. Changes saved and example-data.xlxs file created.

Figure 2 Importing Example Dataset to Power BI

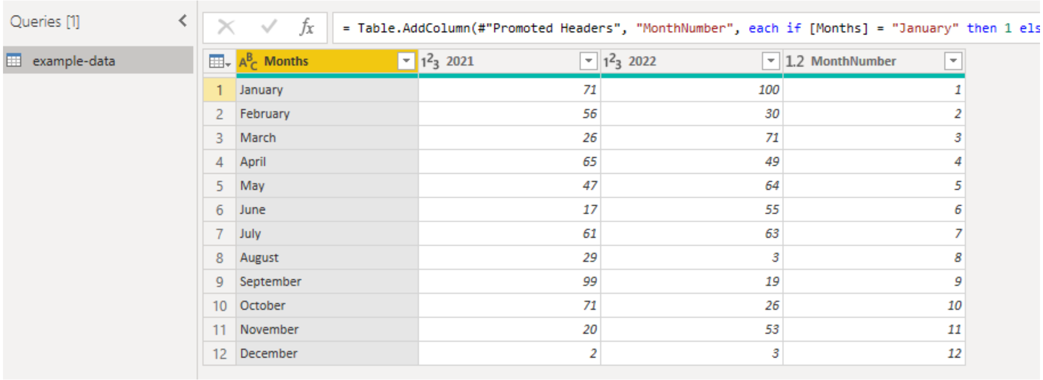


example-data

Column1	Column2	Column3
Months	2021	2022
January	71	100
February	56	30
March	26	71
April	65	49
May	47	64
June	17	55
July	61	63
August	29	3
September	99	19
October	71	26
November	20	53
December	2	3

To import the created dataset, the “Import data from Excel” functionality of Power BI was used. Navigator of Power BI makes it possible to examine data before importing. Now it is ready to consume data from the data set created. Then it will be possible to create visuals with the data.

Figure 3 MonthNumber added for Custom Sorting



```
= Table.AddColumn(#"Promoted Headers", "MonthNumber", each if [Months] = "January" then 1 els
```

	Months	2021	2022	MonthNumber
1	January	71	100	1
2	February	56	30	2
3	March	26	71	3
4	April	65	49	4
5	May	47	64	5
6	June	17	55	6
7	July	61	63	7
8	August	29	3	8
9	September	99	19	9
10	October	71	26	10
11	November	20	53	11
12	December	2	3	12

A custom sorting option was added with Power BI’s Power Query Editor. Hence, Power BI sorts the month names alphabetically. Instead, with a custom sorting option, now it is possible to sort by MonthNumber, starting from 1 to 12.

3.4.2 Bar Chart

Bar chart represents numerical values by points. It has two dimensions, x and y axis and it shows numeric data by categories. Also, a bar chart can be displayed horizontally or vertically. Bar chart usually being used to visualize the quantity quickly and easily.

Figure 4 Example of Clustered Column Chart

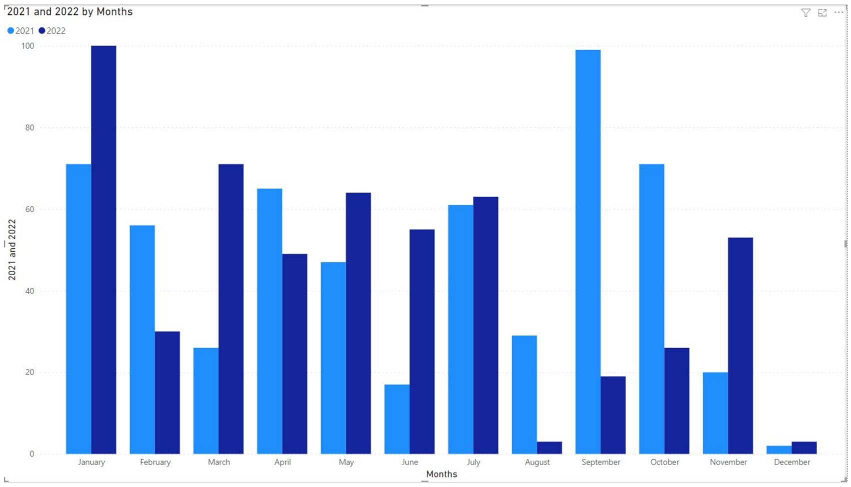


Figure 5 Example of Stacked Column Chart

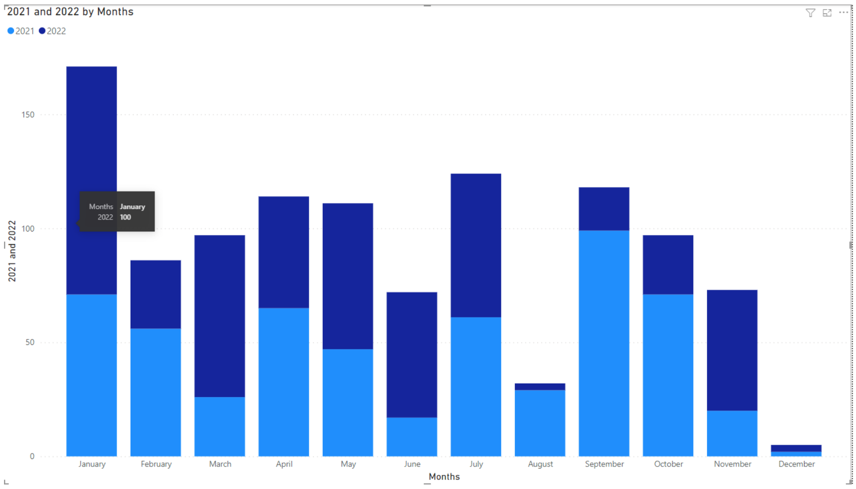


Figure 6 Example of Stacked Bar Chart

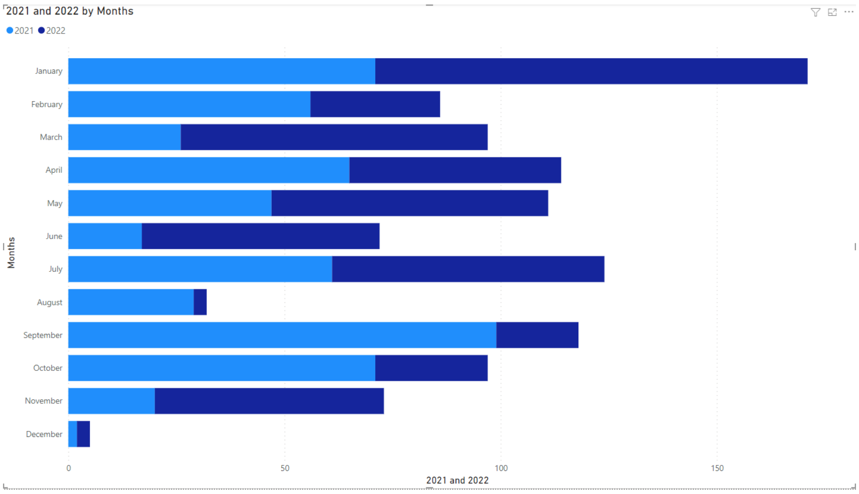
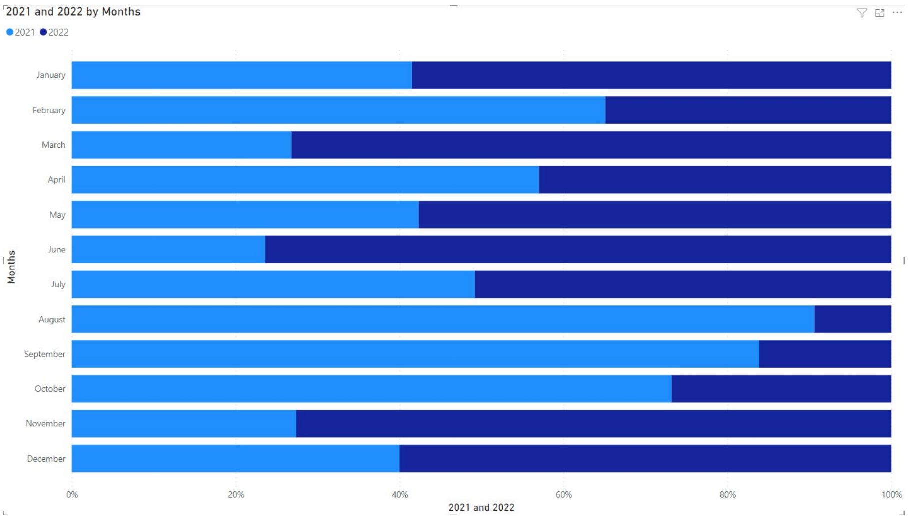


Figure 7 Example of 100% Stacked Bar Chart

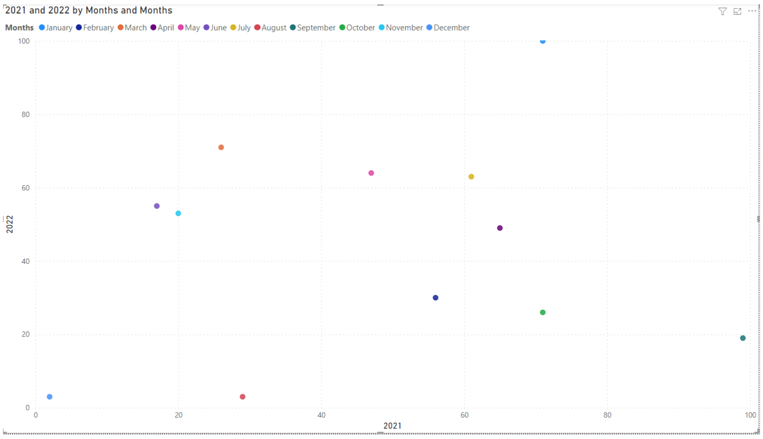


Bar charts are easy for our eyes to read. Our eyes compare the endpoints of the bars, so it is easy to quickly see the biggest category, the smallest category, and the incremental difference between categories. Note that, because of how our eyes compare the relative endpoints of the bars, it is essential that bar charts always have a zero baseline (where the x-axis crosses the y-axis at zero); otherwise, you get a false visual comparison. (Knaflic, 2015)

3.4.3 Scatterplot

A Scatter plot represents numerical values by points, and it has two dimensions, the x-axis, and y-axis, and shows numeric data by categories. A scatter plot usually being used to visualize a linear regression to show the maximum points of the values in the related category.

Figure 8 Example of Scatter Plot



Scatterplots can be useful for showing the relationship between two features because they allow encoding data simultaneously on a horizontal x-axis and vertical y-axis to see whether and what relationship exists. They tend to be more frequently used in scientific fields (and perhaps, because of this, are sometimes viewed as complicated to understand by those less familiar with them). Though infrequent, there are use cases for scatterplots in the business world as well. (Knaflic, 2015)

3.4.4 Line Chart

Line chart represents two different data by continuous lines. It has two dimensions, x, and y axis. A line chart is a visualization that can be easily understand and usually used to show continuous data changes such as price differences.

Figure 9 Example of Line Chart

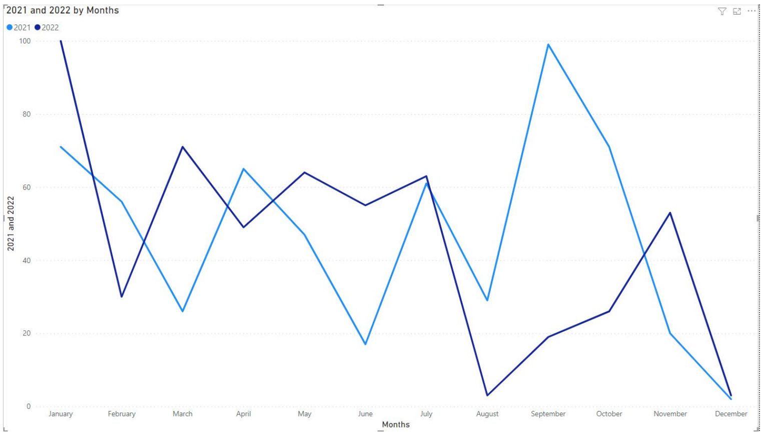
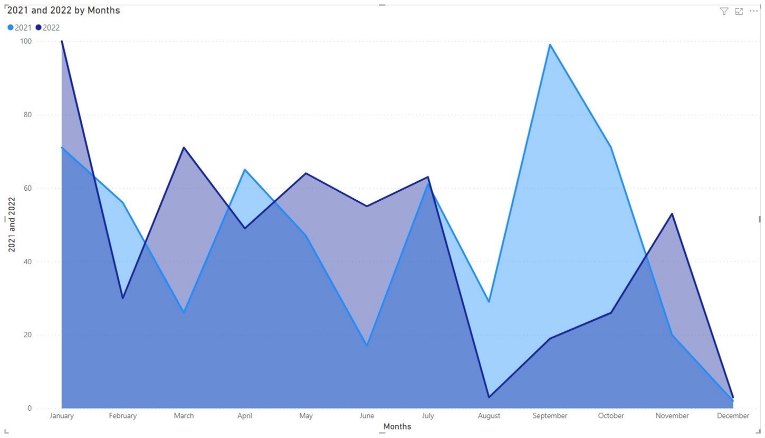


Figure 10 Example of Area Chart



Line graphs are most commonly used to plot continuous data. Because the points are physically connected via the line, it implies a connection between the points that may not make sense for categorical data (a set of data that is sorted or divided into different categories). Often, our continuous data is in some unit of time: days, months, quarters, or years. (Knaflic, 2015)

3.4.5 Pie Chart

A pie chart represents the data as a circle, slice by slice. The number of data set is not important because the pie chart divides all the sets one by one and visualizes them as slices. However, pie charts are not the most straightforward charts to understand. Hence, a horizontal bar chart would be better to show the same data with better graphical visualization.

Figure 11 Example of Pie Chart

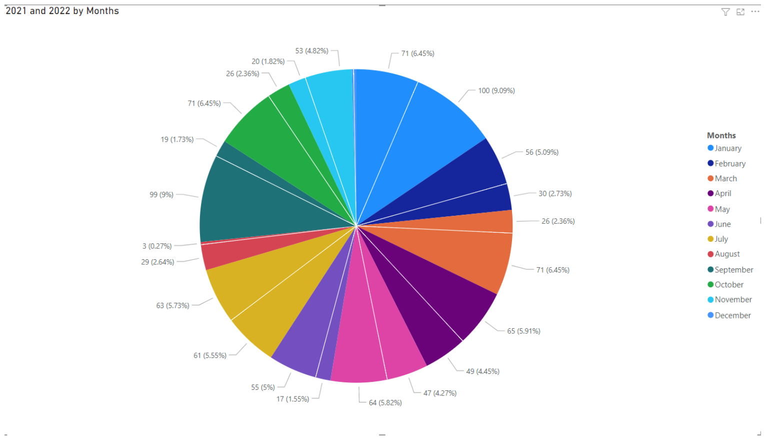
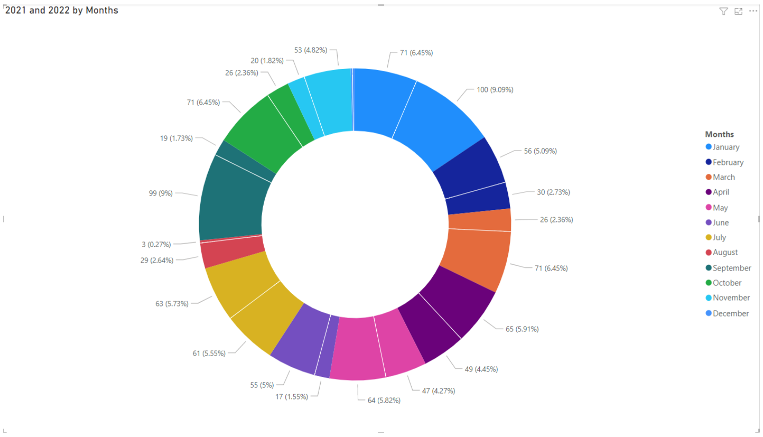


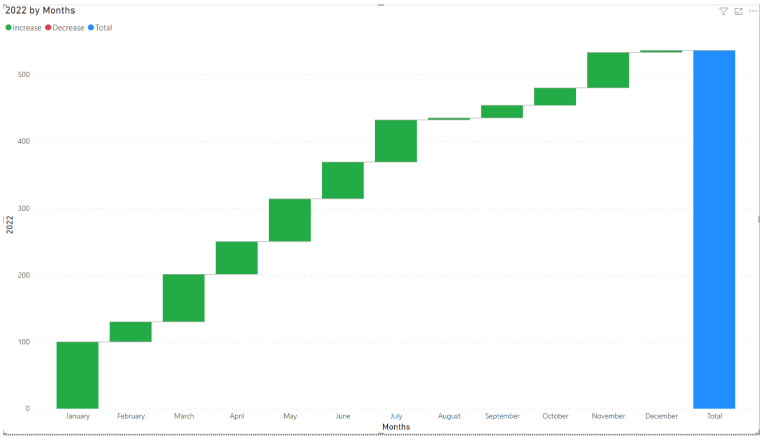
Figure 12 Example of Donut Chart



3.4.6 Waterfall Chart

The waterfall chart represents the numeric values by grouping them with a categorical value. The purpose of the waterfall chart is to show differences between numeric values over time. Usually, waterfall charts are being used to visualize and illustrate the cumulative effects of sequential or categorical values, by negative or positive.

Figure 13 Example of Waterfall Chart

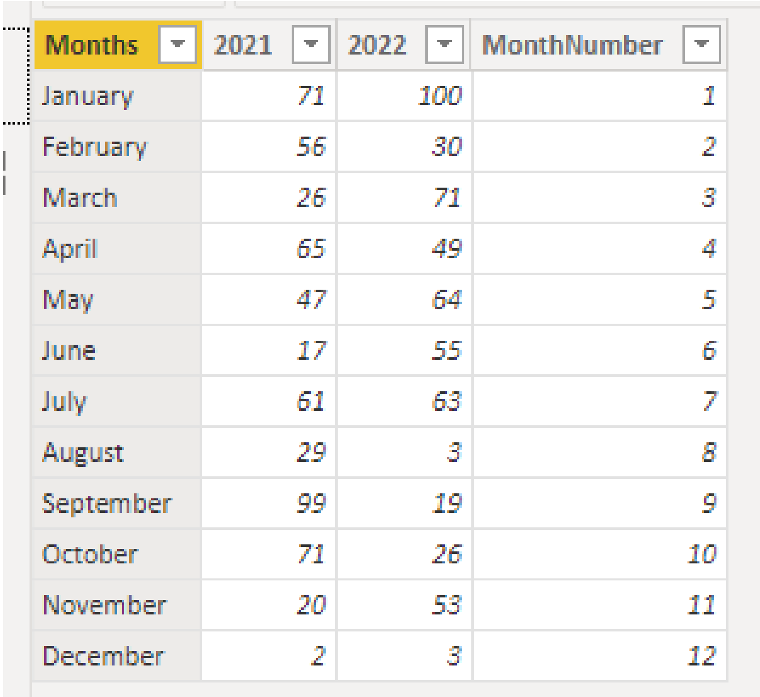


The waterfall chart can be used to pull apart the pieces of a stacked bar chart to focus on one at a time or to show a starting point, increases and decreases, and the resulting ending point. (Knaflic, 2015)

3.4.7 Table

The table represents the data itself in cells. It is possible to show in two dimensions, x and y axis, which are columns and rows in example *Figure 5*. In the example figure, numbers and letters are used and show that. A data table is basically a collection of verbal expressions of data. Each cell can contain various data, such as number, text, date, currency, etc. It is possible to create more variety of data sets.

Figure 14 Example of Data Table



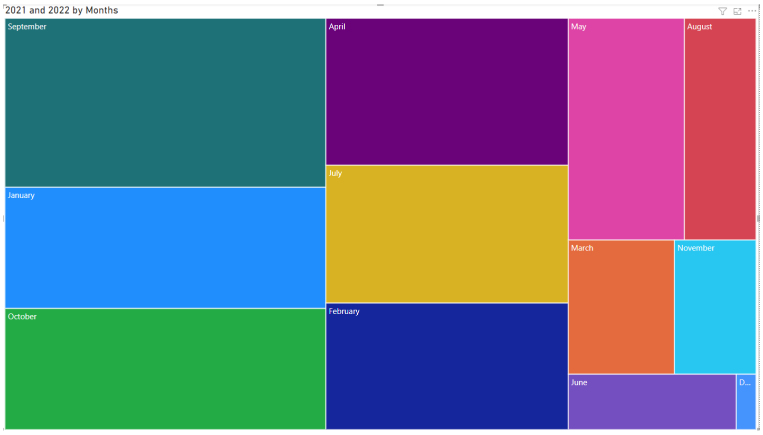
Months	2021	2022	MonthNumber
January	71	100	1
February	56	30	2
March	26	71	3
April	65	49	4
May	47	64	5
June	17	55	6
July	61	63	7
August	29	3	8
September	99	19	9
October	71	26	10
November	20	53	11
December	2	3	12

Tables interact with our verbal system, which means that we read them. When I have a table in front of me, I typically have my index finger out: I'm reading across rows and down columns or I'm comparing values. Tables are great for just that—communicating to a mixed audience whose members will each look for their particular row of interest. If you need to communicate multiple different units of measure, this is also typically easier with a table than a graph. (Knaflic, 2015)

3.4.8 Map

The map represents various data on an area, such as a world map or a small village. A map can show a data set in a circle as an area or show the data by points. Either a map can visualize an area in hexagonal pieces or squares.

Figure 15 Example of TreeMap



Maps draw readers into data that includes a spatial dimension while developing a stronger sense of place. Seeing the relative distance between points on a map or identifying geographic patterns in a choropleth map (where colored polygons represent data values) relays information to readers' eyes more effectively than text, tables, or charts. However, creating meaningful maps that draw our attention to key insights in data requires clear thinking about design choices. (Dougherty, et al., 2021)

3.5 Custom Data Visualization

Visualization has been created and used by people as a need. It is a result of the need to symbolize then visualize the information for later usage on demand. On the other hand, data visualization is a product of accumulated knowledge. Therefore, people use methods to visualize data that are either standard today or also that are specifically designed to visualize specific data.

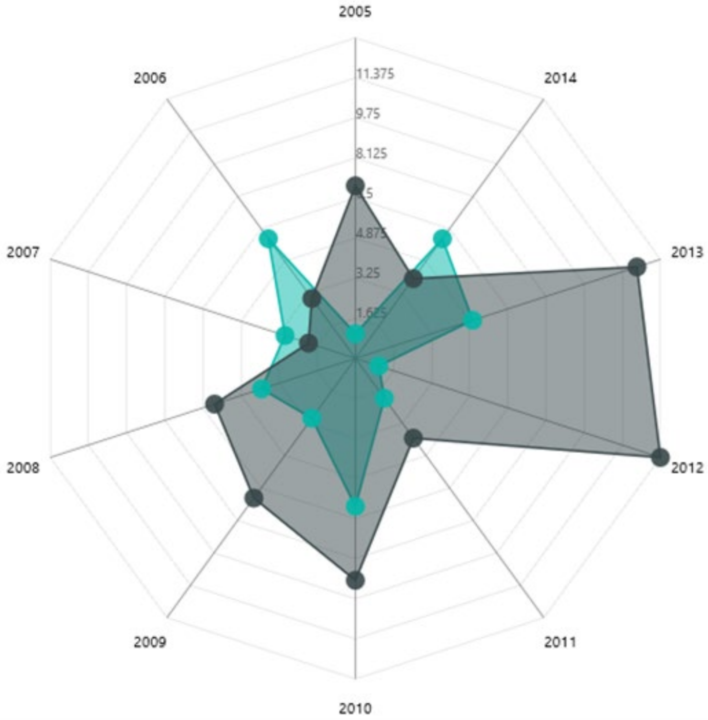
In the previous sections, some examples were already given for standard, in other words, common methods such as bar charts, scatter plots, or tables. In the continuous sections, custom visualization methods will be examined.

Custom visualizations aim to provide specific information with the data prepared specifically for the visualization itself. A custom visualization can either be an innovative design or a design that uses a combination of existing standard visualizations.

Custom visualizations help solve problems by their capabilities to make the data insightful and meaningful. Occasionally some data might be hard to visualize, and standard methods might be unfunctional or impossible to visualize. Alternatively, some data might be visualized if there was a custom-tailored visualization method. Thus, custom visualizations can perform simple and accurate results.

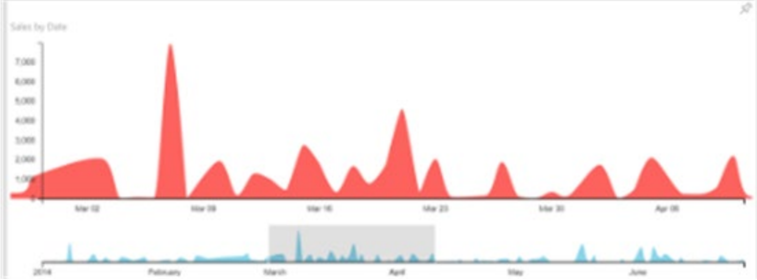
3.5.1 Custom Visualization Examples

Figure 16 Example of a custom visualization: Radar Chart



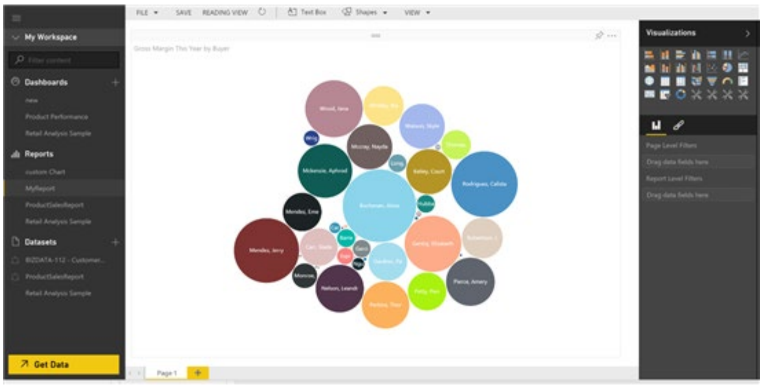
Source: (Microsoft Inc., 2015)

Figure 17 Example of a custom visualization: Advanced time-slicer



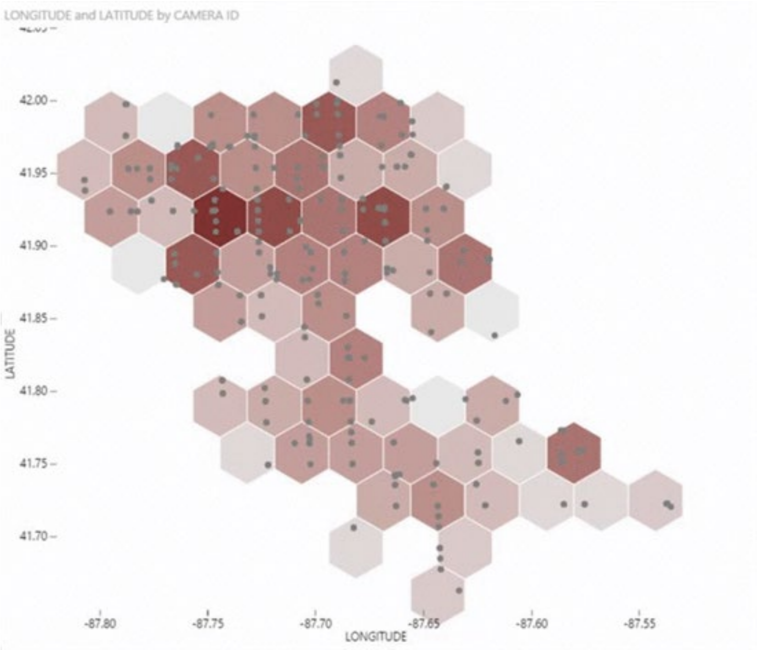
Source: (Microsoft Inc., 2015)

Figure 18 Example of a custom visualization: Bubble Chart for Power BI



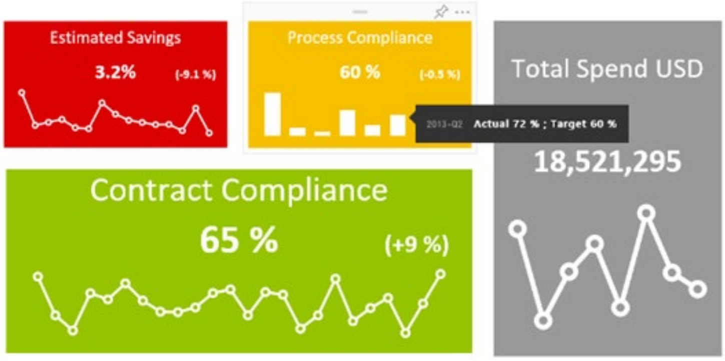
Source: (Microsoft Inc., 2015)

Figure 19 Example of a custom visualization: Hexbin Scatterplot



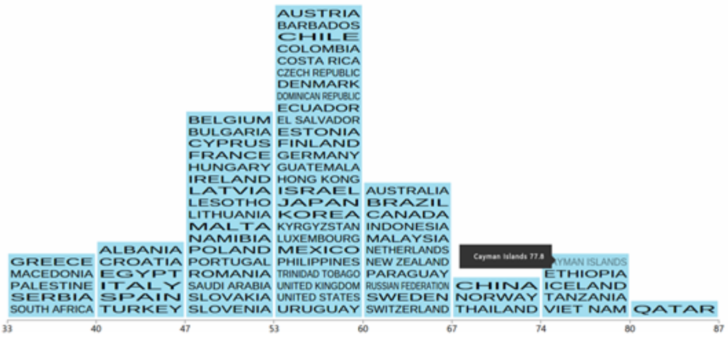
Source (Microsoft Inc., 2015)

Figure 20 Example of a custom visualization: KPI indicator with status, deviation, and history



Source: (Microsoft Inc., 2015)

Figure 21 Example of a custom visualization: Labelled Histogram



Source: (Microsoft Inc., 2015)

3.6 Data Visualization Tools

The development of technology over time has affected visualization like everything else. The visualization process evolved to another level with the visualization tools and programs. Measurable data points increased, data got bigger and bigger. This evolution and increase have created the need for proper data processing as a requirement of visualization.

Data is an asset that all enterprises can profit from, but only if firms have a world-class customer data management platform. To develop an effective strategy, you need to understand how customer data management has helped other enterprises and how it will evolve over the next decade. During the discovery process, you will need to identify the fundamental concepts of a world-class customer data management platform, establish a market landscape, and understand where specific benefits will come from. (Gualtieri, et al., 2014)

Visualization processes are being performed with computers today; therefore, the importance of data has become obvious because visualization tools need accurate data to visualize.

In this thesis, I will present the contemporary programs being used to visualize data, their techniques to visualize and I will focus on the development of a custom visualization tool, a 9 Box Grid.

3.6.1 Microsoft Excel

Microsoft Excel, spreadsheet application launched in 1985 by the Microsoft Corporation. Excel is a popular spreadsheet system, which organizes data in columns and rows that can be manipulated through formulas that allow the software to perform mathematical functions on the data. (Britannica, 2016)

Excel from Microsoft and Excel-like programs such as Google Sheets, Apache OpenOffice Calc, LibreOffice Calc are being used to manage spreadsheets. Although they sometimes lost their popularity against each other, what they served remained a constant need of people, and this need continued to increase.

With the development of the internet and technology over time, programs exist today that are being used not only for spreadsheet management but also for managing, creating, editing, and visualizing data. Software companies also created other programs just for specifically for data analysis and business intelligence.

3.6.2 Microsoft Power BI

Power BI is a business intelligence tool created by Microsoft to create visualizations from data, create reports, and analyze data. Power BI combines business analytics and data visualization in its software by the power of its marketplace and dataflow.

Power BI is a collection of software services, apps, and connectors that work together to turn your unrelated sources of data into coherent, visually immersive, and interactive insights. Your data may be an Excel spreadsheet, or a collection of cloud-based and on-premises hybrid data warehouses. Power BI lets you easily connect to your data sources, visualize, and discover what's important, and share that with anyone or everyone you want. (Microsoft Inc., 2022)

Power BI brings all the visualization power in three ways. It is possible to use for business intelligence and data analysis operations in various options. The diverse ways to use Power BI creates different opportunities for the people in actual use cases. As a developer, it is possible to use Power BI to handle database operations by API’s. As an analyst, it is possible to create reports and dashboards for daily operations. Reaching Power BI is possible through a desktop version, a mobile version, and an online version called Power BI service.

Power BI, Microsoft, is an organization of business analytics tools used to analyze data and share information in reports and dashboards. User data in a variety of ways - spreadsheets, text files, databases, etc. Create Power BI input. Data sets are created by converting data provided by users. Users determine data conversion. This step is used to remove errors and unwanted data, correct formatting, prepare additional analysis data by sorting them into appropriate standard forms, etc. Depending on the report and the dashboard being created, filtering data to include only relevant pieces focuses only on essential data. (Madala, 2021)

Power BI makes it possible to work with different data sources, various data types and handle everything in one place. With the Power BI Query option, it is possible to manipulate the data after acquiring, as demonstrated earlier.

3.6.3 Tableau

Tableau Software is an American computer software company based in Seattle, WA, USA. Produces BI-based data consulting products. The company was established in the Department of Computer Technology at Stanford University between 1997 and 2002. (Madala, 2021)

Tableau is a data visualization and business intelligence software powered by Tableau Software LLC. Tableau is used for reporting and analyzing data. Tableau includes making machine learning, statistics, natural language.

Tableau offers different solutions for different platforms and operations. Tableau Desktop to work with structured data, dashboards, reports, and visualizations. Tableau Server for distributing data and interacting with it is an excellent choice for business enterprises. Tableau servers can quickly connect and process the data, and no scripting knowledge is needed. Tableau Online is an analytics platform fully hosted in the cloud, which provides a platform that makes it possible to create and share. Also, Tableau brings its tools such as developer tools or sharing tools, but with Tableau, there is no need for prior programming knowledge to visualize or create reports.

3.6.4 Marketplace of the Applications

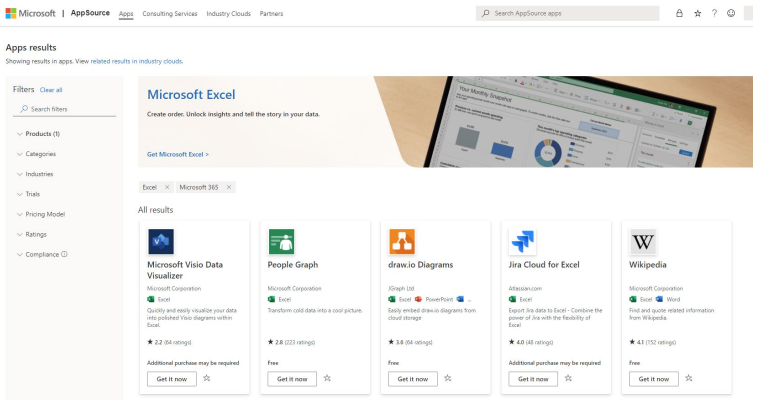
Marketplaces are online shops where applications or tools can be found for the related software. Each software companies that examined in this thesis has its marketplace to publish tools, visualizations, or apps.

3.6.4.1 Marketplace of Excel and Power BI

Microsoft Inc. has one store that users can filter by software name and search the tools created for Excel and Power BI software and other applications. It is possible to get a free or paid application for both programs under Microsoft's secure application market platform. Also, more filter options are available such as category by functionality, category by industry or license, etc. After the log-in process, purchasing or getting an application from the store for a related program is possible.

Applications in the marketplace are developed by Microsoft, other companies as well as individual contributors. It is the same for both Excel and Power BI. That allows the users or companies to develop and publish their own tools, application on a secured marketplace by Microsoft by free or paid license.

Figure 22 Example of Microsoft Application Market for Excel



Apps results

Showing results in apps. View related results in industry clouds.

Microsoft Excel

Create order. Unlock insights and tell the story in your data.

Get Microsoft Excel >

All results

Microsoft Visio Data Visualizer
Microsoft Corporation
Excel
Quickly and easily visualize your data into polished Visio diagrams within Excel.
★ 2.2 (64 ratings)
Additional purchase may be required

People Graph
Microsoft Corporation
Excel
Transform cold data into a cool picture.
★ 2.8 (223 ratings)
Free

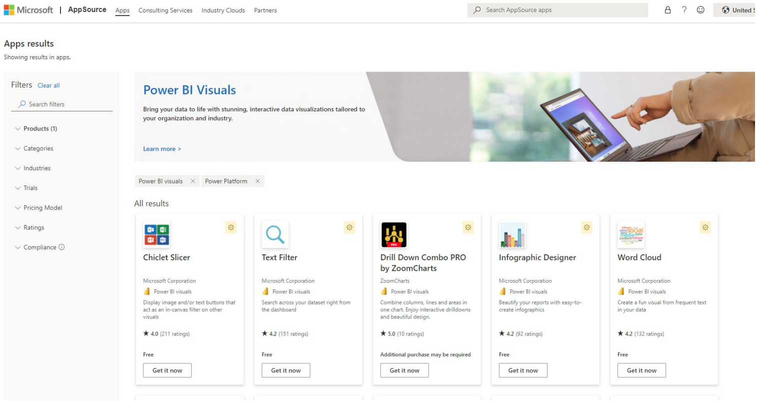
draw.io Diagrams
JGraph Ltd
Excel PowerPoint ...
Easily embed draw.io diagrams from cloud storage
★ 3.6 (64 ratings)
Free

Jira Cloud for Excel
Atlassian.com
Excel
Export Jira data to Excel - Combine the power of Jira with the flexibility of Excel
★ 4.0 (48 ratings)
Additional purchase may be required

Wikipedia
Microsoft Corporation
Excel Word
Find and quote related information from Wikipedia.
★ 4.1 (152 ratings)
Free

Source: appsource.microsoft.com

Figure 23 Example of Microsoft Application Market for Power BI



Apps results

Showing results in apps.

Power BI Visuals

Bring your data to life with stunning, interactive data visualizations tailored to your organization and industry.

All results

Chiclet Slicer
Microsoft Corporation
Power BI visuals
Display image and/or text buttons that act as an in-canvas filter on other visuals
★ 4.0 (211 ratings)
Free

Text Filter
Microsoft Corporation
Power BI visuals
Search across your dataset right from the dashboard
★ 4.2 (151 ratings)
Free

Drill Down Combo PRO by ZoomCharts
ZoomCharts
Power BI visuals
Combine columns, lines and areas in one chart. Enjoy interactive drilldowns and beautiful design.
★ 5.0 (10 ratings)
Additional purchase may be required

Infographic Designer
Microsoft Corporation
Power BI visuals
Beautify your reports with easy-to-create infographics
★ 4.2 (92 ratings)
Free

Word Cloud
Microsoft Corporation
Power BI visuals
Create a fun visual from frequent text in your data
★ 4.2 (132 ratings)
Free

Source: appsource.microsoft.com

3.6.4.2 Marketplace of Tableau

Tableau has its own marketplace for own software called Tableau Exchange. The Tableau store has filters accordingly to Tableau applications. Filtering by license is optional, which means possibility to get free or paid tools from store. After singing in process, store allows the users to get the tool which demanded.

Tableau Exchange marketplace has the tools developed by Tableau itself and more tools developed by individual companies and contributors. It is possible to develop and publish under free or paid license in secure Tableau Exchange marketplace.

Figure 24 Example of Tableau Exchange Application Market

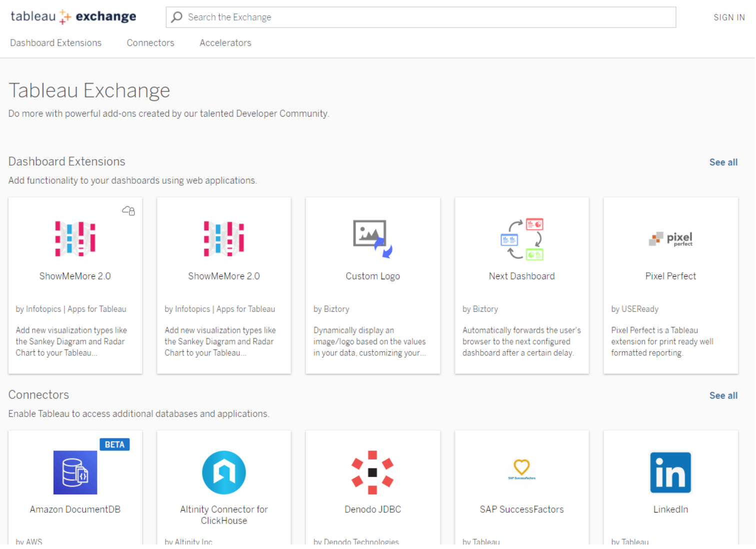


Tableau Exchange

Do more with powerful add-ons created by our talented Developer Community.

Dashboard Extensions

Add functionality to your dashboards using web applications.

ShowMeMore 2.0
by Infotopics | Apps for Tableau
Add new visualization types like the Sankey Diagram and Radar Chart to your Tableau...

ShowMeMore 2.0
by Infotopics | Apps for Tableau
Add new visualization types like the Sankey Diagram and Radar Chart to your Tableau...

Custom Logo
by Biztory
Dynamically display an image/logo based on the values in your data, customizing your...

Next Dashboard
by Biztory
Automatically forwards the user's browser to the next configured dashboard after a certain delay.

Pixel Perfect
by USEReady
Pixel Perfect is a Tableau extension for print ready well formatted reporting.

Connectors

Enable Tableau to access additional databases and applications.

Amazon DocumentDB
by AWS

Altinity Connector for ClickHouse
by Altinity Inc

Denodo JDBC
by Denodo Technologies

SAP SuccessFactors
by Tableau

LinkedIn
by Tableau

Source: exchange.tableau.com

3.6.5 Benchmark

Power BI and Tableau software have similarities and differences in some key features. The first and most apparent difference is the two software. Both have similar solutions; both have individual and enterprise packages. Even so, Power BI seems more affordable than Tableau due to the possibility of buying Microsoft Office365 and Power BI as a whole package. On the other hand, Tableau offers per user basis.

Table 1 Benchmark comparison of Power BI and Tableau

No.	Comparison	Power BI	Tableau
1	Definition	Power BI is the business analytics tool to analyze the business and derive insight from it	Tableau is the business intelligence and data analytics tool for generating reports and data visualization with high flexibility
2	Data Sources	Limited access	Wide range of accessibility
3	Data Capacity	Up to 10GB for each workspace, cloud (Azure) needed over 10GB	Up to billions of rows due to structure of storing data
4	Data Management	Real time data access	Need specification with menu
5	Machine Learning	Integrated Azure	Built in with Python
6	Performance	Limited volume of data	Huge volume of data
7	Users	Beginner and experienced users, easy to use and learn	Usually experienced data analysts, slightly harder to use
8	Price	Significantly lower prices according to Tableau, and free use option for individuals Starter price: 9,99$ (Basic)	High prices according to Power BI, only limited trial version Starter price: 70,00$ (Basic)
9	Customer (Slintel LLC., 2021)	51,725 companies	63,408 companies
10	Market Share (Slintel LLC., 2021)	12.86%	15.77%

Since Power BI is a Microsoft product, it comes with an in-built Office 365 integration. It is available with enterprise plans which make a massive difference in the market for the companies. Enterprise packages of Microsoft include Office, Exchange, OneDrive, and SharePoint, which allows using Power BI with other tools easily and fully integrated.

Visualizing the data and creating insight is vital for business intelligence. Power BI can import data while generating reports that are fast real-time data processing. On the other hand, Tableau offers powerful tools for transforming data into actionable insights with compelling visuals. Users can build informative dashboards and perform a wide range of ad-hoc analyses with a few clicks.

Developing a custom visualization or dashboard is possible with both software. Both are customizable in their setup and knowledge requirements.

Microsoft has already implemented all the security features for its products. That makes Power BI a secure application. Data protection is crucial, and Power BI naturally offers a highly secure environment. Tableau established a visualization environment that focuses on, not security.

Support is also essential for the basic needs of new users and complex solutions for experienced users. Power BI brings to the table various options from Microsoft by default. Tableau offers different packages according to subscription.

Eventually, after consideration of all prior and other topics, due to free usability, security, and easy to develop options, Power BI will be the software for developing 9-Box Grid in our case.

3.7 9-Box Visualization

The 9-Box Grid, also referred Nine Box Grid/Matrix, is a tool that is used to evaluate and plot two different metrics in one view. Usually, it has been used for talent management to assess potential leadership development and succession planning of employees.

Succession planning is essentially the process of identifying and coaching potential future leaders. It has a vital role in the overall long-term success of a company. Often it can be an area of strategic planning that gets overlooked and placed on the back burner when it comes to priorities. (WorkDove)

Well, planning on the development of employees is one of the keys to success. Evaluation of the performance and potential of an employee may help the organizations to prepare themselves for the future. Therefore, organizations are trying to detect the strong and weak sides of the employment process over time.

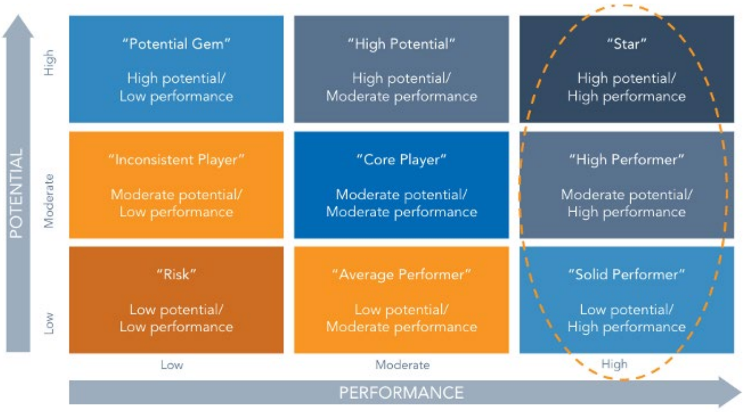
When assessing performance or otherwise considering the value of an individual to an organization, leaders should assess two dimensions: the current contribution made by the individual and their future potential. The performance of the employees in the future is as much as important their performance today.

3.7.1 How 9-Box Tool Works?

The 9-Box Grid contains two main categories: *Performance* and *Potential*. Each category can be assumed to be one of the axes of a matrix. Moreover, each axis contains three boxes. A 9-Box Grid can be described as a 3x3 matrix.

Performance can be described as sustained business results demonstrated over time. Potential can be described as readiness, willingness, and the ability to grow into a future job as determined by functional expertise, aspiration, required competencies, and learning agility. (Los Angeles Unified School District)

Figure 25 Example of the 9-Box Grid


POTENTIAL
High
Moderate
Low
"Potential Gem"
High potential/ Low performance
"High Potential"
High potential/ Moderate performance
"Star"
High potential/ High performance
"Inconsistent Player"
Moderate potential/ Low performance
"Core Player"
Moderate potential/ Moderate performance
"High Performer"
Moderate potential/ High performance
"Risk"
Low potential/ Low performance
"Average Performer"
Low potential/ Moderate performance
"Solid Performer"
Low potential/ High performance
Low
Moderate
High
PERFORMANCE

Source: (WorkDove)

For better visualization in minds, there is one 9-Box Grid example above. The horizontal axis usually measures performance, and the vertical axis measures potential. Under both categories, each box has its range of grades, which are *Low*, *Moderate*, and *High*. Each box has its explanation and reality.

Names of the axes:

- Horizontal axis (x); Performance
- Vertical axis (y); Potential

Names of bottom-line boxes:

- Bottom line left box points Low Potential and Low Performance box, which called “Risk” or “Under Performance”.
- Bottom line middle box points Low Potential and Moderate Performance, which called “Average Performer” or “Effective”.
- Bottom line right box points Low Potential and High Performance, which called “Solid Performer” or “Trusted Employee”.

Names of middle-line boxes:

- Middle line left box points Moderate Potential and Low Performance box, which called “Inconsistent Player” or “Dilemma”.
- Middle line middle box points Moderate Potential and Moderate Performance, which called “Core Player” or “Core Employee”.
- Middle line right box points Moderate Potential and High Performance, which called “High Performer” or “High-Impact Performer”.

Names of top-line boxes:

- Top line left box points High Potential and Low Performance box, which called “Potential Gem” or “Enigma”.
- Top line middle box points High Potential and Moderate Performance, which called “High Potential” or “Growth Employee”.
- Top line right box points High Potential and High Performance, which called “Star” or “Future Leader”.

Under Performer (Risk)

The individuals in this box have low potential and low performance.

- *Poor performance; spotty track record of delivering results; doing just enough to get by; and not considered ready, willing, or able for future roles.*
- *These people are capable of sinking your organization.*
- *Be careful not to make the mistake of investing in more training resources rather than moving them out of the organization, or at least out of the key position they occupy today.*
- *Find a more appropriate assignment for them.*
- *Sometimes employees in this category may be "stuck" due to issues they perceive to be beyond their control – anything ranging from personal (e.g., family crisis, life change) to professional (e.g., conflict with a co-worker, discomfort with a work practice).*
- *In a few cases, your inquiry may reveal hidden potential toward a path different from the one prescribed by their current role. Uncovering these disconnects often leads to a new understanding of what role the employee should be in. The Under Performer in this case is a mismatch and needs to be reassigned.*
- *An often-unforeseen consequence of not dealing with Under Performers is that they can form a sort of roadblock in your organization, keeping others from realizing their full potential. Because of this, it is important to identify and remove the blockers, poor performers with a limited future who stand in the way of potential stars.* (Los Angeles Unified School District)

Average Performer (Effective)

The individuals in this box have low potential and moderate performance.

- *Have a valued, but narrow and non-transferable skill set; limited to current role; solid performance; comfortable with where they are.*
- *The ideal path for Effective employees is to move up/out. The Effective category refers to those performing acceptably and possessing limited potential for future growth.*

- *Depending on short-term and long-term business priorities and organization goals, sometimes you may want to leave this category alone; they may not exceed expectations, but they are steadily reliable.*
- *It is recommended though to push to formulate action plans for this group to improve performance and/or enhance the limited potential they display.*
- *Put the ball in their court rather than invest development dollars in people with limited potential. If, after working their action plan, the employee can move up, then you've achieved success with a minimal outlay of resources.*
- *Perhaps other roles exist in the organization where they can continue to perform but do so with more potential for the future.* (Los Angeles Unified School District)

Solid Performer (Trusted Employee)

The individuals in this box have low potential and high performance.

- *Recognized for a valued, unique, and expert skill set; strong performance; can exceed expectations; can serve as seasoned advisors; thought leaders who typically enjoy their area of expertise and do not typically desire upward mobility.*
- *These individuals are exceeding expectations along Performance but failing along Potential. They are high-performing Backbones in your organization who possess limited potential.*
- *Help your Trusted Professionals to reach their potential. These are the high-value experts that are the go-to people when there are problems. They are performing extremely well in their current role, and the classic mistake in management practice has been to promote these individuals, thereby achieving the oft-maligned "Peter Principle" – promoting a person into a role where they perform incompetently. Instead of risking this blunder by investing developmental dollars on an individual that you have already identified as limited in potential, consider taking the following actions:*
    - *Encourage their retention as a key asset in their present role. Watch for signs of boredom, lack of challenge and other retention risks. Provide recognition and rewards for their accomplishments.*

  - *Look for ways to publicly acknowledge their efforts. Have them take the lead on presenting information or explaining processes to others (corporate presentations, participation at external conferences, etc.).*
  - *Provide them with opportunities to develop in places where they can grow a deeper and broader skill set and knowledge base. Utilize their assets toward teaching or coaching others.* (Los Angeles Unified School District))

Inconsistent Player (Dilemma)

The individuals in this box have moderate potential and low performance.

- *Low or no demonstrated track record; future potential is unclear; may be trying hard but struggling to achieve results; match between the role and their skills is questionable.*
- *The other category that should move up/out is Dilemma. These are employees who have some potential to be great yet are not high performers. These Dilemmas pose unique challenges for your succession plan.*
- *If they are new to the organization, consider reviewing their on-boarding experience. Was something poorly communicated during orientation? Is there a misunderstanding about job expectations? Are there disconnects between recruitment expectations and the realities of the role? New members to an organization often find themselves in this particular box because something has gone wrong.*
- *Alternatively, you may have a Dilemma who is rudderless in your organization. Seek out root causes for the performance issues and encourage the employee to develop and own an action plan for remedying deficits.*
- *Dilemmas benefit greatly from a peer mentor who can guide them through the predicament they are facing.*
- *Assessing the role match is key. If addressing performance barriers and action planning do not work to move them up in the Nine-Box, then moving them out to a different role is another option.* (Los Angeles Unified School District)

Core Player (Core Employee)

The individuals in this box have moderate potential and moderate performance.

- *Backbone to success of business and team.*
- *Well placed with opportunity to grow within current role.*
- *Recognize that your Core talent does not need to be pushed at this time. It's acceptable for them to stay where they are. Until they're ready for that next step, here are some actions you can take:*
    - *Provide coaching and training that builds both technical expertise and leadership skill*
    - *Give them short-term assignments or projects that expose them to the types of challenges they'll face at the next level; gauge their reaction to the experience*
    - *Praise their accomplishments in the present role and build trust with them so they'll let you know when they're ready to make the next move*
    - *Ensure that they know they are valued, listen to their ideas and monitor their behavior for signs of complacence or dissatisfaction* (Los Angeles Unified School District)

High Performer (High-Impact Performer)

The individuals in this box have moderate potential and high performance.

- *Outpace others; very high performance and consistent results; worry-free candidates for future growth and development.*
- *The High Impact Performer group shows some potential for having a greater impact. Often, it's a matter of readiness that prevents them from moving into those larger roles. Accordingly, the focus should be on development and preparation for longer term opportunities.*
- *Look to provide them with "stretch" assignments – projects that may require them to do things that they don't already know how to do or that require skills and abilities that are beyond their current role.*
- *Challenge them to be high performers in a higher profile role.*
- *Find a mentor for them that is at least one level up on your organization chart.*

- *Promote relationship-building among other high performing talent in your 9-box.*
- *Make short-term rotations or job swaps readily available to them; give them a chance to operate in a completely new role; and assess reactions to those experiences.* (Los Angeles Unified School District)

Potential Gem (Enigma)

The individuals in this box have high potential and low performance.

- *Highly driven; ambitiously aspire to move swiftly upward in the organization; junior to the organization or new to the industry; do not have a fully demonstrated track record of performance.*
- *These individuals are exceeding expectations along Potential but failing along Performance. They are the Problem Children who are high potentials ("hi-po's") but who aren't performing up to standard. These Enigmas are much harder to crack – they are employees who have all the potential for greatness yet fail to meet expectations. They are the rookie sensation that flops in the big leagues; the brilliant young minds that can't make it; the disappointing Olympian that comes home with no medals. Several action steps should be taken to address these cases.*
    - *Find the root cause of the failures in performance and collaborate on a development plan to address identified deficiencies. If the issue is more about poor fit than role failure, consider moving them to different roles in the organization. After you have taken actions to address any issues, review the assessment you did on their potential. Are these employees truly hi-po's in your organization?*
    - *Make their developmental plan contingent on performance improvement.*
    - *Include efforts to give them the technical skills they need to perform at the required level.*
    - *Ensure that any investment in development only occurs after measurable improvements are made. If these employees do not respond, consider moving them to another role or out of the organization.* (Los Angeles Unified School District)

High Potential (Growth Employee)

The individuals in this box have high potential and moderate performance.

- *High growth employees: high capacity and ambition to expand role, scope, and complexity; solid performance most of the time and at times exceed goals; high global mobility and willingness to go where the opportunity is.*
- *The last category of your stars is the Growth Employee. These employees in your talent pool may not have achieved in performance what they reveal in potential. The key is to focus on competency gaps and remove performance barriers in an effort to shift this group from "good to great."*
- *Challenge them with a start-up assignment where they have responsibility for creating a new process or opening a new market; make it a high-profile activity that no one else has done.*
- *Consider matching them to a higher performing mentor who can help them along the path.*
- *Make short-term job rotations or job swaps readily available to them; give them a chance to operate in a completely new role; and assess reactions to those experiences.* (Los Angeles Unified School District)

Star (Future Leader)

The individuals in this box have high potential and high performance.

- *Best of the best; exceptional performance; deliver consistent and sustainable results; possess enormous drive for achievement and ambition; stellar role models for both "what" and "how" results are achieved.*
- *These are people in your organization who are realizing their full potential while at the same time performing at their peak. This is the dream team of organization players. They are well-equipped to take on any assignment and poised to transform your organization into a better version of itself.*
- *Caution should be taken with this group, for they can easily become bored and to your dismay may be lured elsewhere. These are some actions you can take to retain them.*

- *Find ways to make them shine. Give them challenging, stretch assignments doing things nobody else has done.*
- *These employees should be tasked with high-stakes, high-profile assignments.*
- *Earmark them for start-ups or spin-offs where they will add even more tools to their arsenal while helping to take your organization in new directions.*
- *Identify parts of your organization that may need financial or operational turnaround and assign a Future leader to transform performance.*
- *Grant them access to exclusive training opportunities, send them to national or international conferences, and appoint them to high-profile committees in the organization.*
- *Allow them elite access and exposure to the CEO, senior leaders, and the governance structures in your organization.* (Los Angeles Unified School District)

3.7.2 Who Uses 9-Box Tool?

The 9-Box Grid tool can be helpful for organizations as well as individuals. Each category and each box of the 9-Box Grid Tool should be adequately defined at both levels.

An organization unit, such as human resources, must define what those boxes mean for the company. What are the requirements for each box? How does the company declare its scores for the requirements? A relevant point of contact may be a team manager, and the manager should describe requirements. Then, the knowledge can shape the future performance reviews in the team with the 9-Box Grid Tool. Also, in an individual scope, each box should be clearly defined, and the requirements or measures must be described. Then, for example, a plan can be set for the future and can be declared with specific goals described clearly. Alternatively, an individual, such as a future employee, can set their own goals according to the definitions.

Decision-makers such as managers or human resources representatives can use the 9-Box Grid while assessing the employees. They can use the matrix to determine the individual abilities of an employee in the company. Basically, the aim of the 9-Box Grid is helping to decision-makers to decide who deserves a promotion, a bonus for some companies, professional support such as a mentor, or sometimes termination of a contract.

The 9-Box Grid is a simple tool with its structure. The crucial part of the practical usage of the 9-Box Grid tool is to know how definitions work. When it comes to evaluations, definitions of the talent and performance profile differ for each organization. There would be similarities, but still, the key measurements will be varied.

The measurements are the variables for getting an end score for the 9-Box Grid tool. Because the 9-Box Grid needs two-dimensional data points at the end. But processing all the variables to create a final score is actual work to be done.

The primary manner of creating accurate data collection is open and honest communication between individuals and decision-makers. Strengths and weaknesses need to be clarified to make an accurate decision and evaluate correctly. Decision-makers must understand how the organization's talent and performance profiles work. Then, every piece of information may combine to be used with the 9-Box Grid for the evaluation.

Once the decision-makers understand how the talent performance evaluation profiles should be and the criteria for each metric, the time comes to collect the necessary information. Placing the employees in one of the nine talent boxes according to their performance and potential depends on their work, their performance in the past, assumptions about their future, their willingness to improve, their abilities, and so on. In the long-term, everything is for to make sure each potential has led correctly. Therefore, the 9-Box Grid tool also brings clues and answers to some questions such as which individual needs to be mentored, who needs a change in self-development, how effective the decision taken in the past, etc.

4 Practical Part

The practical part of this thesis will focus on creating a custom visual tool. According to the benchmark section, due to free usability, security, and freedom of development, Power BI will be the development tool.

Developing a visual tool with business intelligence software requires a proper development environment. Therefore, the environment setup will be established; then, a custom visualization development process will be demonstrated step by step.

The development will be performed on 64 bit-based Windows 10 Home Edition operating system (OS) with 16 gigabytes (GB) of double data rate type 2 low voltage (DDR3L) random-access memory (RAM) and an Intel 4th generation i7 central processing unit (CPU) with four cores eight threads.

4.1 Power BI Data Visualization and Business Intelligence Tool

Power BI comes with built-in visuals when installed freshly. It is possible to import other visuals from Microsoft AppSource, an online marketplace, or import them directly from the local machine. Also, developing a custom visual is possible with Power BI.

Developers can create their own Power BI visuals. After developing a custom visual, it is possible to publish and make it available for organizations or third parties.

4.1.1 Setting Up Development Environment (Prerequisites)

Starting to develop a custom visual by Power BI, needs a development environment. There is a list of requirements in the Power BI's website about. Here is a short list for requirements below and explanations will be written in the following pages.

I. Signing up and having an account for Power BI

II. Integrated Development Environment (IDE): Visual Studio Code

III. Terminal: Command Prompt or Windows PowerShell

IV. Environment for developing a Power BI visual

   a) node.js installation

   b) pbiviz installation

c) Certificate creation

d) Power BI service setting up

e) Additional libraries for development

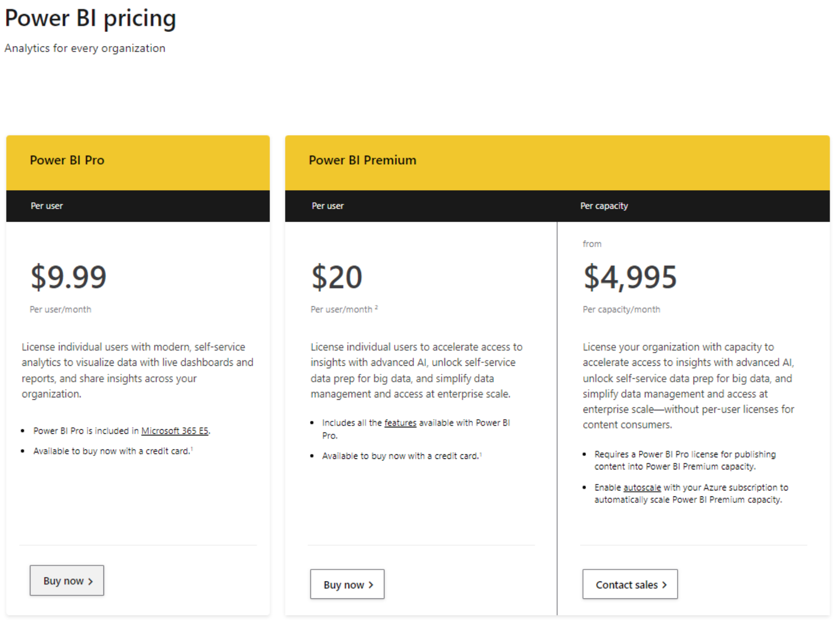
- D3.js JavaScript Library installation
- TypeScript definitions installation
- core-js installation
- Power BI Visuals API installation

Those requirements listed above will be executed step by step, and it will lead us to get a ready to use development environment on the local machine.

4.1.1.1 Signing Up and Having an Account for Power BI

First step starts with a **Power BI Pro** or **Premium Per User (PPU)** account, and here is the website link for signing up https://powerbi.microsoft.com/en-us/pricing/ for the interested ones.

Figure 26 Pricing for Microsoft Power BI



Power BI pricing

Analytics for every organization

Power BI Pro

Per user

$9.99

Per user/month

License individual users with modern, self-service analytics to visualize data with live dashboards and reports, and share insights across your organization.

- Power BI Pro is included in Microsoft 365 E5.
- Available to buy now with a credit card.[1]

Power BI Premium

Per user

$20

Per user/month [2]

License individual users to accelerate access to insights with advanced AI, unlock self-service data prep for big data, and simplify data management and access at enterprise scale.

- Includes all the features available with Power BI Pro.
- Available to buy now with a credit card.[1]

Per capacity

from

$4,995

Per capacity/month

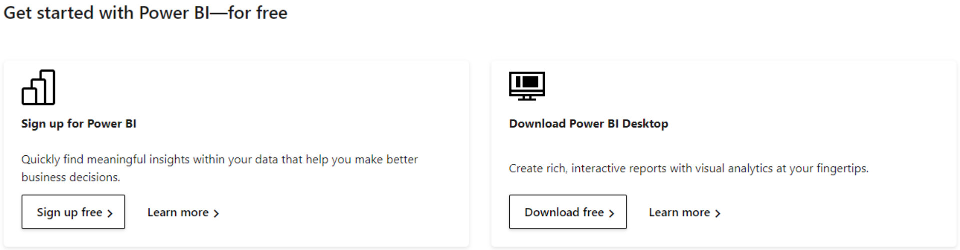
License your organization with capacity to accelerate access to insights with advanced AI, unlock self-service data prep for big data, and simplify data management and access at enterprise scale—without per-user licenses for content consumers.

- Requires a Power BI Pro license for publishing content into Power BI Premium capacity.
- Enable autoscale with your Azure subscription to automatically scale Power BI Premium capacity.

Source: (Microsoft Inc.)

Also, there is a free signing option in the same page, with the heading of "**Get started with Power BI – for free**" and this free option is quite enough for development.

Figure 27 Signing Up for Free to Power BI



Get started with Power BI—for free

Sign up for Power BI

Quickly find meaningful insights within your data that help you make better business decisions.

Download Power BI Desktop

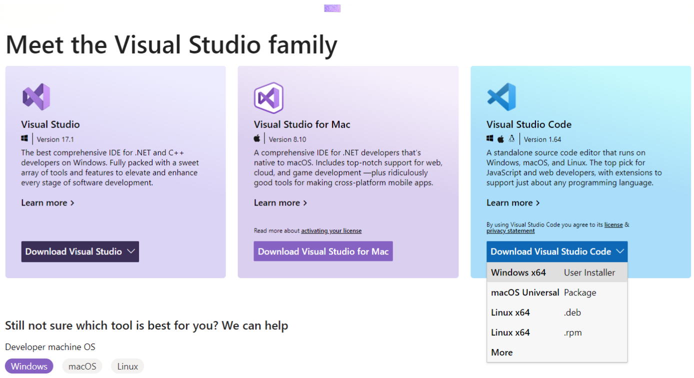
Create rich, interactive reports with visual analytics at your fingertips.

Source: (Microsoft Inc., 2022)

4.1.1.2 Integrated Development Environment (IDE): Visual Studio Code

Second step is to have an Integrated Development Environment (IDE) for development. Microsoft is suggesting Visual Studio Code (VS Code). Also, it is a well-known IDE and easy to use while developing with JavaScript and TypeScript. Relevant software needs to be chosen according to operating system and its own bit base. In this case, relevant software will be for Windows 10, 64 bit-based operating system. Here is the link for downloading VS Code: https://visualstudio.microsoft.com/

Figure 28 Website Page for downloading Visual Studio Code



Meet the Visual Studio family

Visual Studio

Version 17.1

The best comprehensive IDE for .NET and C++ developers on Windows. Fully packed with a sweet array of tools and features to elevate and enhance every stage of software development.

Visual Studio for Mac

Version 8.10

A comprehensive IDE for .NET developers that's native to macOS. Includes top-notch support for web, cloud, and game development —plus ridiculously good tools for making cross-platform mobile apps.

Read more about activating your license

Visual Studio Code

Version 1.64

A standalone source code editor that runs on Windows, macOS, and Linux. The top pick for JavaScript and web developers, with extensions to support just about any programming language.

By using Visual Studio Code you agree to its license & privacy statement

Still not sure which tool is best for you? We can help

Developer machine OS

Source: (Microsoft Inc.)

4.1.1.3 Terminal: Command Prompt or Windows PowerShell

The third step is about having and using terminal which can connect with the application and apply the script commands through the console. There is one built-in terminal, which is called Command Prompt on Windows operating systems. Additionally, Microsoft suggests a more modern version of Command Prompt, called Windows PowerShell, which is also a built-in application since Windows 7 Service Pack 1 (SP1). Mac operating system also has a built-in terminal, which is called Terminal.

Here is the link for the ones who interested to use Windows PowerShell on Windows operating systems: https://docs.microsoft.com/en-us/powershell/scripting/install/installing-powershell-on-windows?view=powershell-7.2

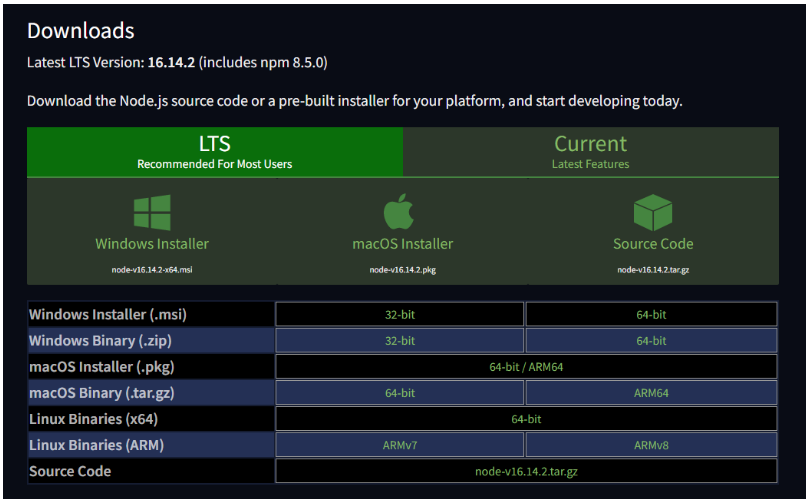
There are several ways to use script codes in terminals yet there is no best option. It is depending on user habits in this case. Therefore, in this thesis, default Windows Command Prompt will be used as terminal in VS Code.

4.1.1.4 Environment for Developing a Power BI Visual

The fourth step is about installing necessary runtime platforms such as node.js or pbiviz tool. Developing a visual for Power BI requires node.js, an open-source JavaScript engine, and a runtime platform where developers can run their codes on the server-side. The following link redirects to the necessary webpage to download node.js: https://nodejs.org/en/

4.1.1.4.1 Node.js Installation

Figure 29 Webpage of node.js



Downloads

Latest LTS Version: **16.14.2** (includes npm 8.5.0)

Download the Node.js source code or a pre-built installer for your platform, and start developing today.

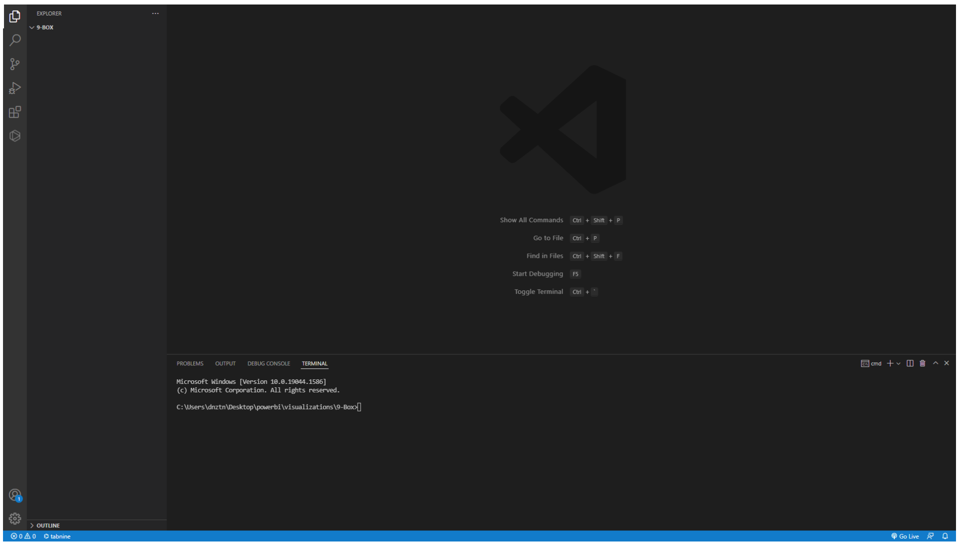
Windows Installer (.msi)	32-bit	64-bit
Windows Binary (.zip)	32-bit	64-bit
macOS Installer (.pkg)	64-bit / ARM64	
macOS Binary (.tar.gz)	64-bit	ARM64
Linux Binaries (x64)	64-bit	
Linux Binaries (ARM)	ARMv7	ARMv8
Source Code	node-v16.14.2.tar.gz	

Source: (Node.js))

Several options exist to install node.js for various operating systems with various bit-bases. In this thesis, 64bit based LTS 16.14.2 version of node.js will be used with the Windows installer.

Using and handling are possible with VS Code and its built-in terminal after node.js installation. The terminal options may be varied according to installed terminal-like applications in VS Code options. Command Prompt will be selected terminal as VS Code default terminal during the development.

Figure 30 Visual Studio Code and built-in terminal (Command Prompt)



```
Microsoft Windows [Version 10.0.19044.1586]
(c) Microsoft Corporation. All rights reserved.

C:\Users\dnztn\Desktop\powerbi\visualizations\9-Box>
```

To check if node.js and npm is installed properly, following codes can be used in the terminal.

For node.js

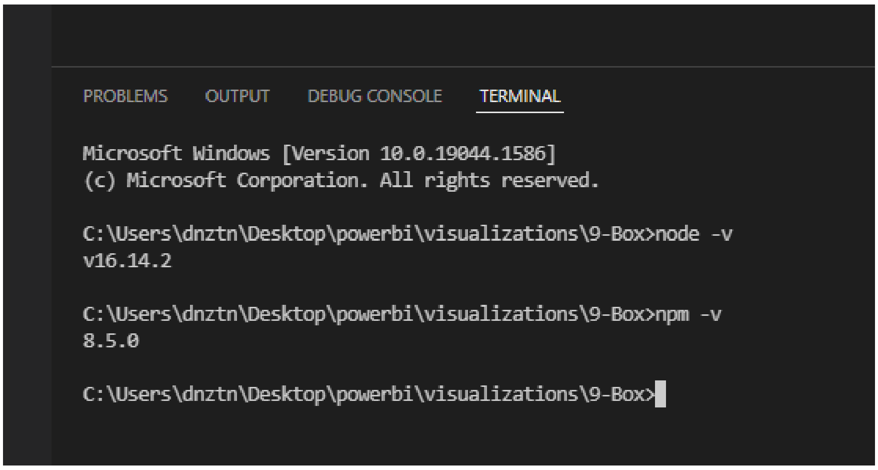
```
node -v
```

For npm:

```
npm -v
```

Expected output:

Figure 31 Checking if the node.js and the npm were installed properly



```
Microsoft Windows [Version 10.0.19044.1586]
(c) Microsoft Corporation. All rights reserved.

C:\Users\dnztn\Desktop\powerbi\visualizations\9-Box>node -v
v16.14.2

C:\Users\dnztn\Desktop\powerbi\visualizations\9-Box>npm -v
8.5.0

C:\Users\dnztn\Desktop\powerbi\visualizations\9-Box>
```

4.1.1.4.2 Pbiviz Installation

After successful node.js installation, pbiviz needed to be installed as another requirement. The pbiviz is a package written in JavaScript, that can compile the visual source code. The package includes all needed scripts and assets. To install pbiviz, following code must be executed in terminal.

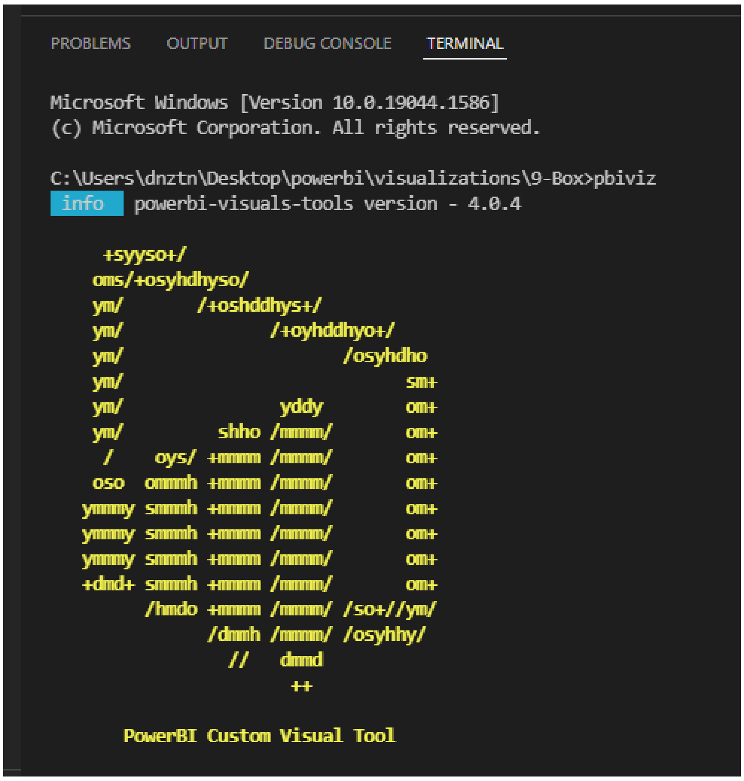
```
npm i -g powerbi-visuals-tools
```

To check if pbiviz package is installed properly, following code can be used in the terminal:

```
pbiviz
```

The expected result must be like following terminal output:

Figure 32 Checking if the pbiviz package was installed properly



```
Microsoft Windows [Version 10.0.19044.1586]
(c) Microsoft Corporation. All rights reserved.

C:\Users\dnztn\Desktop\powerbi\visualizations\9-Box>pbiviz
 info  powerbi-visuals-tools version - 4.0.4

     +syyso+/
    oms/+osyhdhyso/
    ym/       /+oshddhys+/
    ym/              /+oyhddhyo+/
    ym/                     /osyhdho
    ym/                           sm+
    ym/               yddy        om+
    ym/         shho /mmmm/       om+
     /    oys/ +mmmm /mmmm/       om+
    oso  ommmh +mmmm /mmmm/       om+
   ymmmy smmmh +mmmm /mmmm/       om+
   ymmmy smmmh +mmmm /mmmm/       om+
   ymmmy smmmh +mmmm /mmmm/       om+
   +dmd+ smmmh +mmmm /mmmm/       om+
         /hmdo +mmmm /mmmm/ /so+//ym/
               /dmmh /mmmm/ /osyhhy/
                 //   dmmd
                       ++

       PowerBI Custom Visual Tool
```

4.1.1.4.3 Certificate Creation

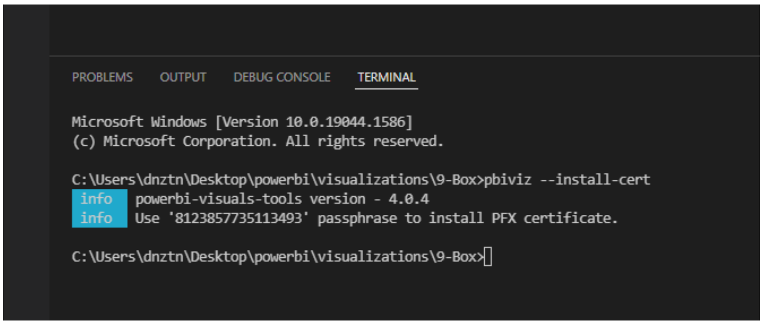
After confirmation of successful installation of pbiviz, a certification needs to be created and installed. To install pbiviz certificate, following code can be used.

```
pbiviz --install-cert
```

This command returns two outputs:

- First, the command returns a passphrase. In this case the passphrase is "8123857735113493"
- Second, the command starts Certificate Import Wizard

Figure 33 Return of certificate command



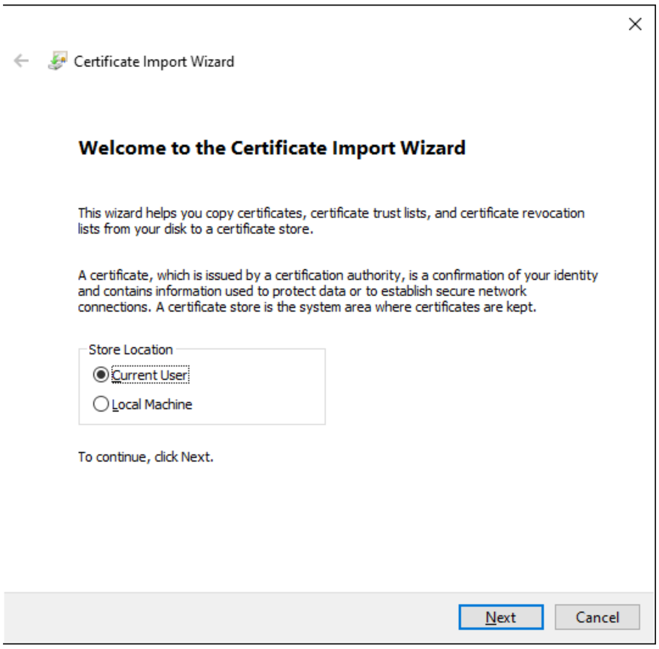
```
Microsoft Windows [Version 10.0.19044.1586]
(c) Microsoft Corporation. All rights reserved.

C:\Users\dnztn\Desktop\powerbi\visualizations\9-Box>pbiviz --install-cert
 info   powerbi-visuals-tools version - 4.0.4
 info   Use '8123857735113493' passphrase to install PFX certificate.

C:\Users\dnztn\Desktop\powerbi\visualizations\9-Box>
```

Note: If running pbiviz interrupts due to lack of permission, solution is to start selected terminal as an administrator and run the command "Set-ExecutionPolicy RemoteSigned"

Note: If the Certificate Import Wizard doesn't open automatically, solution is to navigate to the certificate location in File Explorer, right-clicking on it, and selecting Install.

In Certificate Import Wizard, "Current User" needs to be selected, then "Next" button needs to be clicked.

Figure 34 Certificate Import Wizard



Certificate Import Wizard

Welcome to the Certificate Import Wizard

This wizard helps you copy certificates, certificate trust lists, and certificate revocation lists from your disk to a certificate store.

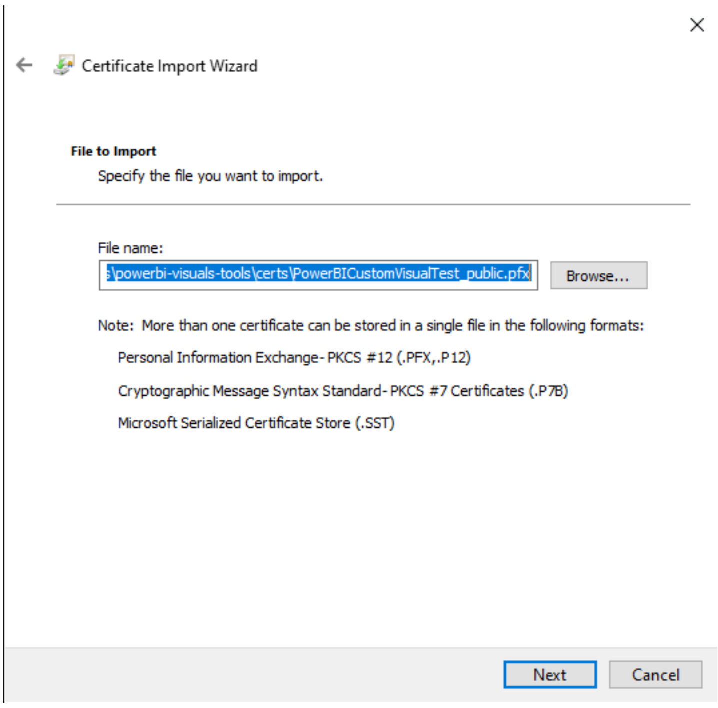
A certificate, which is issued by a certification authority, is a confirmation of your identity and contains information used to protect data or to establish secure network connections. A certificate store is the system area where certificates are kept.

Store Location
● Current User
○ Local Machine

To continue, click Next.

In File to Import window, Certificate Import Wizard will find the certificate automatically. In this phase “Next” button needs to be clicked.

Figure 35 Certificate Import Wizard, File to Import window



Certificate Import Wizard

File to Import

Specify the file you want to import.

File name:

s\powerbi-visuals-tools\certs\PowerBICustomVisualTest_public.pfx

Note: More than one certificate can be stored in a single file in the following formats:

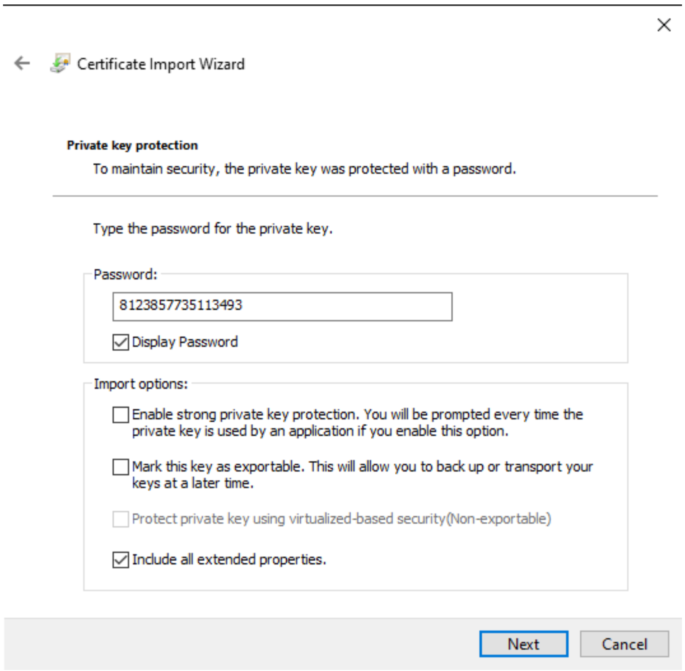
Personal Information Exchange- PKCS #12 (.PFX,.P12)

Cryptographic Message Syntax Standard- PKCS #7 Certificates (.P7B)

Microsoft Serialized Certificate Store (.SST)

In the Private key protection window, passphrase needs to be used in Password text box, and then “Next” button needs to be clicked.

Figure 36 Private key protection window



Certificate Import Wizard

Private key protection

To maintain security, the private key was protected with a password.

Type the password for the private key.

Password:

8123857735113493

☑ Display Password

Import options:

☐ Enable strong private key protection. You will be prompted every time the private key is used by an application if you enable this option.

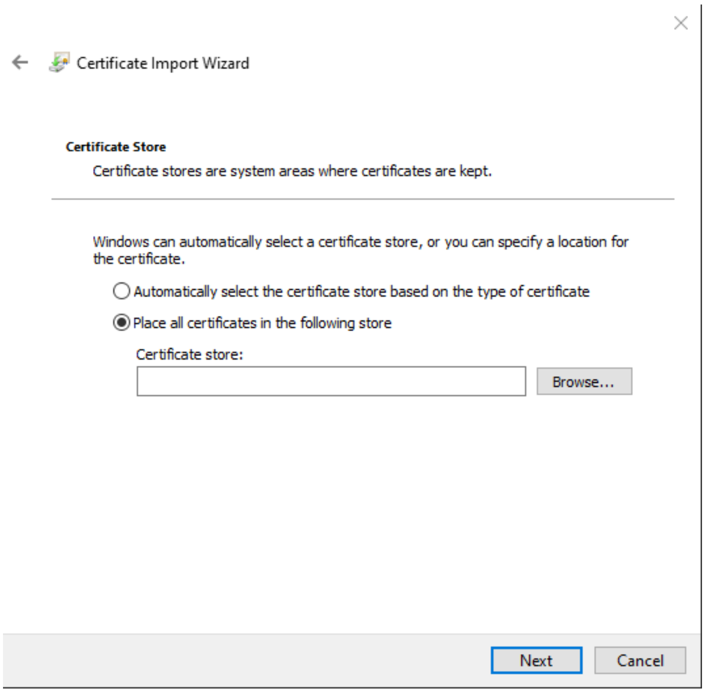
☐ Mark this key as exportable. This will allow you to back up or transport your keys at a later time.

☐ Protect private key using virtualized-based security(Non-exportable)

☑ Include all extended properties.

In Certificate Store window, “Place all certificates in the following store” option needs to be selected, and then “Browse” button needs to be clicked.

Figure 37 Certificate Store window



Certificate Import Wizard

Certificate Store

Certificate stores are system areas where certificates are kept.

Windows can automatically select a certificate store, or you can specify a location for the certificate.

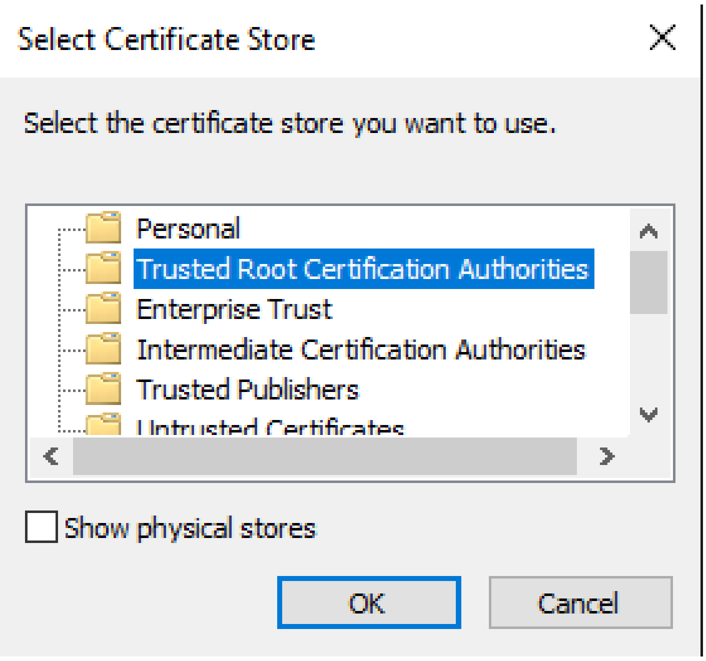
○ Automatically select the certificate store based on the type of certificate

● Place all certificates in the following store

Certificate store:

In the Select Certificate Store window, “Trusted Root Certification Authorities” needs to be selected. Then “OK” button needs to be clicked.

Figure 38 Select Certificate Store window



Select Certificate Store

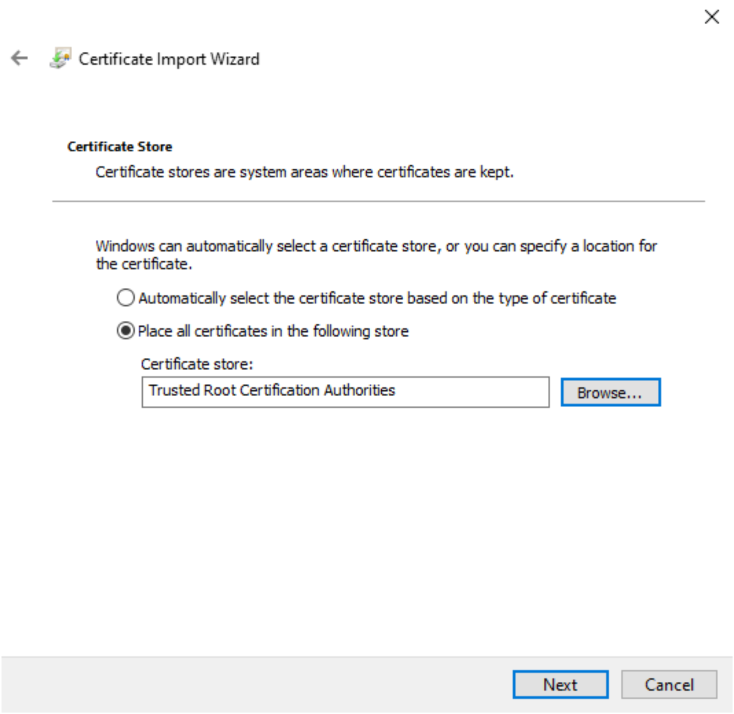
Select the certificate store you want to use.

- Personal
- Trusted Root Certification Authorities
- Enterprise Trust
- Intermediate Certification Authorities
- Trusted Publishers
- Untrusted Certificates

□ Show physical stores

In the Certificate Store window, “Next” button needs to be clicked.

Figure 39 Certificate Store window after placing the certificate



Certificate Import Wizard

Certificate Store

Certificate stores are system areas where certificates are kept.

Windows can automatically select a certificate store, or you can specify a location for the certificate.

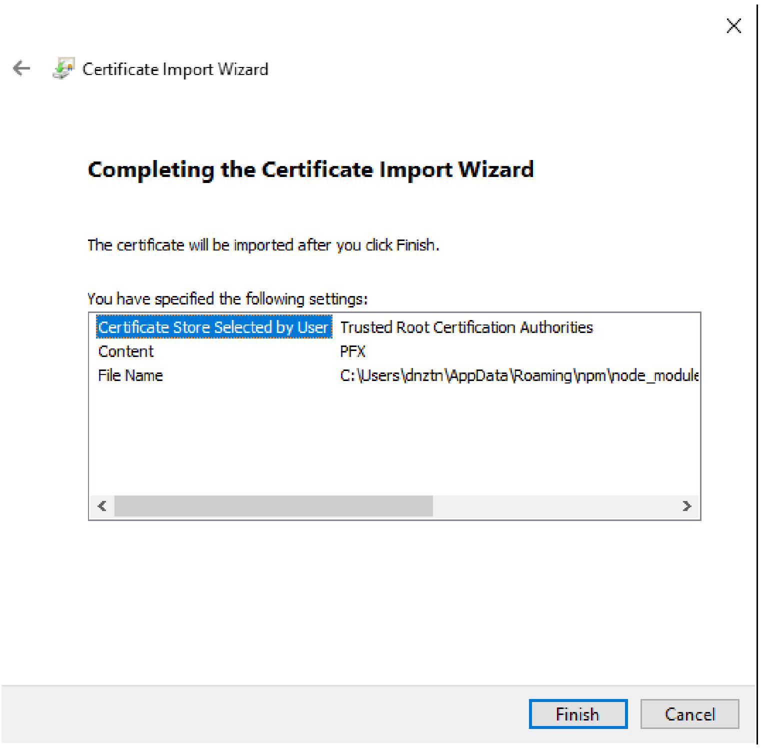
○ Automatically select the certificate store based on the type of certificate

● Place all certificates in the following store

Certificate store: Trusted Root Certification Authorities

In the Completing the Certificate Import Wizard window, settings need to be verified and "Finish" button needs to be clicked to finalize the certificate import.

Figure 40 Completing the Certificate Import Wizard window



Certificate Import Wizard

Completing the Certificate Import Wizard

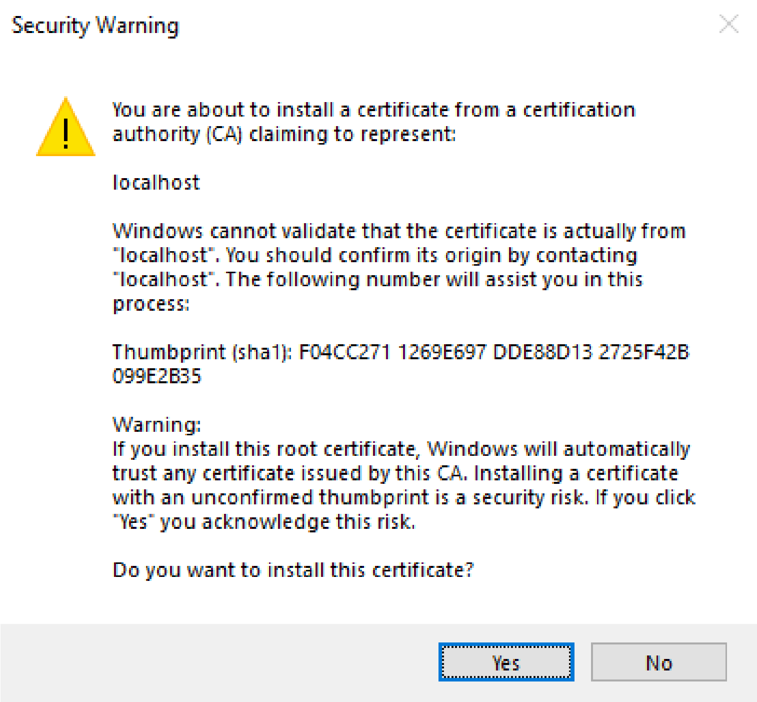
The certificate will be imported after you click Finish.

You have specified the following settings:

Certificate Store Selected by User	Trusted Root Certification Authorities
Content	PFX
File Name	C:\Users\dnztn\AppData\Roaming\npm\node_module

If a security warning pope up, "Yes" button needs to be selected.

Figure 41 Security Warning about certificate installation



Security Warning

You are about to install a certificate from a certification authority (CA) claiming to represent:

localhost

Windows cannot validate that the certificate is actually from "localhost". You should confirm its origin by contacting "localhost". The following number will assist you in this process:

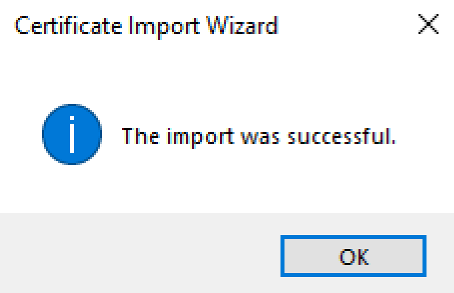
Thumbprint (sha1): F04CC271 1269E697 DDE88D13 2725F42B 099E2B35

Warning:
If you install this root certificate, Windows will automatically trust any certificate issued by this CA. Installing a certificate with an unconfirmed thumbprint is a security risk. If you click "Yes" you acknowledge this risk.

Do you want to install this certificate?

Certificate Import Wizard sends an alert box at the end about successful import.

Figure 42 Certificate Import Wizard alert



Certificate Import Wizard

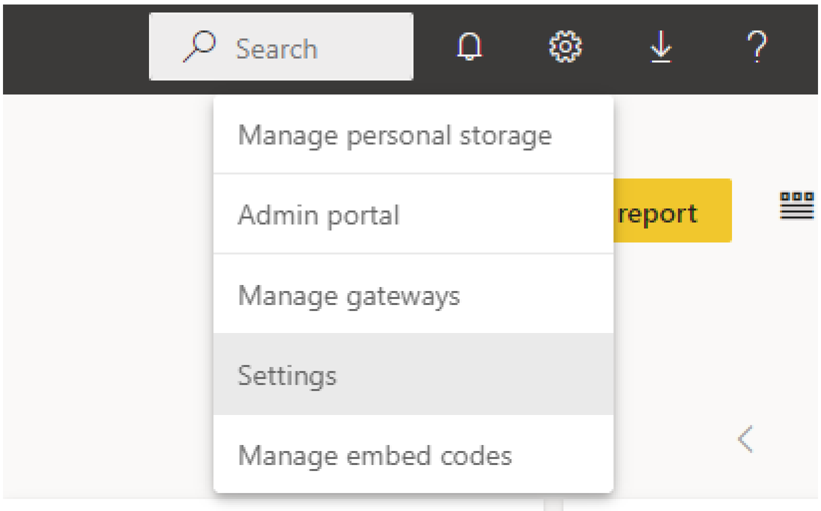
The import was successful.

4.1.1.4.4 Power BI Service Settings

Developing a visual with Power BI is possible after enabling custom visual debugging in Power BI service, which also called “Developer Mode”. Following instructions will help to enable developer mode.

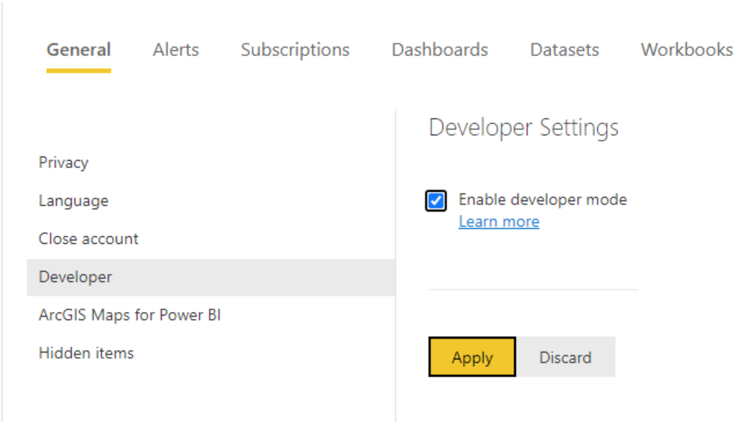
First step is signing in to PowerBI.com which signing up told in earlier section. Second step is to navigate Settings of Power BI service.

Figure 43 Power BI service settings



From “General” tab, “Developer” option needs to be selected. In “Developer Settings” page, developer mode needs to be enabled.

Figure 44 Enabling developer mode



☑ Enable developer mode
Learn more

4.1.1.4.5 Additional Libraries for Development

Developing a visual for Power BI depends on core development libraries, such as core-js, the package that includes TypeScript definitions, and Power BI visual API package. In this section, necessary libraries will be installed.

D3 is a JavaScript library to develop dynamic, interactive visualizations in web browsers. D3.js implements Scalable Vector Graphics (SVG), Hyper Text Mark-up Language 5 (HTML5), and Cascading Style Sheet (CSS). Using following code in the terminal will install the D3.js library.

```
npm i d3@^5.0.0 --save
```

TypeScript definitions package is for developing visuals for Power BI using TypeScript, which is a superset of JavaScript. Using following code in the terminal will install the definitions package for D3.js library.

```
npm i @types/d3@^5.0.0 --save
```

Another necessary package is core-js, which is a modular standard library for JavaScript that includes polyfills for ECMAScript. Using following code in the terminal will install the core-js library.

```
npm i core-js@3.2.1 --save
```

Last necessary package is Power BI Visuals API. Using following code in the terminal will install the powerbi-visuals-api library.

```
npm i powerbi-visuals-api --save-dev
```

After the installation of necessary libraries, the development environment is ready to develop a visual for Power BI. In the next sections, an actual development will be demonstrated step by step.

4.2 Dataset for 9-Box Custom Visual

Dataset to demonstrate the 9-Box Grid tool will be created randomly. All the names are picked from random name generator websites for names of individuals, cities, or departments. All the numeric values are generated by *RANDBETWEEN* function in Excel. In the following explanations, the column names are described in the dataset. 75 records created.

- Name: Name and last name for individual
- Performance score: Performance score in range from 1 to 100
- Potential score: Potential score in range from 1 to 100
- Final Score: Crossing box of Performance and Potential Letter
- Gender: Gender of individual
- Department: Department of the individual in the company
- City: City of individual

4.3 Development of the 9-Box Custom Visual

Developing a custom visual for Power BI requires several steps for starting. First, the project folder needs to be created with pbiviz package. Visual Studio Code and its terminal will be enough to handle that. Also, Power BI Service will assist, which is the online platform of Power BI that we can follow our development in real-time.

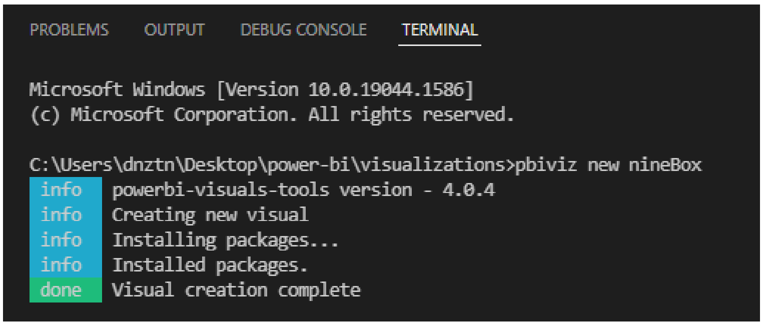
For a clean demonstration, empty folders will be created on the desktop with the following location: “~/Desktop/power-bi/visualization/”

The following code will create the project folder with pbiviz package to the current location with the name of “nineBox” on the terminal.

```
pbiviz new nineBox
```

The expected output is:

Figure 45 Creation of nineBox project with pbiviz



```
Microsoft Windows [Version 10.0.19044.1586]
(c) Microsoft Corporation. All rights reserved.

C:\Users\dnztn\Desktop\power-bi\visualizations>pbiviz new nineBox
 info   powerbi-visuals-tools version - 4.0.4
 info   Creating new visual
 info   Installing packages...
 info   Installed packages.
 done   Visual creation complete
```

In the next steps, after navigating the nineBox folder, pbiviz server needs to start. Following codes will handle and run the package.

To navigate:

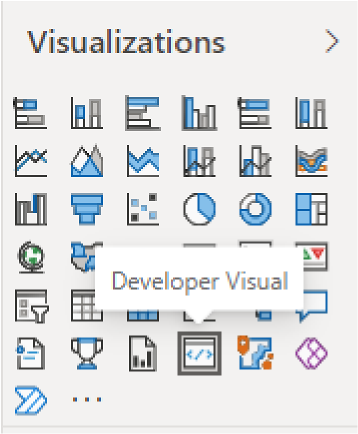
```
cd nineBox
```

To run the server:

```
pbiviz start
```

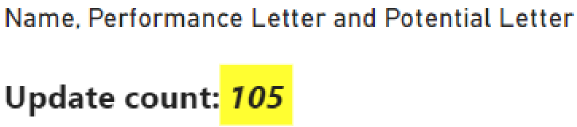
To demonstrate and follow the custom visual that running on the local machine, developers use “Developer Visual” visual, on Power BI Service. Signing in is possible the Power BI Service from the following link https://powerbi.microsoft.com/, and under the current workspace, a report needs to be open in a new page. Then Developer Visual can be selected in the Visualization pane.

Figure 46 Power BI Visualizations pane



When the Developer Visual added in the Power BI Service, it is possible to track every change if the server is up and running. Saving in the Visual Studio Code will update the Developer Visual every time.

Figure 47 Developer Visual at first look after first run of pbiviz package



Name, Performance Letter and Potential Letter

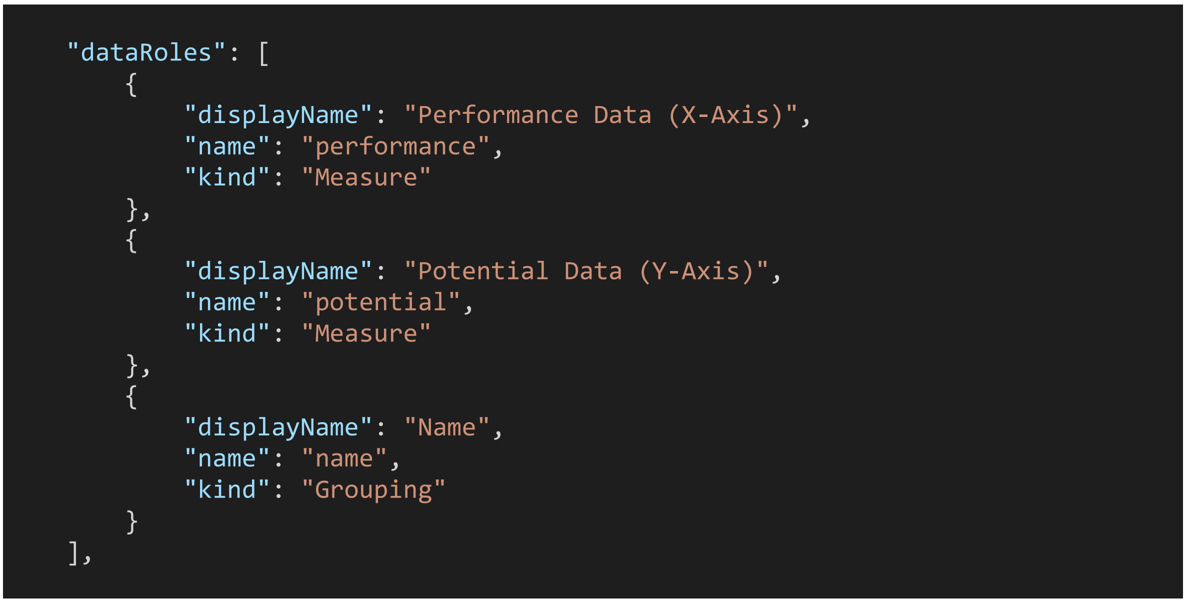
Update count: *105*

Confirming by Developer Visual output that the initial pbiviz package is working properly means the custom visual is ready for development. The main files to be developed will be demonstrated in the following sections.

4.3.1 Capabilities.json

Capabilities.json is the main file which can be written in JavaScript Object Notation (JSON) format. This file is related to data which can consumed by the visual. Here we can add the data role, data view mappings and objects.

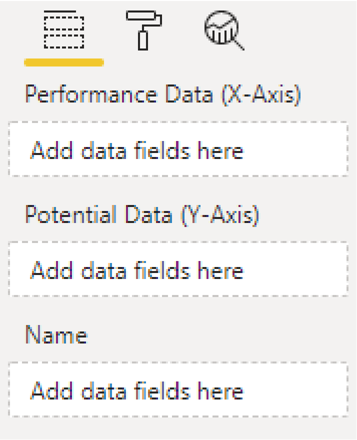
The 9-Box Grid needs three data roles. One for the names of individuals, one for the x axis which is performance score, and the last one is for y axis which is potential scores. Following code will create the data roles which 9-Box needs.



```
"dataRoles": [
    {
        "displayName": "Performance Data (X-Axis)",
        "name": "performance",
        "kind": "Measure"
    },
    {
        "displayName": "Potential Data (Y-Axis)",
        "name": "potential",
        "kind": "Measure"
    },
    {
        "displayName": "Name",
        "name": "name",
        "kind": "Grouping"
    }
],
```

Expected output will be like following:

Figure 48 Data roles created



Performance Data (X-Axis)

Add data fields here

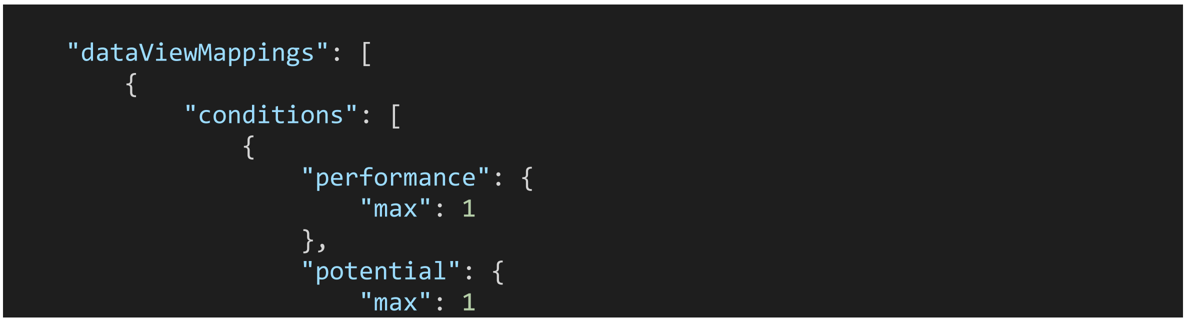
Potential Data (Y-Axis)

Add data fields here

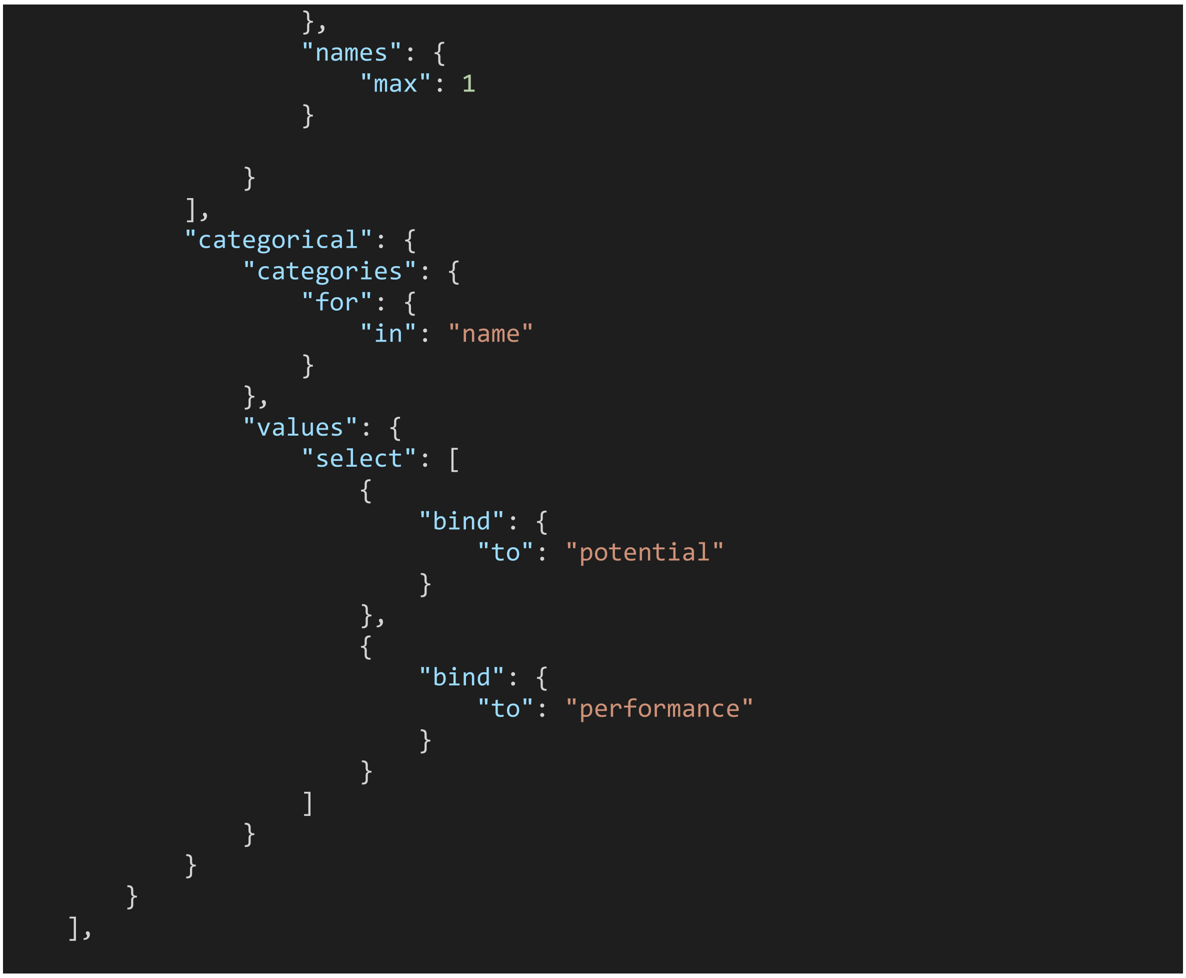
Name

Add data fields here

Data roles can be bind with using categorical under the data view mappings part of the capabilities.json file. Also, conditions can be added for the data role, such as limiting data consumption to 1 as maximum. Following code will create data view mappings for the data roles.

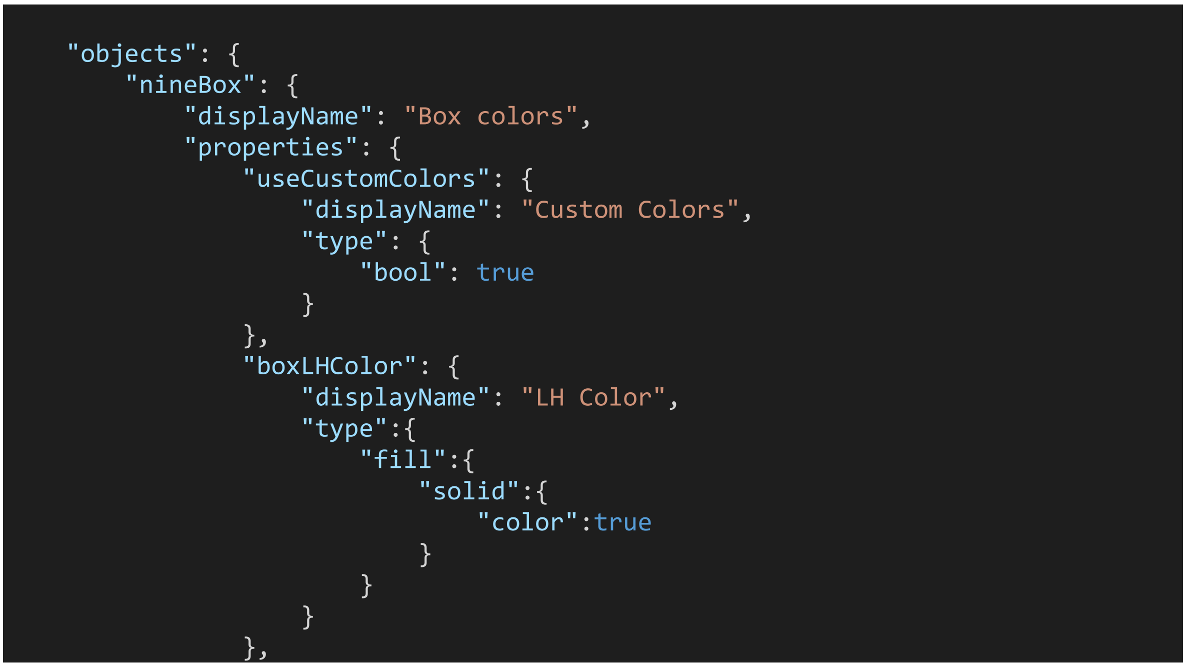


```
"dataViewMappings": [
    {
        "conditions": [
            {
                "performance": {
                    "max": 1
                },
                "potential": {
                    "max": 1
```

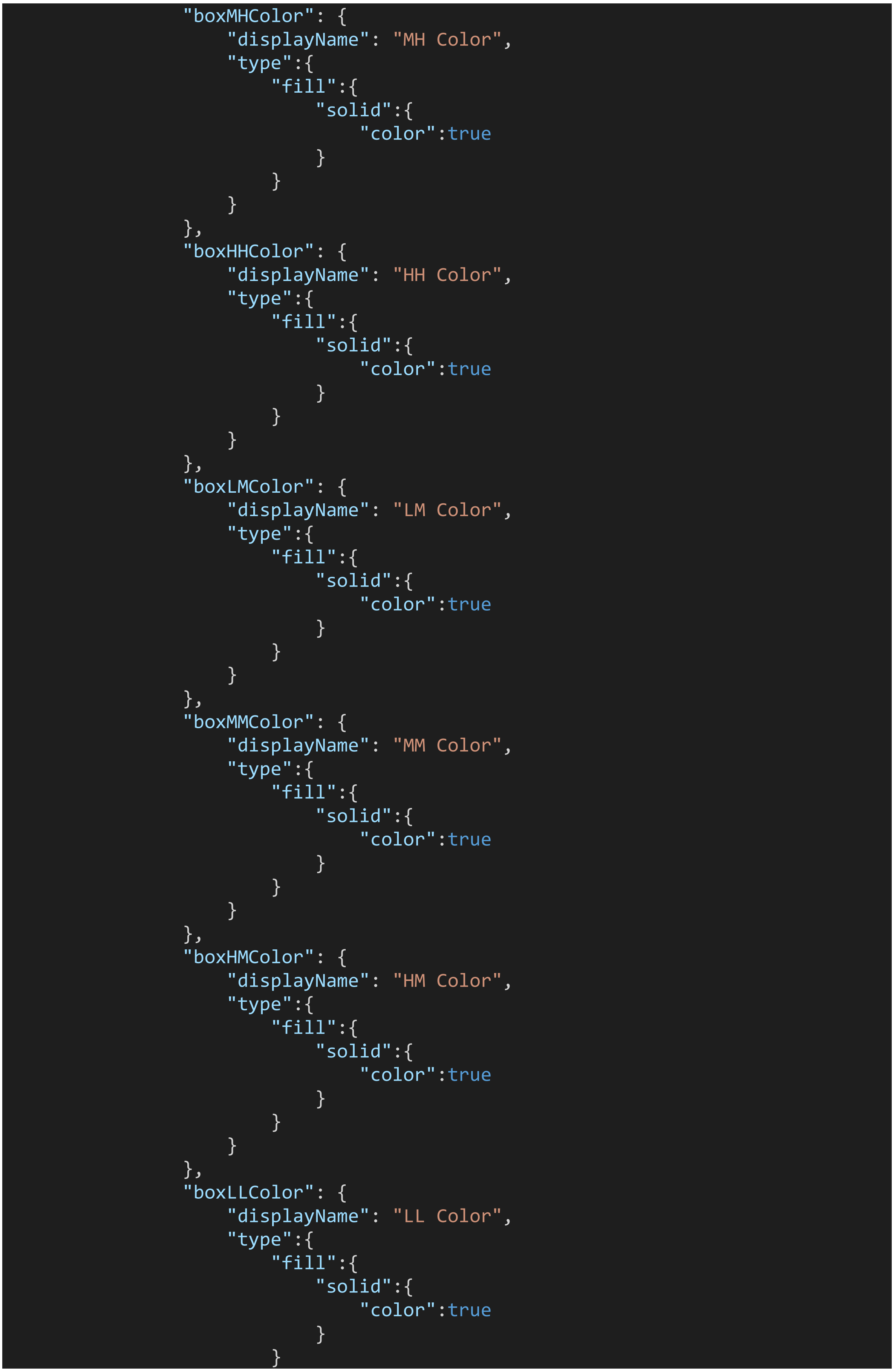


```
                    },
                    "names": {
                        "max": 1
                    }

                }
            ],
            "categorical": {
                "categories": {
                    "for": {
                        "in": "name"
                    }
                },
                "values": {
                    "select": [
                        {
                            "bind": {
                                "to": "potential"
                            }
                        },
                        {
                            "bind": {
                                "to": "performance"
                            }
                        }
                    ]
                }
            }
        }
    ],
```

Additionally, formatting options can be added under objects. In our case, changing the box colors is possible. Following code will make this possible.



```
    "objects": {
        "nineBox": {
            "displayName": "Box colors",
            "properties": {
                "useCustomColors": {
                    "displayName": "Custom Colors",
                    "type": {
                        "bool": true
                    }
                },
                "boxLHColor": {
                    "displayName": "LH Color",
                    "type":{
                        "fill":{
                            "solid":{
                                "color":true
                            }
                        }
                    }
                },
```



```
                "boxMHColor": {
                    "displayName": "MH Color",
                    "type":{
                        "fill":{
                            "solid":{
                                "color":true
                            }
                        }
                    }
                },
                "boxHHColor": {
                    "displayName": "HH Color",
                    "type":{
                        "fill":{
                            "solid":{
                                "color":true
                            }
                        }
                    }
                },
                "boxLMColor": {
                    "displayName": "LM Color",
                    "type":{
                        "fill":{
                            "solid":{
                                "color":true
                            }
                        }
                    }
                },
                "boxMMColor": {
                    "displayName": "MM Color",
                    "type":{
                        "fill":{
                            "solid":{
                                "color":true
                            }
                        }
                    }
                },
                "boxHMColor": {
                    "displayName": "HM Color",
                    "type":{
                        "fill":{
                            "solid":{
                                "color":true
                            }
                        }
                    }
                },
                "boxLLColor": {
                    "displayName": "LL Color",
                    "type":{
                        "fill":{
                            "solid":{
                                "color":true
                            }
                        }
                    }
                },
                "boxMLColor": {
                    "displayName": "ML Color",
                    "type":{
                        "fill":{
                            "solid":{
                                "color":true
                            }
                        }
                    }
                },
                "boxHLColor": {
                    "displayName": "HL Color",
                    "type":{
                        "fill":{
                            "solid":{
                                "color":true
                            }
                        }
                    }
                },
                 "fontSize": {
                    "displayName": "Text Size",
                    "type": {
                        "formatting": {
                            "fontSize": true
                        }
                    }
                },
                "filter": {
                    "type": {
                        "filter": true
                    }
                }
            }
        }
    },
```

Another additional setting added by the following code, for the 9-Box Grid custom visual, which sorting the titles by names, but empty as a default.

```
"suppressDefaultTitle": true,
"sorting": {
    "default": { }
}
```

4.3.2 Package.json

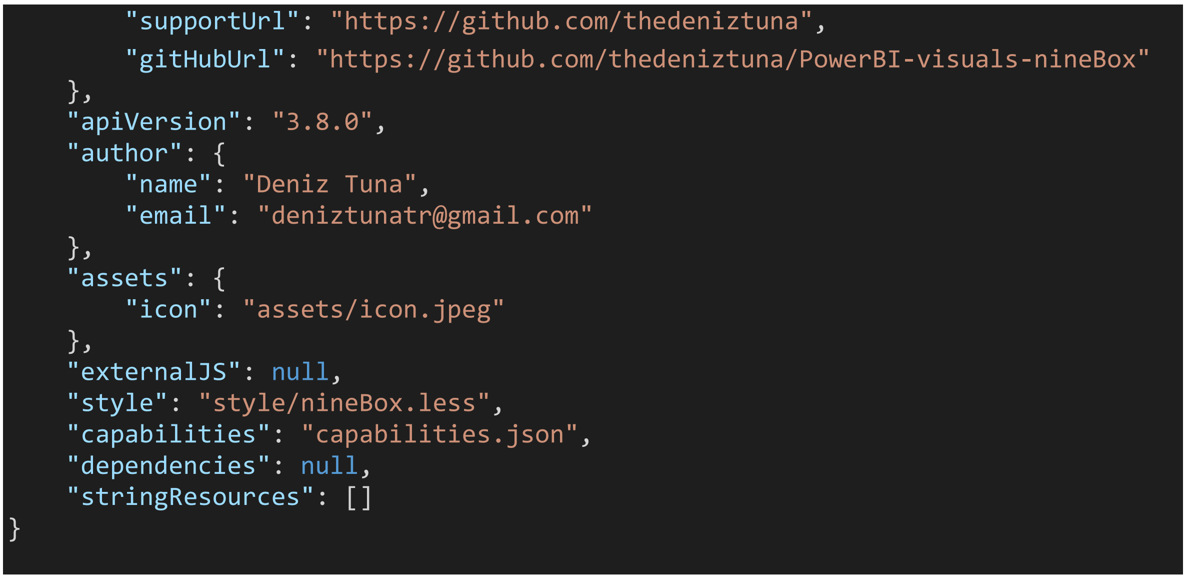
Package.json is the file that contains project dependencies. There we can modify the dependencies of the project. Also, project scrips can be modified here, such as starting the server, or the script for creating the visualization package. Following code is used for this project.

```
{
  "name": "visual",
  "description": "default_template_value",
  "repository": {
    "type": "default_template_value",
    "url": "default_template_value"
  },
  "license": "MIT",
  "scripts": {
    "pbiviz": "pbiviz",
    "start": "pbiviz start",
    "package": "pbiviz package",
    "lint": "tslint -c tslint.json -p tsconfig.json"
  },
  "dependencies": {
    "powerbi-visuals-utils-dataviewutils": "2.2.1",
    "powerbi-visuals-api": "~3.8.0"
  },
  "devDependencies": {
    "ts-loader": "6.1.0",
    "tslint": "^5.18.0",
    "tslint-microsoft-contrib": "^6.2.0",
    "typescript": "3.6.3"
  }
}
```

4.3.3 Pbiviz.json

Pbiviz.json package contains the project identification information. In a custom visual development case, there must specified a support URL, there must be a GitHub URL. Also, author name must be here, and an email belongs to author must be specify. Following code is used in our project.

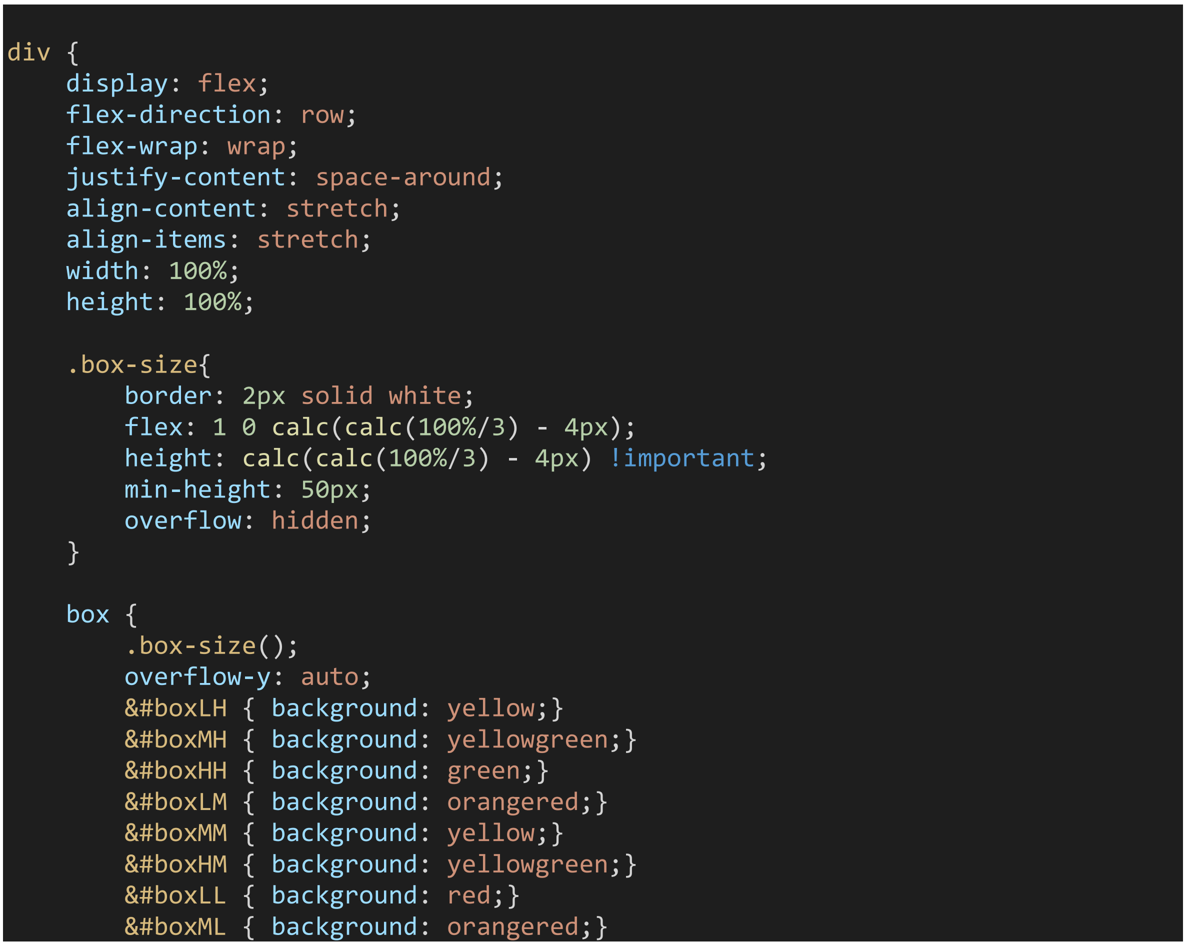
```
{
    "visual": {
        "name": "nineBox",
        "displayName": "nineBox",
        "guid": "nineBox4A7E574D681741E698F60CB345057E88",
        "visualClassName": "NineBox",
        "version": "1.0.0",
        "description": "9-Box Grid Custom Visual",
```



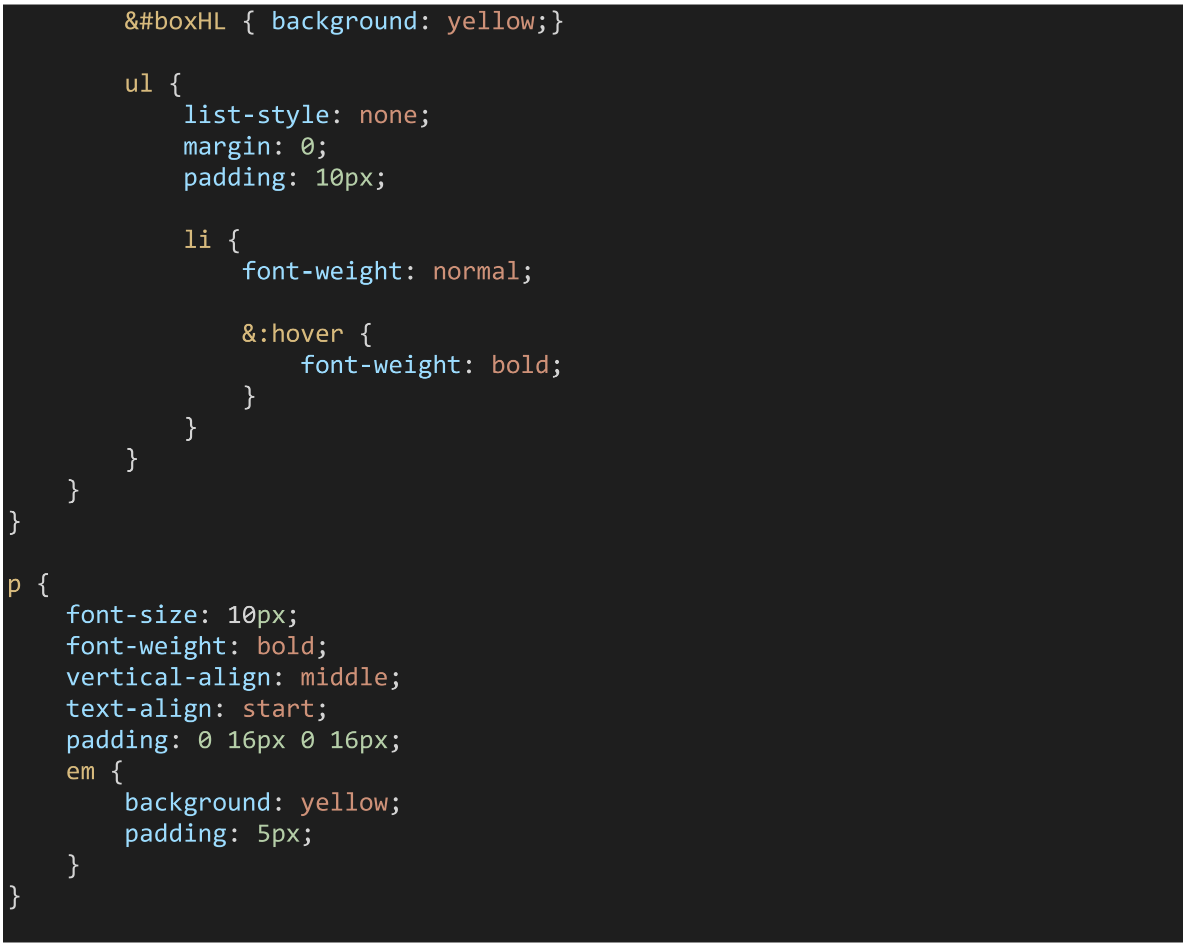
```
        "supportUrl": "https://github.com/thedeniztuna",
        "gitHubUrl": "https://github.com/thedeniztuna/PowerBI-visuals-nineBox"
    },
    "apiVersion": "3.8.0",
    "author": {
        "name": "Deniz Tuna",
        "email": "deniztunatr@gmail.com"
    },
    "assets": {
        "icon": "assets/icon.jpeg"
    },
    "externalJS": null,
    "style": "style/nineBox.less",
    "capabilities": "capabilities.json",
    "dependencies": null,
    "stringResources": []
}
```

4.3.4 NineBox.less

NineBox.less is a Leaner Style Sheet which contains the styles of the elements in the visual. This file is compiling and being used by the visual automatically when its updated. In our case, boxes, p html elements or the canvas itself styled by the following code.



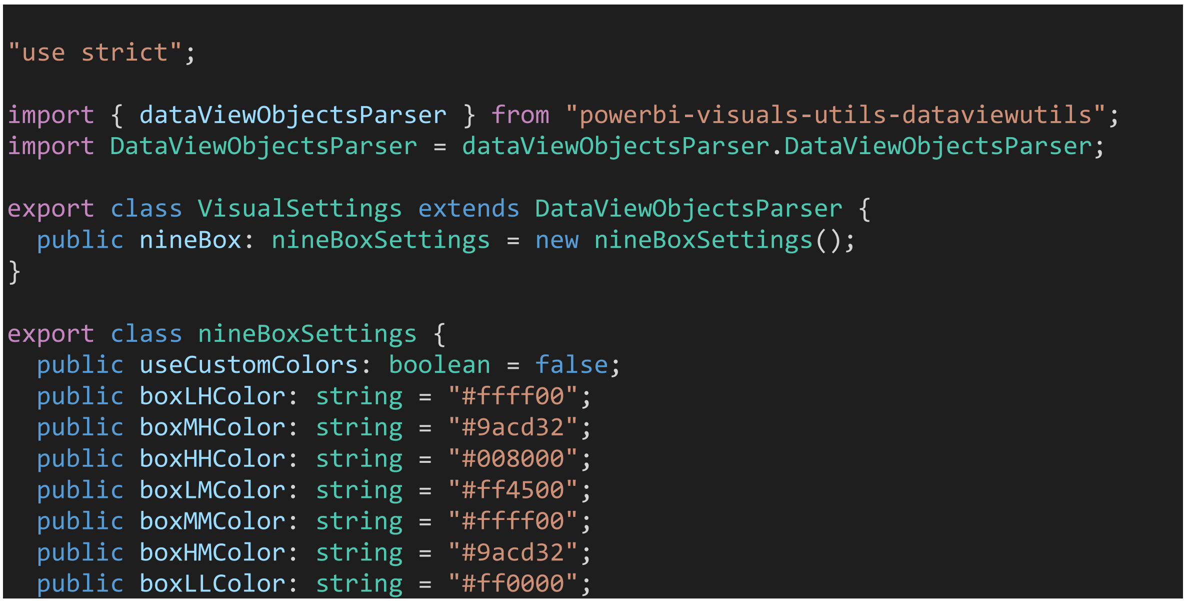
```
div {
    display: flex;
    flex-direction: row;
    flex-wrap: wrap;
    justify-content: space-around;
    align-content: stretch;
    align-items: stretch;
    width: 100%;
    height: 100%;

    .box-size{
        border: 2px solid white;
        flex: 1 0 calc(calc(100%/3) - 4px);
        height: calc(calc(100%/3) - 4px) !important;
        min-height: 50px;
        overflow: hidden;
    }

    box {
        .box-size();
        overflow-y: auto;
        &#boxLH { background: yellow;}
        &#boxMH { background: yellowgreen;}
        &#boxHH { background: green;}
        &#boxLM { background: orangered;}
        &#boxMM { background: yellow;}
        &#boxHM { background: yellowgreen;}
        &#boxLL { background: red;}
        &#boxML { background: orangered;}
```



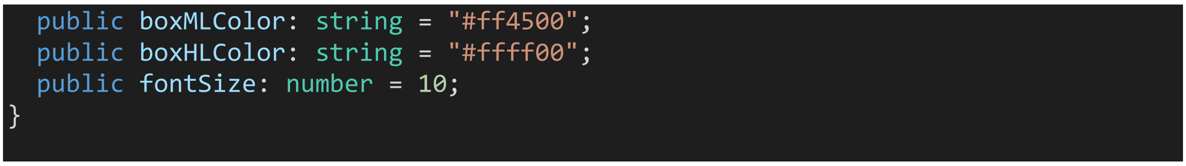
```
        &#boxHL { background: yellow;}

        ul {
            list-style: none;
            margin: 0;
            padding: 10px;

            li {
                font-weight: normal;

                &:hover {
                    font-weight: bold;
                }
            }
        }
    }
}

p {
    font-size: 10px;
    font-weight: bold;
    vertical-align: middle;
    text-align: start;
    padding: 0 16px 0 16px;
    em {
        background: yellow;
        padding: 5px;
    }
}
```

4.3.5 Settings.ts

Setting.ts is one of the main files which written in TypeScript and contains main visualization options. In our case, settings.ts file used to set default box colors and style texts by default by the following code.



```
"use strict";

import { dataViewObjectsParser } from "powerbi-visuals-utils-dataviewutils";
import DataViewObjectsParser = dataViewObjectsParser.DataViewObjectsParser;

export class VisualSettings extends DataViewObjectsParser {
  public nineBox: nineBoxSettings = new nineBoxSettings();
}

export class nineBoxSettings {
  public useCustomColors: boolean = false;
  public boxLHColor: string = "#ffff00";
  public boxMHColor: string = "#9acd32";
  public boxHHColor: string = "#008000";
  public boxLMColor: string = "#ff4500";
  public boxMMColor: string = "#ffff00";
  public boxHMColor: string = "#9acd32";
  public boxLLColor: string = "#ff0000";
```

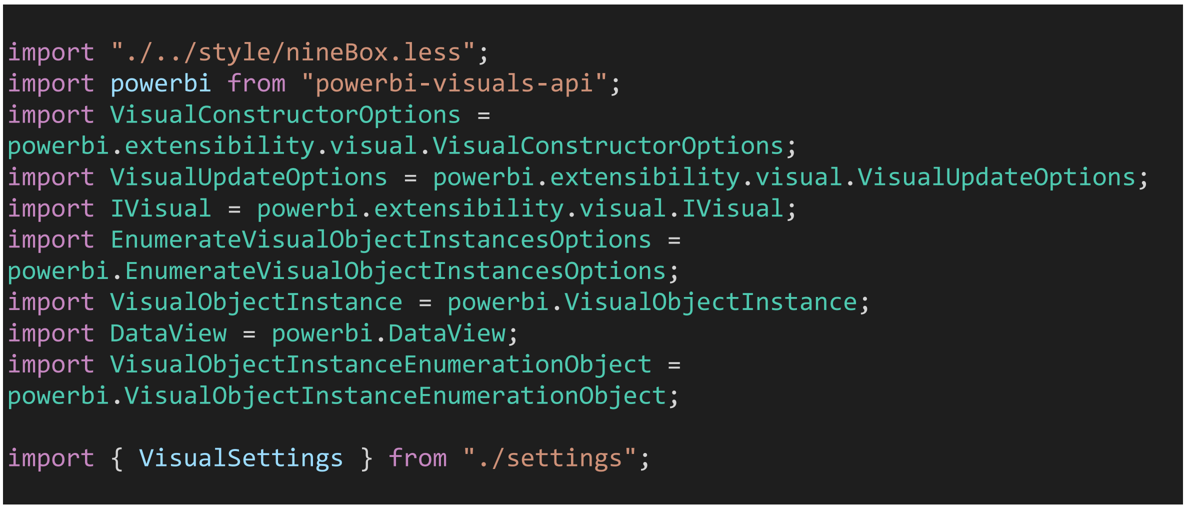


```
  public boxMLColor: string = "#ff4500";
  public boxHLColor: string = "#ffff00";
  public fontSize: number = 10;
}
```

4.3.6 NineBox.ts

NineBox.ts is the one of the main files that written in TypeScript and contains the main elements of the visual. The skeleton of the visual initialized here in this nineBox.ts file. In the following section, the nineBox.ts file will be demonstrated step by step.

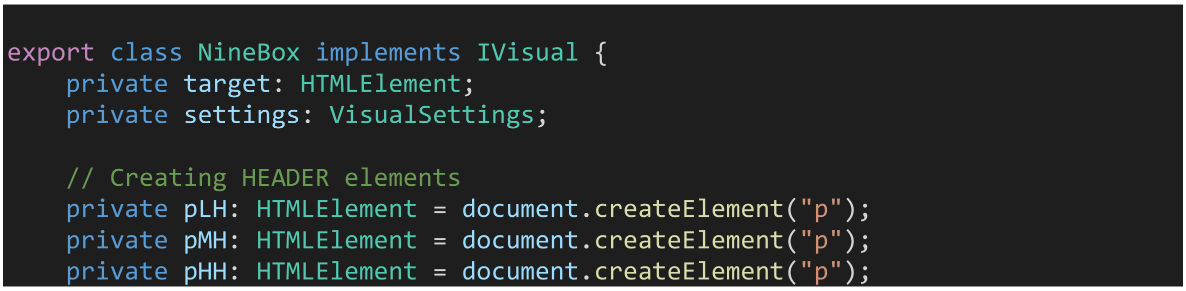
At the beginning of the nineBox.ts, we can see the imported packages all together. Style file is at the top, and followed by powerbi package itself, and the other main packages for the rest.



```
import "./../style/nineBox.less";
import powerbi from "powerbi-visuals-api";
import VisualConstructorOptions =
powerbi.extensibility.visual.VisualConstructorOptions;
import VisualUpdateOptions = powerbi.extensibility.visual.VisualUpdateOptions;
import IVisual = powerbi.extensibility.visual.IVisual;
import EnumerateVisualObjectInstancesOptions =
powerbi.EnumerateVisualObjectInstancesOptions;
import VisualObjectInstance = powerbi.VisualObjectInstance;
import DataView = powerbi.DataView;
import VisualObjectInstanceEnumerationObject =
powerbi.VisualObjectInstanceEnumerationObject;

import { VisualSettings } from "./settings";
```

Following code creates the main NineBox class, to create the 9-Box Grid custom visual itself. It’s starting with the instantiates of the main elements which used in the visual, such as canvas, div, p or boxes.

Boxes and list for the individuals added to the related list for further usage. Header also created but they used one for each related box.



```
export class NineBox implements IVisual {
    private target: HTMLElement;
    private settings: VisualSettings;

    // Creating HEADER elements
    private pLH: HTMLElement = document.createElement("p");
    private pMH: HTMLElement = document.createElement("p");
    private pHH: HTMLElement = document.createElement("p");
    private pLM: HTMLElement = document.createElement("p");
    private pMM: HTMLElement = document.createElement("p");
    private pHM: HTMLElement = document.createElement("p");
    private pLL: HTMLElement = document.createElement("p");
    private pML: HTMLElement = document.createElement("p");
    private pHL: HTMLElement = document.createElement("p");

    // Creating BOX elements
    private boxLH: HTMLElement = document.createElement("box");
    private boxMH: HTMLElement = document.createElement("box");
    private boxHH: HTMLElement = document.createElement("box");
    private boxLM: HTMLElement = document.createElement("box");
    private boxMM: HTMLElement = document.createElement("box");
    private boxHM: HTMLElement = document.createElement("box");
    private boxLL: HTMLElement = document.createElement("box");
    private boxML: HTMLElement = document.createElement("box");
    private boxHL: HTMLElement = document.createElement("box");

    private boxes = [this.boxLH, this.boxMH, this.boxHH, this.boxLM,
this.boxMM, this.boxHM, this.boxLL, this.boxML, this.boxHL]

    // Creating LIST elements
    private listLH: HTMLElement = document.createElement("ul");
    private listMH: HTMLElement = document.createElement("ul");
    private listHH: HTMLElement = document.createElement("ul");
    private listLM: HTMLElement = document.createElement("ul");
    private listMM: HTMLElement = document.createElement("ul");
    private listHM: HTMLElement = document.createElement("ul");
    private listLL: HTMLElement = document.createElement("ul");
    private listML: HTMLElement = document.createElement("ul");
    private listHL: HTMLElement = document.createElement("ul");

    private lists = [this.listLH, this.listMH, this.listHH, this.listLM,
this.listMM, this.listHM, this.listLL, this.listML, this.listHL]
```

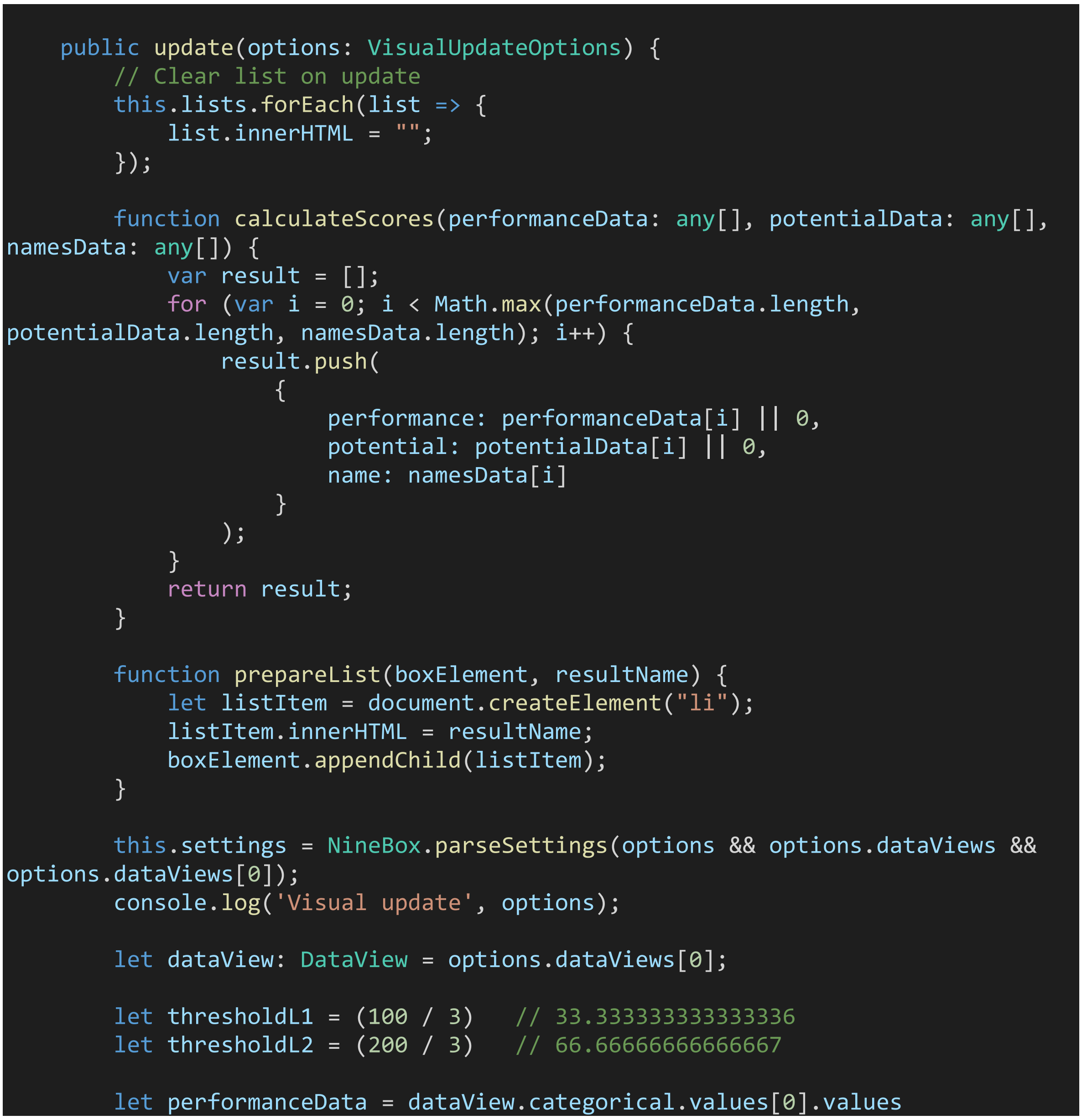
The main NineBox class will export the 9-Box Grid custom visual by creating every instantiated element in its constructor method. Constructor method is used to create and bind the elements, basically to use and to modify them. Following code will create constructor method of the 9-Box Grid visual.

```
constructor(options: VisualConstructorOptions) {
        this.target = options.element;
        if (document) {

            // Creating Canvas for Visualization
            const canvas: HTMLElement = document.createElement("div");
            canvas.setAttribute("id", "nineBox");

            // Settting ID attributes
            this.boxLH.setAttribute("id", "boxLH");
            this.boxMH.setAttribute("id", "boxMH");
            this.boxHH.setAttribute("id", "boxHH");
            this.boxLM.setAttribute("id", "boxLM");
            this.boxMM.setAttribute("id", "boxMM");
            this.boxHM.setAttribute("id", "boxHM");
            this.boxLL.setAttribute("id", "boxLL");
            this.boxML.setAttribute("id", "boxML");
            this.boxHL.setAttribute("id", "boxHL");

            // Adding headers
            this.pLH.appendChild(document.createTextNode("Potential Gem"));
            this.pMH.appendChild(document.createTextNode("High Potential"));
            this.pHH.appendChild(document.createTextNode("Star"));
            this.pLM.appendChild(document.createTextNode("Inconsistent 
Player"));
            this.pMM.appendChild(document.createTextNode("Core Player"));
            this.pHM.appendChild(document.createTextNode("High Performer"));
            this.pLL.appendChild(document.createTextNode("Risk"));
            this.pML.appendChild(document.createTextNode("Average Performer"));
            this.pHL.appendChild(document.createTextNode("Solid Performer"));

            // Adding HTML elements (headers and lists) to boxes
            this.boxLH.appendChild(this.pLH).appendChild(this.listLH);
            this.boxMH.appendChild(this.pMH).appendChild(this.listMH);
            this.boxHH.appendChild(this.pHH).appendChild(this.listHH);
            this.boxLM.appendChild(this.pLM).appendChild(this.listLM);
            this.boxMM.appendChild(this.pMM).appendChild(this.listMM);
            this.boxHM.appendChild(this.pHM).appendChild(this.listHM);
            this.boxLL.appendChild(this.pLL).appendChild(this.listLL);
            this.boxML.appendChild(this.pML).appendChild(this.listML);
            this.boxHL.appendChild(this.pHL).appendChild(this.listHL);

            // Add boxes to canvas
            this.boxes.forEach(box => {
                canvas.appendChild(box);
            });

            // Add canvas to target
            this.target.appendChild(canvas);
        }
    }
```

Elements which created in class level, called in the constructor method, then modified with the other relevant elements. The progress started with creating the main element, which is canvas, an id property added in this case. In the next part, id properties added to each box element. Headers created in the next part. Later, the list elements and headers are added to relevant boxes all together. Each box added to canvas individually, and then canvas added to the main target visual element. Therefore, the final look received on the Developer visual after compilation.

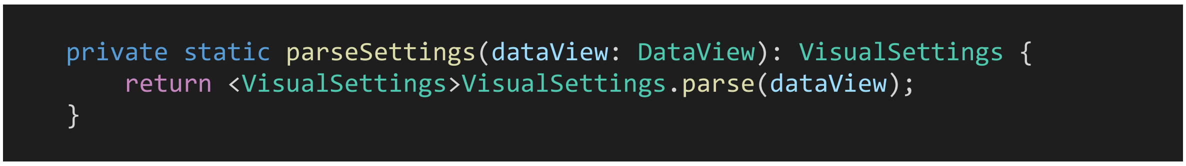
Constructed visual needs a method called “update” to handle selections and colors, also to render the consumed data properly. Update method includes calculations and clearing the rendered data functions.

The 9-Box custom visual contains its own calculations to render individuals in the correct box as a list. Performance and potential scores are being calculated in the update method. Custom color selection is also being handled in the update method. Following code shows the inside of update method.



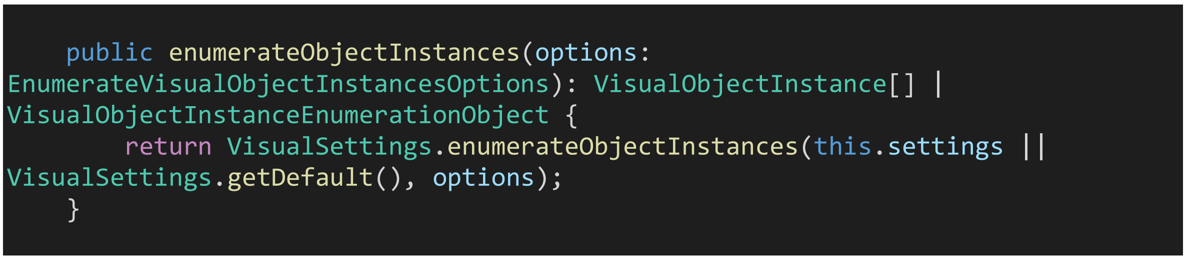
```
    public update(options: VisualUpdateOptions) {
        // Clear list on update
        this.lists.forEach(list => {
            list.innerHTML = "";
        });

        function calculateScores(performanceData: any[], potentialData: any[],
namesData: any[]) {
            var result = [];
            for (var i = 0; i < Math.max(performanceData.length,
potentialData.length, namesData.length); i++) {
                result.push(
                    {
                        performance: performanceData[i] || 0,
                        potential: potentialData[i] || 0,
                        name: namesData[i]
                    }
                );
            }
            return result;
        }

        function prepareList(boxElement, resultName) {
            let listItem = document.createElement("li");
            listItem.innerHTML = resultName;
            boxElement.appendChild(listItem);
        }

        this.settings = NineBox.parseSettings(options && options.dataViews &&
options.dataViews[0]);
        console.log('Visual update', options);

        let dataView: DataView = options.dataViews[0];

        let thresholdL1 = (100 / 3)   // 33.333333333333336
        let thresholdL2 = (200 / 3)   // 66.66666666666667

        let performanceData = dataView.categorical.values[0].values
        let potentialData = dataView.categorical.values[1].values
        let namesData = dataView.categorical.categories[0].values
        let results = calculateScores(performanceData, potentialData,
namesData)

        results.forEach(result => {
            if (result.performance < thresholdL1 && result.potential <
thresholdL1) { prepareList(this.listLL, result.name) }
            else if (result.performance < thresholdL1 && result.potential >
thresholdL1 && result.potential < thresholdL2) { prepareList(this.listLM,
result.name) }
            else if (result.performance < thresholdL1 && result.potential >
thresholdL2) { prepareList(this.listLH, result.name) }
            else if (result.performance > thresholdL1 && result.performance <
thresholdL2 && result.potential < thresholdL1) { prepareList(this.listML,
result.name) }
            else if (result.performance > thresholdL1 && result.performance <
thresholdL2 && result.potential > thresholdL1 && result.potential <
thresholdL2) { prepareList(this.listMM, result.name) }
            else if (result.performance > thresholdL1 && result.performance <
thresholdL2 && result.potential > thresholdL2) { prepareList(this.listMH,
result.name) }
            else if (result.performance > thresholdL2 && result.potential <
thresholdL1) { prepareList(this.listHL, result.name) }
            else if (result.performance > thresholdL2 && result.potential >
thresholdL1 && result.potential < thresholdL2) { prepareList(this.listHM,
result.name) }
            else if (result.performance > thresholdL2 && result.potential >
thresholdL2) { prepareList(this.listHH, result.name) }
        });

        // Override Custom BG Color to boxes
        if (this.settings.nineBox.useCustomColors) {
            this.boxLH.style.background = this.settings.nineBox.boxLHColor;
            this.boxMH.style.background = this.settings.nineBox.boxMHColor;
            this.boxHH.style.background = this.settings.nineBox.boxHHColor;
            this.boxLM.style.background = this.settings.nineBox.boxLMColor;
            this.boxMM.style.background = this.settings.nineBox.boxMMColor;
            this.boxHM.style.background = this.settings.nineBox.boxHMColor;
            this.boxLL.style.background = this.settings.nineBox.boxLLColor;
            this.boxML.style.background = this.settings.nineBox.boxMLColor;
            this.boxHL.style.background = this.settings.nineBox.boxHLColor;
        } else {
            this.boxes.forEach(box => {
                box.style.background = "";
            });
        }

        // Override LI font size
        let listItemsEl = document.getElementsByTagName("li");
        for (let index = 0; index < listItemsEl.length; index++) {
            listItemsEl[index].style.fontSize =
this.settings.nineBox.fontSize.toString() + "px";
        }
    }
```

Next two methods are default methods when the pbiviz package created for the first time. First one includes parsing settings of the data itself, by returning the data view.



```
    private static parseSettings(dataView: DataView): VisualSettings {
        return <VisualSettings>VisualSettings.parse(dataView);
    }
```

Last method is for to make possible object selections, in other words it is for the expose options in the properties pane for the users.

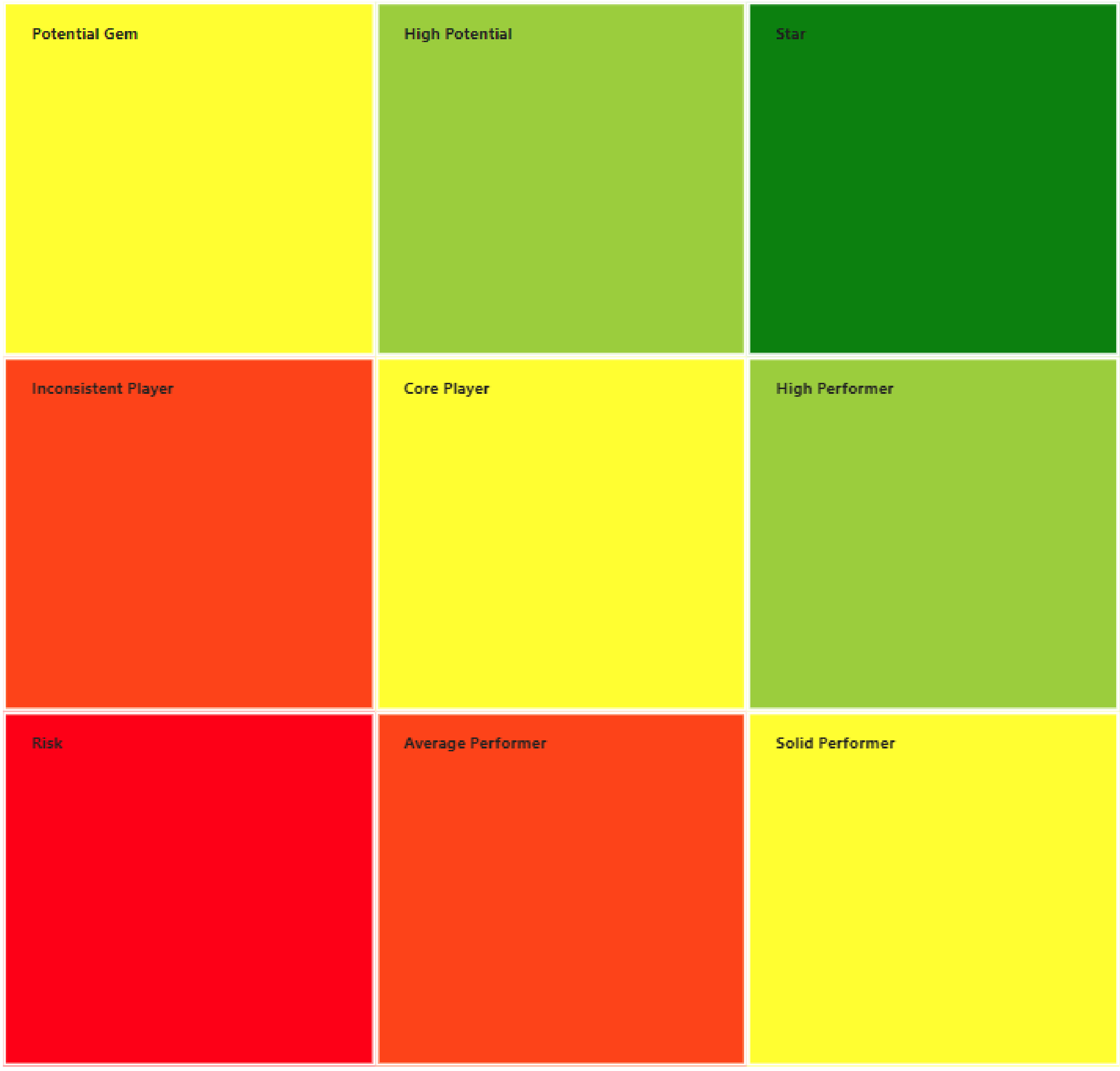


```
    public enumerateObjectInstances(options:
EnumerateVisualObjectInstancesOptions): VisualObjectInstance[] |
VisualObjectInstanceEnumerationObject {
        return VisualSettings.enumerateObjectInstances(this.settings ||
VisualSettings.getDefault(), options);
    }
```

4.3.7 Rendering 9-Box Grid Custom Visual and Getting Report

The 9-Box Grid custom visual will be rendered after the code implementation demonstrated in the earlier sections, and the final output will be presented in Developer Visual like below.

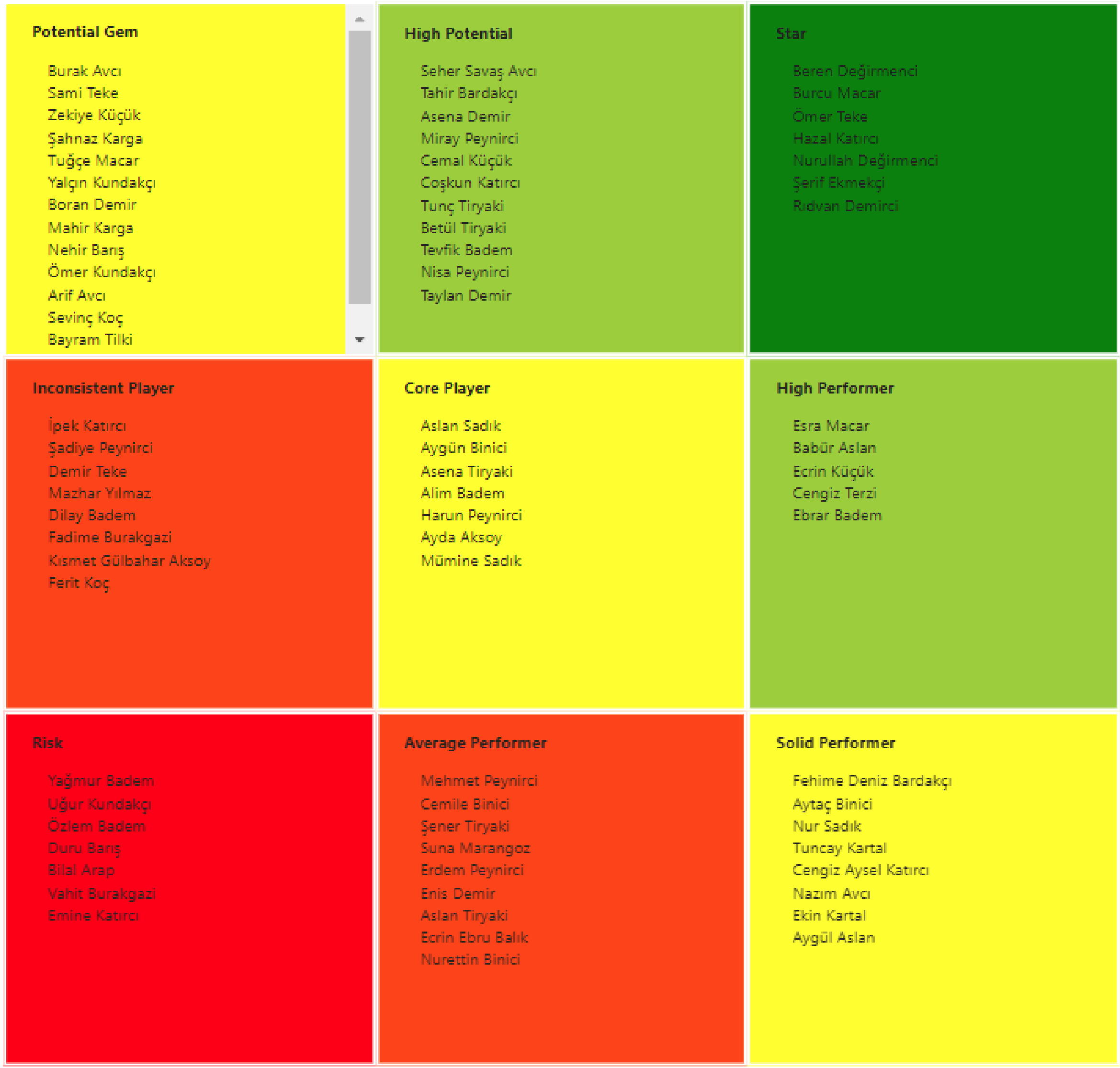
Figure 49 The 9-Box Grid Custom Visual



Potential Gem	High Potential	Star
Inconsistent Player	Core Player	High Performer
Risk	Average Performer	Solid Performer

Example data can be used with the 9-Box Grid tool from now on. To demonstrate the tool with the example data which created in the earlier sections, data fields must be selected in the Field pane. After selection of "Performance Score", "Potential Score" and the "Name" fields in the field pane, the 9-Box Grid tool will render the data properly.

Figure 50 The 9-Box Grid tool, rendering example data



Potential Gem

Burak Avcı
Sami Teke
Zekiye Küçük
Şahnaz Karga
Tuğçe Macar
Yalçın Kundakçı
Boran Demir
Mahir Karga
Nehir Barış
Ömer Kundakçı
Arif Avcı
Sevinç Koç
Bayram Tilki

High Potential

Seher Savaş Avcı
Tahir Bardakçı
Asena Demir
Miray Peynirci
Cemal Küçük
Coşkun Katırcı
Tunç Tiryaki
Betül Tiryaki
Tevfik Badem
Nisa Peynirci
Taylan Demir

Star

Beren Değirmenci
Burcu Macar
Ömer Teke
Hazal Katırcı
Nurullah Değirmenci
Şerif Ekmekçi
Rıdvan Demirci

Inconsistent Player

İpek Katırcı
Şadiye Peynirci
Demir Teke
Mazhar Yılmaz
Dilay Badem
Fadime Burakgazi
Kısmet Gülbahar Aksoy
Ferit Koç

Core Player

Aslan Sadık
Aygün Binici
Asena Tiryaki
Alim Badem
Harun Peynirci
Ayda Aksoy
Mümine Sadık

High Performer

Esra Macar
Babür Aslan
Ecrin Küçük
Cengiz Terzi
Ebrar Badem

Risk

Yağmur Badem
Uğur Kundakçı
Özlem Badem
Duru Barış
Bilal Arap
Vahit Burakgazi
Emine Katırcı

Average Performer

Mehmet Peynirci
Cemile Binici
Şener Tiryaki
Suna Marangoz
Erdem Peynirci
Enis Demir
Aslan Tiryaki
Ecrin Ebru Balık
Nurettin Binici

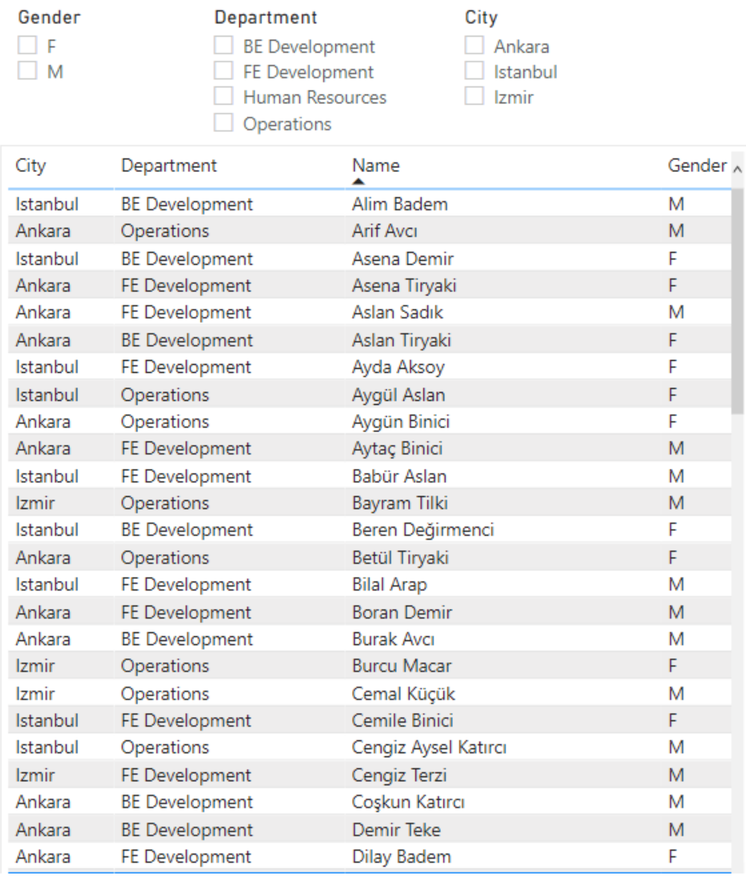
Solid Performer

Fehime Deniz Bardakçı
Aytaç Binici
Nur Sadık
Tuncay Kartal
Cengiz Aysel Katırcı
Nazım Avcı
Ekin Kartal
Aygül Aslan

The 9-Box Grid custom visual consumed the data and rendered. For a proper and better understanding of the created report by custom visuals, there must be more visuals to help the main visual. Therefore, an example usage of the 9-Box Grid tool demonstrated with more other default visual tools of Power BI Service below. In the whole report, beside 9-Box Grid tool, a Table visual used to show the raw data, and Slicer visual used to filter data.

Slicer visuals takes the Gender. Department and City variables from the raw data and uses as a filter. Also, the 9-Box visual renders the data when filters are used with the update method. Table visual renders the individuals according to selected filter. That makes better understanding and sight for the data being used. Output is becoming more useful.

Figure 51 Slicer visuals, Table visual



Gender
□ F
□ M

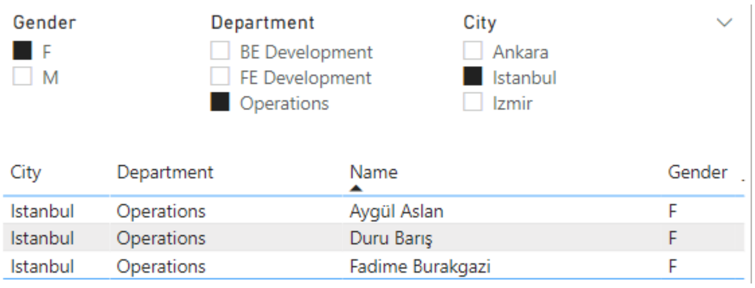
Department
□ BE Development
□ FE Development
□ Human Resources
□ Operations

City
□ Ankara
□ Istanbul
□ Izmir

City	Department	Name	Gender
Istanbul	BE Development	Alim Badem	M
Ankara	Operations	Arif Avcı	M
Istanbul	BE Development	Asena Demir	F
Ankara	FE Development	Asena Tiryaki	F
Ankara	FE Development	Aslan Sadık	M
Ankara	BE Development	Aslan Tiryaki	F
Istanbul	FE Development	Ayda Aksoy	F
Istanbul	Operations	Aygül Aslan	F
Ankara	Operations	Aygün Binici	F
Ankara	FE Development	Aytaç Binici	M
Istanbul	FE Development	Babür Aslan	M
Izmir	Operations	Bayram Tilki	M
Istanbul	BE Development	Beren Değirmenci	F
Ankara	Operations	Betül Tiryaki	F
Istanbul	FE Development	Bilal Arap	M
Ankara	FE Development	Boran Demir	M
Ankara	BE Development	Burak Avcı	M
Izmir	Operations	Burcu Macar	F
Izmir	Operations	Cemal Küçük	M
Istanbul	FE Development	Cemile Binici	F
Istanbul	Operations	Cengiz Aysel Katırcı	M
Izmir	FE Development	Cengiz Terzi	M
Ankara	BE Development	Coşkun Katırcı	M
Ankara	BE Development	Demir Teke	M
Ankara	FE Development	Dilay Badem	F

When the filters are used with the slicers, the output in the table is being like below.

Figure 52 Output in the Table after filters used with Slicer



Gender
■ F
□ M

Department
□ BE Development
□ FE Development
■ Operations

City
□ Ankara
■ Istanbul
□ Izmir

City	Department	Name	Gender
Istanbul	Operations	Aygül Aslan	F
Istanbul	Operations	Duru Barış	F
Istanbul	Operations	Fadime Burakgazi	F

5 Results and Discussion

Results of this thesis that were acquired after the theoretical and practical part will be examined in this section. The data types, the history of visualization, data visualization, and custom data visualization are studied in the practical part with examples.

Data visualization tools such as Power BI and Tableau were examined and compared in detail. As an output, comparing the data visualization tools produced a benchmark report. In the benchmark part, a comparison between Power BI and Tableau brings the differences to the table. Power BI came to the front in these contexts: the price of the tool, secure environment for development, and ease to learn and develop a custom visual with it. Therefore, Power BI was selected as the tool to develop custom visualization, which is the 9-Box Grid tool.

The next part is spared to discuss the meaning of the 9-Box Grid and its features. The visual tool was questioned, and its history was presented. Also, the advantages of using the 9-Box Grid are discussed. In an organization or individual, the topics delivered are about measuring the performance and potential of the individuals and managing their talents.

In the practical part, the development environment is introduced. Power BI Data Visualization and Business Intelligence tool presented. Setting up of an environment for developing custom visualization tool by Power BI demonstrated. Dataset preparation method discussed, and a dataset prepared to use in development.

The 9-Box Grid was developed as a custom visual by Power BI after setting up the environment correctly and demonstrated step by step. At the end of the practical part, the prepared dataset is rendered by the developed the 9-Box Grid tool, and the output is shared. For the output, real use case examples were added, such as using the 9-Box Grid tool with a table and slicers in a report, for better understanding.

The acquired output of this thesis reached its purpose through the successful development of the 9-Box Grid tool and the report result on Power BI Service.

Power BI has a secure and robust development environment and various possibilities to improve custom visuals. This strength brings custom visualizations, endless ways to serve its users, and challenging ideas to developers.

6 Conclusion

The purpose of this thesis includes developing a custom visualization tool for data visualization and business intelligence software, the 9-Box Grid. The thesis represents the data visualization, custom data visualization and development variations, and the 9-Box Grid tool.

Data visualization and reading the data more meaningfully became crucial over time. Modern-day data visualization and business intelligence applications are giving their fight on the market. Power BI and Tableau are useful software that companies, organizations, and individuals use in day-to-day work. Therefore, the data visualization became, creating a report from the raw data is much more critical in such a competitive market.

The study compares Power BI and Tableau and suggests the most suitable software to develop custom visualization. Power BI and Tableau are well-developed for data visualization, which was hard to select one of them. When it comes to developing a custom visual, in an easier way, in a secure environment, Power BI was the decision with its free-to-use option, well-structured and ready-to-use visuals. Therefore, Power BI was selected to develop the 9-Box Grid custom visualization during the development process.

The 9-Box Grid tool brings its features to talent management. It becomes insightful when supported by tables and slicers, like in real use cases. A unique tool was developed, and it is ready to use.

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8 List of Pictures, Tables, Graphs, and Abbreviations

8.1 List of Pictures

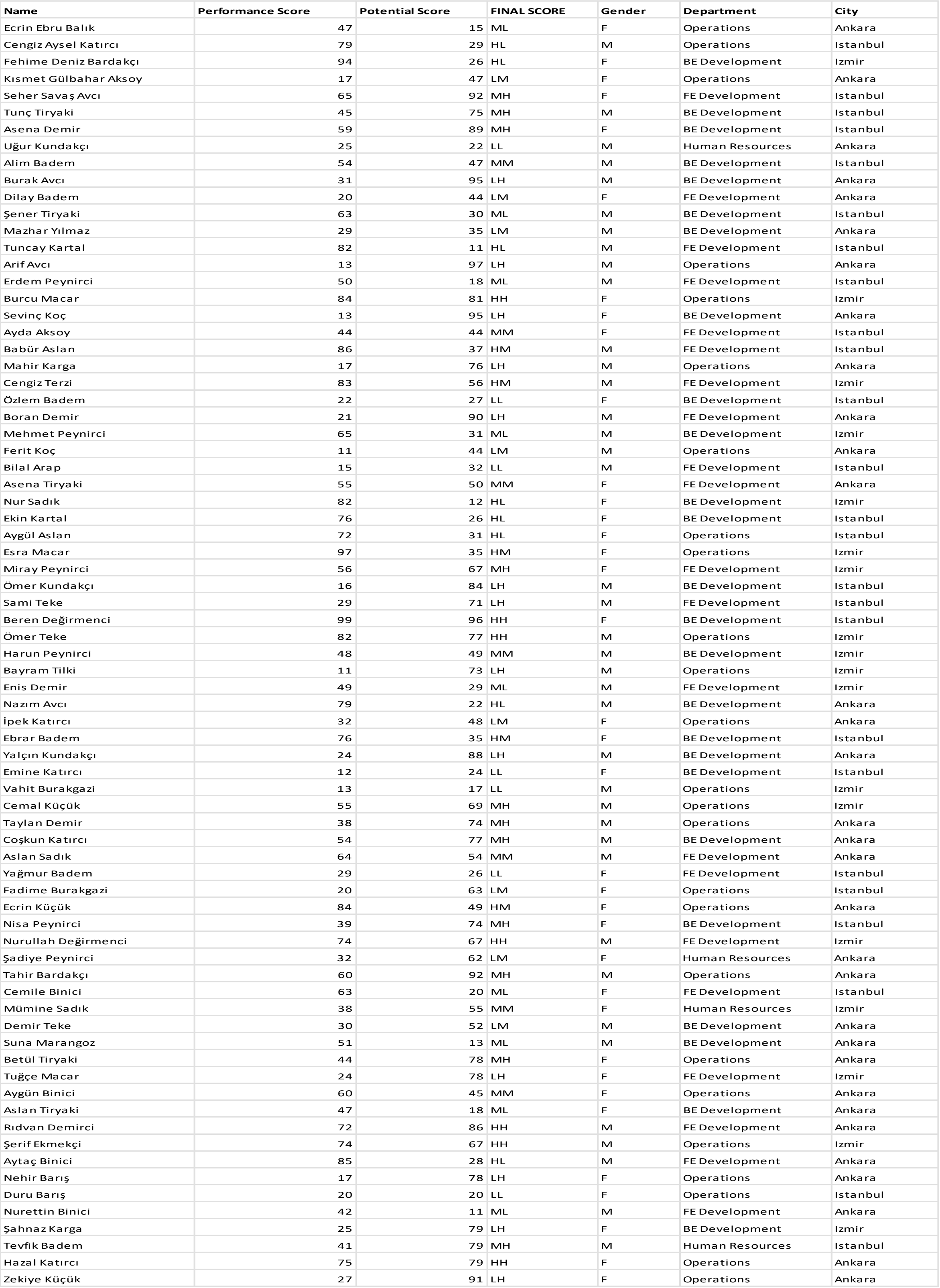
8.2 List of Tables

8.3 List of Abbreviations

CPU:	Central Processing Unit
CSS:	Cascading Style Sheet
DDR3L	Double Data Rate Type 2 Low Voltage
GB	Giga Bytes
GP	Goal Programming
HTML5	Hyper Text Mark-up Language 5
IDE	Integrated Development Environment
JSON	JavaScript Object Notation
MCDA	Multi-Criteria Decision System
OS	Operating System
PPU	Premium Per User
RAM	Random Access Memory

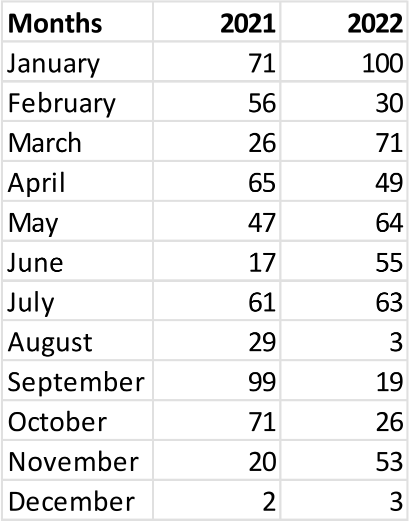
9 Appendix

Appendix A Dataset for 9-Box Custom Visualization



Name	Performance Score	Potential Score	FINAL SCORE	Gender	Department	City
Ecrin Ebru Balık	47	15	ML	F	Operations	Ankara
Cengiz Aysel Katırcı	79	29	HL	M	Operations	Istanbul
Fehime Deniz Bardakçı	94	26	HL	F	BE Development	Izmir
Kısmet Gülbahar Aksoy	17	47	LM	F	Operations	Ankara
Seher Savaş Avcı	65	92	MH	F	FE Development	Istanbul
Tunç Tiryaki	45	75	MH	M	BE Development	Istanbul
Asena Demir	59	89	MH	F	BE Development	Istanbul
Uğur Kundakçı	25	22	LL	M	Human Resources	Ankara
Alim Badem	54	47	MM	M	BE Development	Istanbul
Burak Avcı	31	95	LH	M	BE Development	Ankara
Dilay Badem	20	44	LM	F	FE Development	Ankara
Şener Tiryaki	63	30	ML	M	BE Development	Istanbul
Mazhar Yılmaz	29	35	LM	M	BE Development	Ankara
Tuncay Kartal	82	11	HL	M	FE Development	Istanbul
Arif Avcı	13	97	LH	M	Operations	Ankara
Erdem Peynirci	50	18	ML	M	FE Development	Istanbul
Burcu Macar	84	81	HH	F	Operations	Izmir
Sevinç Koç	13	95	LH	F	BE Development	Ankara
Ayda Aksoy	44	44	MM	F	FE Development	Istanbul
Babür Aslan	86	37	HM	M	FE Development	Istanbul
Mahir Karga	17	76	LH	M	Operations	Ankara
Cengiz Terzi	83	56	HM	M	FE Development	Izmir
Özlem Badem	22	27	LL	F	BE Development	Istanbul
Boran Demir	21	90	LH	M	FE Development	Ankara
Mehmet Peynirci	65	31	ML	M	BE Development	Izmir
Ferit Koç	11	44	LM	M	Operations	Ankara
Bilal Arap	15	32	LL	M	FE Development	Istanbul
Asena Tiryaki	55	50	MM	F	FE Development	Ankara
Nur Sadık	82	12	HL	F	BE Development	Izmir
Ekin Kartal	76	26	HL	F	BE Development	Istanbul
Aygül Aslan	72	31	HL	F	Operations	Istanbul
Esra Macar	97	35	HM	F	Operations	Izmir
Miray Peynirci	56	67	MH	F	FE Development	Izmir
Ömer Kundakçı	16	84	LH	M	BE Development	Istanbul
Sami Teke	29	71	LH	M	FE Development	Istanbul
Beren Değirmenci	99	96	HH	F	BE Development	Istanbul
Ömer Teke	82	77	HH	M	Operations	Izmir
Harun Peynirci	48	49	MM	M	BE Development	Izmir
Bayram Tilki	11	73	LH	M	Operations	Izmir
Enis Demir	49	29	ML	M	FE Development	Izmir
Nazım Avcı	79	22	HL	M	BE Development	Ankara
İpek Katırcı	32	48	LM	F	Operations	Ankara
Ebrar Badem	76	35	HM	F	BE Development	Istanbul
Yalçın Kundakçı	24	88	LH	M	BE Development	Ankara
Emine Katırcı	12	24	LL	F	BE Development	Istanbul
Vahit Burakgazi	13	17	LL	M	Operations	Izmir
Cemal Küçük	55	69	MH	M	Operations	Izmir
Taylan Demir	38	74	MH	M	Operations	Ankara
Coşkun Katırcı	54	77	MH	M	BE Development	Ankara
Aslan Sadık	64	54	MM	M	FE Development	Ankara
Yağmur Badem	29	26	LL	F	FE Development	Istanbul
Fadime Burakgazi	20	63	LM	F	Operations	Istanbul
Ecrin Küçük	84	49	HM	F	Operations	Ankara
Nisa Peynirci	39	74	MH	F	BE Development	Istanbul
Nurullah Değirmenci	74	67	HH	M	FE Development	Izmir
Şadiye Peynirci	32	62	LM	F	Human Resources	Ankara
Tahir Bardakçı	60	92	MH	M	Operations	Ankara
Cemile Binici	63	20	ML	F	FE Development	Istanbul
Mümine Sadık	38	55	MM	F	Human Resources	Izmir
Demir Teke	30	52	LM	M	BE Development	Ankara
Suna Marangoz	51	13	ML	M	BE Development	Ankara
Betül Tiryaki	44	78	MH	F	Operations	Ankara
Tuğçe Macar	24	78	LH	F	FE Development	Izmir
Aygün Binici	60	45	MM	F	Operations	Ankara
Aslan Tiryaki	47	18	ML	F	BE Development	Ankara
Rıdvan Demirci	72	86	HH	M	FE Development	Ankara
Şerif Ekmekçi	74	67	HH	M	Operations	Izmir
Aytaç Binici	85	28	HL	M	FE Development	Ankara
Nehir Barış	17	78	LH	F	Operations	Ankara
Duru Barış	20	20	LL	F	Operations	Istanbul
Nurettin Binici	42	11	ML	M	FE Development	Ankara
Şahnaz Karga	25	79	LH	F	BE Development	Izmir
Tevfik Badem	41	79	MH	M	Human Resources	Istanbul
Hazal Katırcı	75	79	HH	F	Operations	Ankara
Zekiye Küçük	27	91	LH	F	Operations	Ankara

Appendix B Dataset for visualization examples



Months	2021	2022
January	71	100
February	56	30
March	26	71
April	65	49
May	47	64
June	17	55
July	61	63
August	29	3
September	99	19
October	71	26
November	20	53
December	2	3