

UNIVERSITÀ DEGLI STUDI DI PADOVA

DEPARTMENT OF INFORMATION ENGINEERING

MASTER'S DEGREE IN
COMPUTER ENGINEERING

**Integration and improving of Actual
management procedure in SAP data
warehousing system**

Supervisor:

PROF. GIANMARIA SILVELLO

Candidate:

RICCARDO SMERILLI

2019162

Academic Year 2022/2023

Date of Graduation 10/07/2023

Abstract

In this thesis, we aim to describe the design and development of the process of management closing and business consolidation for a holding operating in the fashion industry. We present the integration and optimization of two specific applications into the most updated version of their EPM system's process flow. After a quick overview in the introduction, in Chapter 2 we start to describe who are the entities involved in this project, what is the initial state of the EPM system, and the goals set after the analysis of processes. In Chapter 3, we illustrate the EPM software and the SAP technologies on which all the application is based. Particular attention is paid to the description of how the data warehouse software SAP BW/4HANA is structured. Each application has its Chapter: Chapter 4 for the allocation engine and Chapter 4.5 for revaluation. In these chapters, we describe the core of the work, explaining the technical concepts chosen to integrate the processes and to improve the performance of complex computation for the application.

Contents

1	Introduction	1
2	Project Management	6
2.1	Descriptions of Companies	6
2.1.1	PricewaterhouseCoopers Spa	6
2.1.2	Fashion Group	7
2.2	Project Framework	8
2.2.1	Data Model	9
2.2.2	Planning application	11
2.2.3	Indirect Costs Workflow application	16
2.2.4	”Actual New” project	18
2.2.5	Analysis of needs	20
3	Project Technologies	23
3.1	SAP Modules	23
3.1.1	SAP ECC	23
3.1.2	SAP HANA	25
3.1.3	SAP BW/4HANA	27
3.1.4	SAP BPC	27
3.1.5	SAP Analytics Cloud	29
3.2	SAP Software Components	30
3.2.1	InfoObjects	30
3.2.2	Advanced DataStore Objects	32
3.2.3	Composite Provider and Queries	34
3.2.4	Planning Sequence	36

3.2.5	Process Chain	37
3.2.6	HANA Calculation View	38
4	Management Closing and Consolidation	
	processes	39
4.1	BPC Securities	39
4.2	Actual Management Data	40
4.2.1	Data Model	41
4.2.2	Data Flow	44
4.3	Management Closing BPF	49
4.4	Allocation Engine	52
4.5	Revaluation of Cogs	69
5	Conclusion	83

1 Introduction

In today's digital landscape, businesses of all sizes face the challenge of handling and managing an ever-increasing volume of data. As data grows in size and complexity, efficient data flow management becomes crucial. This necessity often calls for the expertise of specialized companies capable of remodeling procedures and implementing technology upgrades. This is where PwC comes into play. PwC's internal team was entrusted with the task of finance transformation for one of the leading fashion industry conglomerates, referred to here as Fashion Group for confidentiality reasons. The client sought to revamp their planning and consolidation processes, which were hampered by outdated software and inefficient data access between their various entities. PwC proposed a solution to address their needs through the redesign of an Enterprise Performance Management (EPM) process, leveraging specialized software resources to monitor and enhance performance across the entire enterprise.

The goal of the project was to revolve around migration and improvement of the existing processes and applications within Fashion Group, specifically focusing on the management closing and consolidation processes of the group's businesses. These intricate processes entail multiple planning and reporting steps, aimed at analyzing accounting information to assist management and prepare financial statements. Among all the steps, this thesis is focused on two essential features that significantly contribute to the organization's objectives:

- Allocation Engine: its primary objective is to distribute cash accord-

ing to specific criteria. However, this feature had received considerable attention due to its complexity and limited user satisfaction regarding usability. Users were required to navigate a sequence of rigid and repetitive tasks to achieve desired outcomes.

- Revaluation of COGS: this application involved revising the previously defined Cost of Goods Sold (COGS) using a new list of unit costs for products, following a specific procedure. This particular aspect also faced challenges as it required an unreasonable amount of time to perform the necessary computations, rendering the feature practically unusable.

Given the extensive experience and expertise of our team in SAP environment development, and considering the client's existing utilization of SAP software for their internal processes, it was an obvious choice to employ SAP BW/4HANA as the underlying software for our EPM process implementation. This decision ensures seamless integration with the client's current infrastructure and takes advantage on the team's proficiency in SAP technologies. By utilization of the columnar storage and in-memory processing capabilities of HANA, we can deliver a robust and tailored EPM solution that aligns perfectly with the client's requirements, providing them with a powerful platform for effective financial planning and management.

The implementation of our solution on SAP BW/4HANA use the fundamental capabilities of Planning Sequences and Process Chains. The first enables the automation and structured execution of complex planning processes, ensuring a systematic approach to data entry and consolidation. It is used frequently along the processes since several steps require to perform

more than a simple direct input of data. The other feature automate the execution of multiple activities, such as data extraction, transformation, loading, calculations, and reporting. They help eliminate manual intervention, reduce errors, and improve overall process reliability and repeatability. Process chains was necessary for the only COGS Revaluation application because substantial volume of data was involved and a inadequate management of the data could potentially cause the process to block the entire server indefinitely. The strategic use of Planning Sequences and Process Chains strengthens the effectiveness and efficiency of our EPM solution, enabling businesses to achieve improved data management, enhanced financial planning, and optimized performance.

Beyond technological aspect, to achieve our objective, we redesigned the workflow of business' process and introducing new features to enhance user productivity. We approached the two applications differently, taking into consideration their unique requirements. For the allocation engine, a comprehensive review of user experience was necessary to meet user demands for a streamlined process that eliminates repetitive tasks. To address this, we developed a new engine that computes allocations based on predefined rules set by controllers for each company. A key feature of the engine is the storage of allocation results in a proper data source, allowing users to verify the accuracy of the allocation after computation. On the other hand, the primary obstacle in implementing the COGS revaluation was to develop a high time-cost application while ensuring it doesn't disrupt users' workflow. To ensure that, we operated on application level implementing background processes through Process chains. However, this led to a lack of visibility into

the progress of the computation. To address this issue, we implemented a logging system to track the progress and provide users with real-time updates on the process.

The project's technical and design decisions yielded significant outcomes that successfully met the requirements of all FG's companies. For the allocation engine, despite initial challenges during user training due to a completely revamped approach, we successfully implemented a streamlined workflow. By incorporating a rule storage mechanism, we enhanced time efficiency by eliminating the need to re-enter allocation instructions. About COGS revaluation, the implementation of the new application was able to overcome various technical obstacles, thanks to the adoption of SAP BW/4HANA. By migrating the application from an unsuitable environment (SAP ECC) to the data warehouse software suite, we achieved efficient management of large data volumes without impeding user workflow or burdening the server.

This research study highlights the significance of the EPM system and demonstrates how it can greatly enhance various business processes in terms of time efficiency and software usability. Specifically, the applications in question in the FG's environment serve as exemplary illustrations of these improvements, which can have a profound impact on business outcomes. Through our investigation, we effectively showcase how software optimization can significantly expedite a particular feature, while also emphasizing the importance of streamlining internal processes to enhance user comfort and job performance.

After a quick overview in the introduction, in Chapter 2 we start to describe who are the entities involved in this project, what is the initial

state of the EPM system, and the goals set after the analysis of processes. In Chapter 3, we illustrate the EPM software and the SAP technologies on which all the application is based. Particular attention is paid to the description of how the data warehouse software SAP BW/4HANA is structured. Each application has its Chapter: Chapter 4 for the allocation engine and Chapter 4.5 for revaluation. In these chapters, we describe the core of the work, explaining the technical concepts chosen to integrate the processes and to improve the performance of complex computation for the application.

2 Project Management

This chapter makes clear to the reader what the current status of the project is, describing the organization of the involved companies, the needs of customers, and which objective must be reached.

2.1 Descriptions of Companies

The involved companies are two of the biggest businesses of their branch and are related by a consultancy agreement. Cause of company policy, the name of customer is replaced with a fictional one.

2.1.1 PricewaterhouseCoopers Spa

PricewaterhouseCoopers Spa is an international professional services brand of firms operating as partnerships under the PwC brand. The PwC firms are in 157 countries with 328.000 people and offer several services for a variety of industries including financial services, healthcare, technology, and energy, among others. Among all the professional services provided around the world, the main ones are the following:

- **Audit and Assurance:** aims to reduce information risk by improving the quality of the information through an examination of a company's processes. The audit is a type of assurance service which is focused on objective examination and evaluation of a company's financial statements.
- **Consulting:** aims to improve clients' business processes and to achieve

their strategic objectives. The firm utilizes methods that include technology consulting, human resources, and sustainability consulting.

- **Tax and Legal:** provides services as international tax and tax controversy to help clients to manage their tax compliance and minimize tax liabilities.

PwC Italy is a firm in the Italian area that offers me the opportunity to draw up this work. The team under this office provides services to guide the transformation of operational and financial aspects of the client's businesses thanks to the intersection of business, experience, and modern digital technologies. The goal of the team is to enable organizations to become more efficient, effective, and agile in managing their finances, while also improving the quality and accuracy of their financial reporting.

2.1.2 Fashion Group

As mentioned before, customer company information is replaced with fictional ones cause of privacy and security preventative measures to avoid the leak of sensitive data and to respect the policies of the business's image. From now on, the company will be mentioned as Fashion Group, or with the abbreviation FG.

FG is a holding whose line of business includes designing, manufacturing, and selling articles of clothing for women, with several own brands. It was founded in Italy and is in more than 100 countries with around 2.000 stores. In addition to retail companies, FG possesses also production companies that manufacture and distribute both clothing and materials.

2.2 Project Framework

Before the current version of EPM system, Fashion Group has already possessed on-premises SAP systems for resources planning and performance monitoring:

- **ERP system - SAP ECC:** integrated management of day-to-day business processes which provides a continuously updated view of processes using common databases maintained by a DBMS. ERP systems support all aspects of financial management, human resources, supply chain management, and manufacturing.
- **EPM System - SAP BW/4HANA:** process of monitoring that provides budgeting, forecasting and financial management methods in order to improve the performance of business.
- **User Application - SAP BPC e AFO:** software application which interfaces the underlying management system with the users.

The above technologies will be explained deeply in the next chapters.

Starting from this system, FG and PwC started working together to improve and speed up the finance transformation of the business taking advantage of potential and possibilities offered by newer SAP technologies. The upgrade of the technologies with BPC 11.1 and SAP Analytics Cloud and the remodelling of processes have brought the following benefits to the customer:

- Unique and consistent data among management closing, planning and reporting BW/4
- Increasing of details of data of reporting

- Greater frequency of data loading from ERP system
- Simplification of architecture and optimization of present system
- Digital boardroom, self-reporting and improved UX with SAP Analytics Cloud for an easier navigation of data
- Processes are supported by several Business Process Flows and workflow which make progress visible
- Removing of COPA's inefficiency with BW/4HANA "real-time"
- Collaborative planning through predictive analysis for a next implementation of SAP S/4HANA

2.2.1 Data Model

The following table contains the definitions and examples of main data used among designed applications. Other dimensions are defined in each process in according to the specific goal to reach.

Name	Description	Example
Time	temporal information defined by month, semester, quarter and year	"001.2023", "012.2021"
Category	identify the type of transactional data.	"Actual", "Budget"
Company	identifies the societies of the group through an unique code.	"M001", "M220"

Country	describe geographical information of the company	"IT", "EN"
Division	define in which field the company operates	"RETAIL", "DIVISION", "INDUSTRIAL"
Account	represents the accounts among the processes. They are divided in five levels which identifies a type of a set of accounts.	"1.2.1.2" "V.10.23"
Trading partner	set of third-party companies and internal one which have a trading agreement with the the FG's company to which is allocated the transactional data	"M001", "M004"
Season	temporal data which is a peculiar characteristic of fashion industry. It is necessary to assign the data to the fashion's season calendar which is imposed by mismatch between seasonal clothes' sale and design and manufacturing period. A fashion calendar year may be split up to five seasons	"2022-1", "2023-2"
Cost Center and POS	identify a business unit that incur costs but only indirectly contribute to revenue generation. A child dimension is the POS that is a physical or virtual place where sales transactions are made	"M0010340", "M1202304"

Vendor and Customer	identify respectively who supplies and buys	"230", "3", "50"
Contract type and Channel	define respectively the set of available contracts and the type of sales channels used by company, e.g. resellers, general marketplace and so on	"B2C", "PROP"
Profit and Loss Line	reports the financial statements which summarizes the revenues and costs used for comprehending the ability to generate profit. Each line is mapped to data in according of combination of Entity, Account, Cost Center and Group Cost Center	"PL100", "PL930"
Currency	identifies the currency of the considered amount	"EUR", "USD"

2.2.2 Planning application

Financial budgeting represents the overall financial position and goals of an organization. This regular practice of timely operational and financial budgeting creates a baseline for comparison to see how actual results vary from expected performance. Through this application, the company can perform **strategic cost planning** and **performance measurement**.

During the analysis of this process, the main goal was to simplify the data flow and the number of steps along the path to complete the proce-

ture. Particular attention was paid to eliminating a criticality caused by the redundancy of data during the upload of these.

As a result of the design, the companies figured out to implement two distinct process flows based on the aspect of the planning phase. Each process is further distinct in versions similar to each other according to the division of the company's group. The processes can be explained as follows:

- **OPEX Budgeting:** OPEX term intends the operational expenditure, one-time or recurring, for running the business. In other words, this is the money the business spends to turn inventory into throughput. These amounts were fetched and inserted into the system manually by managers who exchange Excel templates via email. The implemented application provides an automated procedure for data input through the SAC web interface.
- **Sales and Margin (S&M):** it measures the amount of profit made on the sale of products by subtracting all the expenses related to the cost of goods, i.e. materials, labor, and so on. This part was improved by migrating the process from the Microsoft Office environment to SAP BW and BPC and implementing two distinct versions for diffusion and retail companies.

In both processes, the users are assisted by the Business Process Flow within BPC 11.1 in order to have an overview of all steps and the progress. An example of user interface is shown in the following Figure 1.

In the next sub-chapters it is drawn up an overview of the steps for each process, since they are not fundamental for this paper.

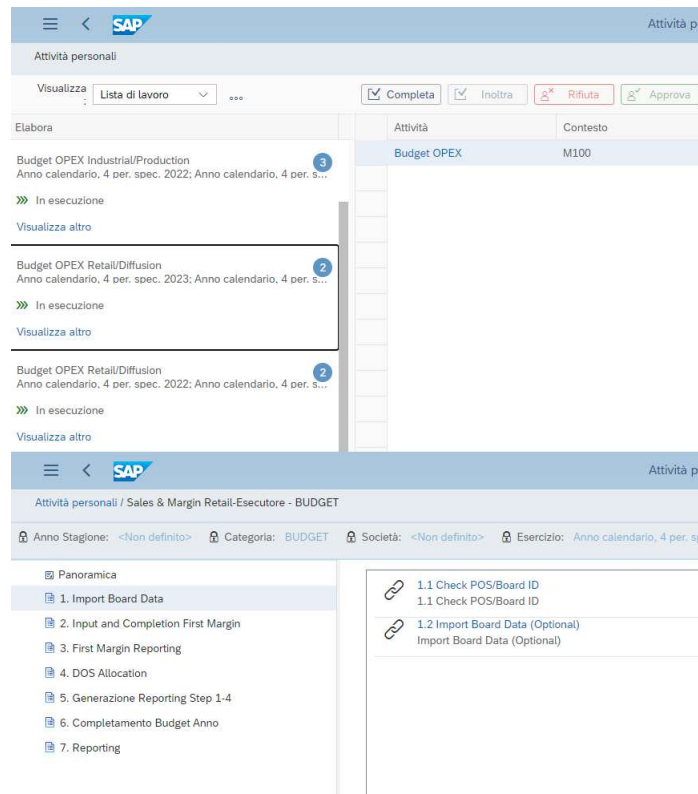


Figure 1: user interface of a Business Process Flow (BPF) in BPC 11.1. The figure is composed by two pages: the main page and the process flow of an application. The upper page is the main page where there is a list of instances of applications that differ per application and context (calendar, year, company and division). The lower page shows main process' steps on the left side and the elementary steps on the right side.

OPEX Budgeting BPF

The steps defined in the process flow of OPEX Budgeting are:

1. **Setup:** after a first sub-step in which the controller must verify the right reference timing of each cost center and right mapping between Cost Center and Company, next activities consists of:

- initialization of Actual data and KPI of the three previous years from the scenario's fiscal year.
 - mapping between Cost Center and Accounts and between KPI and Cost Center for the combinations without Actual data.
 - creation and distribution of OPEX Budgeting's tasks performed by controller.
2. **Input Budget OPEX SAC:** during this step, users are able to access to SAC stories in order to insert budget in according to which division they are responsible.
 3. **Check & Adjustment Input:** the controller can visualize the inserted data from users and adjust them. Each sub-step differs by division and timing.
 4. **Labour costs and depreciation input:** this step allows to insert labour costs and depreciation can be inserted manually or via flat file.
 5. **Input KPI:** at the beginning, management controller can visualize a report which shows KPI that are planned by supervisor with Budget and Pre-Budget data. Then, he can plan periodic or seasonal KPI for analysis and reporting purpose over statistical indicators.
 6. **Monthly Scheduling:** allows to split the amount of all the inserted data, including labour costs and depreciation, over specific months in according to the selected season and the referential cost center. Controller may also adjust the amounts with a proper board.

7. **Cost Distribution:** this step aims to overturn costs in Budget to each cost center that generated them directly or not through statistical indicators. After the initialization of the data of July period to February one, the mapping of cost center can be defined with a desired allocation type: by amount, percentage, KPI or rate. The last sub-steps allows to check and adjust the calculated amounts.
8. **Reporting:** collects reports that provide different views for planning analysis comparing Budget and Actual data.
9. **Workstatus:** single step which allows to block budget planning process.
10. **Export to WFI:** cause of technical limit between SAP modules, this step is implemented to export a flat file from BW for uploading WFI data to SAP ECC environment.

Sales and Margin BPF

Planning of the sales and margin will be carried out for single season for retail companies and for month and associated to two seasons for diffusion companies. Then, the budgets are spread over months. Three BPF are published for retail, diffusion and foreign companies which differ how data is inserted. The main steps of S&M application are defined as follows:

- **Input Budget S&M:** users start the process inserting the budgets using different sheets for each division in order to compute the margin.
- **Cogs Calculation:** this is a step reserved for diffusion companies.

The user can upload a flat file that contains the amounts of cost of goods sold. In addition, the user can adjust the percentage of previous COGS.

- **Monthly Scheduling:** similar to OPEX monthly distribution of budgets.
- **DOS Allocation:** this is a step reserved for retail companies. Similar to OPEX process, the user can allocate the operative costs over companies' POS in according to a mapping writing up during the first step. It is provided a report to check which data have been allocated.
- **Reporting:** after a first function which copy the previous inserted budget into the reports' data store objects, the application provides several reports through which analyse entered budgets.

2.2.3 Indirect Costs Workflow application

The scope of the Indirect Workflow workstream (see Figure 2) includes the monitoring of expenditure relating to indirect purchases which differ in the allocation of expenditure to cost centre, asset and project (WBS). Expenditure monitoring is carried out by comparing parameters such as Budget, Engaged by RF/PO, Approved by RF, Actual and takes place on the basis of a hierarchical structure that defines the responsibilities and access to data on the various control objects.

The goal of WFI application is to provide users with the ability to consult and monitor the budget KPIs available for indirect purchases, on the basis of their own assignment of responsibilities, by browsing through a series of

information details made available in organic form and user-friendly thanks to the SAP Analytics Cloud interface. A further detailed analysis is then performed in an ad-hoc report on the Analysis for Office tool regarding the management of WBSs, even outside the perimeter of indirect workflows.

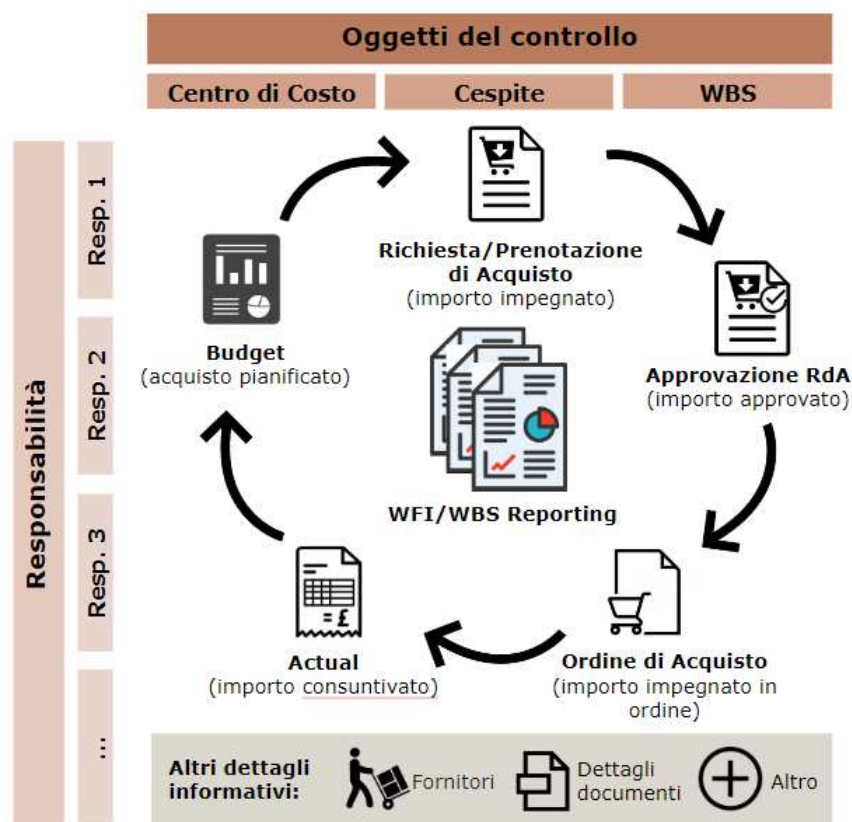


Figure 2: The figure describe the workflow of the indirect costs. The flow is composed by the following ordered tasks: Purchase/Request Booking, PR approval, generation of Purchase order, evaluation of Actual amount, evaluation of Budget amount. Cost Centers, Assets and WBS are the elements that produce indirect costs.

2.2.4 "Actual New" project

This application was implemented to analyse the actuals of business, that is the real finance results of the organization over a specific period of time defining by actual revenues, expenses, profits and so on. A well-structured analysis of actuals and a comparison with budgeted amounts is useful to evaluate how well the company is performing against its objectives. Another advantage is the improving of **forecasting** and **decision-making**, enabling the company to make more accurate predictions about the future revenues, expenses and profits and to plan next moves efficiently.

Note that the following description represents the process' state from which the designed and implemented solution in this paper was started. In the next chapter, we will evaluate the adjustment to improve the process.

Therefore, "Actual New" is an important process to evaluate the past performance and to plan the next choices. To do that, the actual data are used to write up two distinct documents: *financial statement* (i.e. consolidation outcome) is a mandatory document by law which represents "what's happened" in the business at the end of fiscal year, while *management report* (i.e. management closing outcome) aims to recap frequently the financial health of the company in order to be aware on how manage every single company's area. For each of these was defined two similar processes which elaborate actual data from ERP system to build the necessary documentation.

Before the core of these application, there is a setup step focused to ingest necessary information performed by the IT office of FG:

1. **Master Data insertion:** inserting of set of immutable information

that dimensions can assume. This kind of data is important to define a restricted domain of values for specific dimensions, ensuring data consistency.

2. **Currency Rates update:** list of currency's rates provided by the Finance Office calculated as the arithmetic average of the exchange rates reported daily by the European Central Bank (ECB).
3. **Data Loading:** this is a automated procedure executed by a Loading Chain at night. It aims to retrieve all the transactional data entered in the ERP system during the day and to load them into the EPM system. Consequently, a function is executed to apply the currency conversion to the new data.

From this point, the process is passed to the *controllers* which differs for company, division and assigned process (management closing or consolidation). The only difference between these two processes is that consolidation is performed for every society by a single user while the closing by a controller for each company. Meanwhile, the data used by the processes are stored with a proper label to indicate the resulting data of one of the closing's procedure. We denotes output data of consolidation as Working Version 2, i.e. WK2, and data of management closing as Working Version 1, i.e. WK1. Then, controllers follow the following steps:

- **Adjustments:** aims to fix the inequalities between the current data in the EPM and the transactional data officially inserted in the previous day.

- **Revaluation of COGS:** it is an important steps that allows to give value to the production costs of a product or a component in order to perform a variance analysis of costs. The goal is adapt of starting costs of sold goods in order to evaluates how efficient a company is in managing its labor and supplies in the production process.
- **Allocation:** controller can allocate a certain amount for a specific combination of dimensions to the desired members. This long procedure follows an allocation logic based on:
 - which costs should be allocated
 - on which dimension the allocation will be done
 - in according which logic we want allocate

The latter element is also known as *driver*.

- **Reporting:** computed data can be checked via many reports which differ each other to the structure of P&L and the assigned division. Some of these reports make a comparison between Actual and Budget in order to evaluate the quality of forecasting.

2.2.5 Analysis of needs

During the analysis period, PwC have drafted a list of essential points, highlighting focal weakness and the related solution. Thus, we can define the essential needs of overall process as follows:

- **Full migration of existing features into the new data-warehousing system:** the entire processes are located among the ECC's modules,

the old BW version and on AFO module. Through the transposition of all features to BW/4HANA and BPC environment, we point to centralize data and tasks in order to provide clear procedure's activities list and arranged data flow. For this purpose, HANA database is important since we can simplify the technical architecture, reducing the number of accesses on different data sources. In addition, this migration is carried out preparing a new DataStore Object with the same dimensions of older one which provides to divide actual data with transactional ones and therefore manage the historical data.

- **Implementation of virtual P&L line:** currently, profit and loss dimension is calculated via a mapping table and it is stored as transactional data. An error in mapping definition leads to a temporary unavailability of reporting during reloading of data. This plausible issue can be bypassed with real-time P&L line feature which doesn't impose no data extraction and introduces temporal dependence to the detriment of higher load on system hardware resources.
- **Computation performance:** this is a key topic which affects most of activities cause of huge amount of data and complexity of algorithms for calculation. A fundamental help is the use of HANA thanks to its columnar characteristic, which enhances performance of computations and data retrieving significantly. With this underlying technologies and the right structural design, time for reports' opening and for function execution will decrease achieving an improvement on user working status. We pay particular attention to enhance the steps related to

allocation of amounts and revaluation of COGS.

- **Streamlining of User Experience:** since the decentralized nature of old environment, users were used to encounter slowing down on their activities because they lost time to move between different environment which weren't interfaced properly and cause of absence of exact process' tasks scheduling. With analysis phase, it was defined the requirement to design a Business Process Flow to provide an ordered outline for users in order to execute and to monitor each step in the correct order.

While the second point listed holds significant importance as a fundamental feature of the new process, it is not the primary focus of this thesis. It is essential to keep in mind that this thesis will primarily address the other three requirements mentioned earlier, providing answers and insights into those specific areas.

In the next chapters, we define the technologies and methods which represents the available tools used by PwC to implement the designed solution. Then, in Chapter 4, we explain technical aspects which characterized the old and the new systems, highlighting the difference between them and what are the improvements brought by this project.

3 Project Technologies

In this chapter we introduce essential foundations of the technologies used for this project. We begin explaining the ERP and EPM software from the definition to the specific SAP modules that compose them. Then, we move the focus to the main module SAP BW/4HANA and its software objects that we have used for implementation of data warehouse's applications. At the end, we mention briefly architecture of the server architecture of FG in order to illustrate how we have developed.

3.1 SAP Modules

3.1.1 SAP ECC

SAP ERP Central Component, abbreviated SAP ECC, is an on-premises ERP system which incorporates the key business functions of an organization. ERP has the benefit to integrate information that's created in one area of the business with data from other areas in real-time. In fact, through this system, data coming from multiple sources are gathered and managed in a centralized way.

In this project we don't use directly this suite but it's important to talk about that because is the source of the data that we elaborate in the data warehouse system.

It belongs to the previous generation of SAP products and has been replaced by SAP S/4HANA, the solution that implements SAP HANA technology. SAP ECC consists of several modules, as shown in Figure 4.3, namely applications that support the various business processes that a society can

have. SAP ECC contains and creates all the transactional information of the company, that is, every economic transaction that affects the operation of it such as invoices, requests and purchase orders. The three main modules that IFC SPA implements are FI, CO, COPA.

- **FI:** Financial module manages the accounts and collects the financial data of the company. This module is essential for the development of the statutory consolidation.
- **CO:** Controlling module is used to ensure that resources are used efficiently. It includes analysis by individual cost center and profit center.
- **COPA:** Profitability analysis module is fundamental for the elaboration of the consolidated management. It includes the production costs related to the sales allowing to easily carry out the analysis of company productivity.

Since SAP is going to end the support to SAP ECC in 2030, FG is planning to adopt the latest generation of the ERP software, called SAP S/4HANA. It works on on-premise and in the cloud and it uses most recent technologies to improve the business efficiency and speed, offering the possibility to analyze large amounts of data in real-time. The main differences between these two softwares are listed below:

- **Database:** ECC supports databases from other providers such as Oracle or MySQL, however, S/4HANA only runs on SAP HANA. As a result, S/4HANA has much faster reaction times thanks to its in-memory database.

- **CO and FI merger:** In SAP S/4HANA, FI and CO are part of a single table in ACDOCA, the Universal Journal. This means you no longer have to reconcile them with the General Ledger at each period-end. ACDOCA reconciles them automatically in real-time, so period-end closings are simpler in SAP S/4HANA.
- **Integrated Business Partners:** S/4HANA combines the common data structure elements of both into a Business Partner record.
- **UI/UX:** the interface implemented in SAP S/4HANA is the modern SAP Fiori UX, while SAP ECC is limited to the standard SAP GUI interface and has a limited number of Fiori apps. SAP Fiori is a collection of features with a user-friendly interface accessible from multiple devices such as desktops, tablets and smartphones.

3.1.2 SAP HANA

SAP HANA (High-performance ANalytic Application) is the in-memory DBMS developed by SAP that processes high volume of data in real-time. It is tightly integrated with other SAP products because, being configured as underlying database, it provides seamless data integration, real-time analytics, and better performance.

Key feature of HANA is the in-memory for computer data storage. These kind of databases place data storage, analytics capabilities, and transactions which load data on the same level. RAM storage- They are faster than disk-optimized database because disk access is slower than memory access. Accessing data in memory eliminates seek time when querying the data.

Another main characteristic is the columnar data storage of tables. SAP HANA database is designed to enhance read operations and maintain decent performance for write operations by organizing tables into columns. By employing efficient data compression techniques, memory usage is minimized, resulting in faster searches and calculations. Additionally, certain advanced functionalities, like partitioning, are exclusively offered for column tables. Column-based storage is particularly beneficial for large tables that undergo bulk updates. Conversely, row-based storage excels in update and insert performance, making it ideal for smaller tables that frequently undergo individual updates.

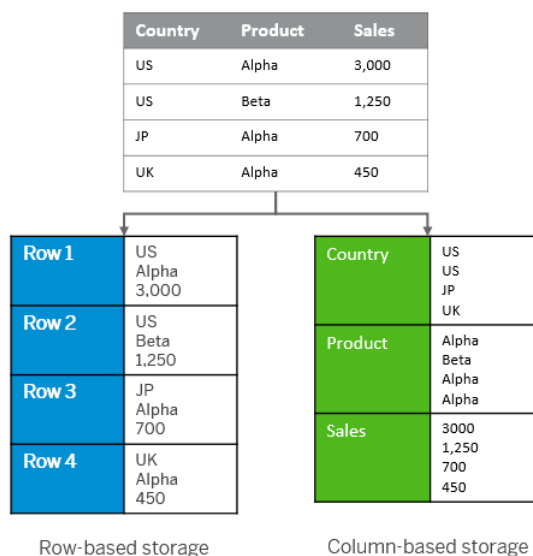


Figure 3: How tables are managed by row-based and column-based methods.

3.1.3 SAP BW/4HANA

SAP BW/4HANA is an advanced data warehousing solution developed by SAP, specifically designed to run on the SAP HANA platform. With SAP BW/4HANA, all the data in the entire company can be prepared for a consistent view across all departments. One of its key characteristics is the ability to leverage in-memory processing, which enables real-time data access, analysis, and reporting. With SAP BW/4HANA, organizations benefit from a simplified data model, reducing complexity and enhancing performance. Modelling phase is realizable through SAP BPC 11.1 or Eclipse IDE. This solution seamlessly integrates with various data sources, ensuring reliable data integration through extraction, transformation, and loading processes. Another notable characteristic is its support for advanced analytics, including predictive analytics, machine learning, and statistical functions, empowering organizations to uncover valuable insights and make accurate predictions. SAP BW/4HANA also enables real-time reporting and visualization, allowing users to monitor key metrics and gain instant insights into business performance. It offers flexibility in deployment, supporting on-premises, cloud, and hybrid scenarios. Additionally, SAP BW/4HANA integrates seamlessly with both SAP and non-SAP applications, providing a unified view of business operations and facilitating data-driven decision-making.

3.1.4 SAP BPC

SAP BPC 11.1, also known as SAP Business Planning and Consolidation, serves as a central platform for financial planning, consolidation, and reporting, helping organizations align their financial strategies with business

objectives. It enhances the accuracy, transparency, and efficiency of financial processes, enabling organizations to make informed decisions and meet regulatory requirements. This platform is extremely customizable, especially for more complex infrastructures. It is powered by heterogeneous data sources and being compatible with Microsoft Excel provides users with a familiar graphical interface.

The solution is not a successor of previous versions of BPC for SAP NetWeaver or Microsoft platform but a complete new product that is exclusively available for BW/4HANA. Since it is running on BW/4HANA, the solution also takes advantage of the benefits related to the BW/4HANA Platform and inherits its fundamental characteristics and delivers additional features specific to the product:

- **Simplicity:** In line with BW/4HANA, BPC focuses on simplifying the back-end and front-end. The latter is simplified also by a new ad-hoc reporting with query enhancements in SAP BusinessObjects Analysis for Office (AFO). This tool is designed to combine the power of Excel with the data connectivity and capabilities of SAP systems, providing users with a flexible and efficient tool for data analysis, reporting, and planning.
- **Openness:** SAP BPC 11 offers enhanced integration with SAP Analytics Cloud (SAC), enabling seamless and near real-time data synchronization between the two platforms. This integration allows users to leverage the capabilities of SAP Analytics Cloud alongside the BPC 11.0 Planning Process. By utilizing SAP Analytics Cloud, users gain

access to a wide range of additional features, such as applying Predictive Analytics for improved forecasting, conducting advanced BI Analysis on BPC data, and integrating with SAP Digital Boardroom to provide real-time visibility into company metrics.

- **Modern Interface:** SAP BPC 11 follows SAP Fiori 2.0 design principles for a harmonized look and experience. The home page now includes tiles for charts or any graphical representation, quick access to any object or page, and personal activities sorted by due dates. Also, users can personalize their home page by re-ordering and re-sizing the tiles.
- **High Performance:** Beside the performance improvements part of the BW/4HANA, BPC 11.0 benefits from extra performance enhancements such as query formula operations pushed down into SAP Hana.

3.1.5 SAP Analytics Cloud

SAP Analytics Cloud (SAC) is a comprehensive cloud-based analytics platform developed by SAP. It is designed to provide organizations with a wide range of analytics and business intelligence capabilities. SAC allows users to connect, visualize, explore, and analyze data from various sources in real-time. Since FG uses SAP BPC to perform the planning phase of every process, SAC is involved in the project for real-time data visualization with interactive dashboards.

Users can interact with SAC through a user-friendly web-based interface. They can access pre-built or custom dashboards and reports that present data

in visual formats such as charts, graphs, and tables. They can interact with these visual elements by drilling down into specific data points, applying filters, and selecting different dimensions or measures to explore the data further. About planning, users can interact with planning models within SAC to create, modify, and update budgets, forecasts, and what-if scenarios. They can input values, adjust assumptions, and view the impact of changes in real-time.

It's worth noting that SAC provides a user-friendly and intuitive interface, making it accessible to users with varying levels of technical expertise. The platform focuses on providing a seamless and interactive experience, empowering users to explore, analyze, and derive insights from their data efficiently.

3.2 SAP Software Components

This section aims to explain basic modeling components of SAP BW/4HANA that are used to build the structures and the flow of our application in the data warehouse system.

3.2.1 InfoObjects

The smallest data structure in SAP BW/4HANA is represented by InfoObjects (IO). They provide a way to define and categorize data attributes, such as customer ID, product code, date, or region, that are relevant to the organization's business processes and reporting needs.

Developers can choose to use standard InfoObjects which represents the most common characteristic of businesses or create custom ones. There are

different type of InfoObjects in according to what kind of data the developer wants to represent:

- **Characteristics:** are sorting keys that specify the granularity (the degree of detail) at which the key figures are stored in the InfoProvider.
- **Time Characteristics:** are characteristics that represent timing information.
- **Technical Characteristics:** are used for administrative purposes. An example of a technical characteristic is the request number.
- **Key Figure:** provides the values that are reported on in a query. Key figures can be quantity, amount, or number of items.
- **Unit:** are required so that the values for the key figures have meanings. Key figures of type amount are always assigned a currency key and key figures of type quantity also receive a unit of measurement.

InfoObjects can be enriched using the following several special features:

- **Attributes:** are InfoObjects that exist already, and that are assigned logically to a characteristic. They can be specified to provide additional information about characteristics (*display attributes*) or to be part of queries as a linked InfoObject evaluated on its own (*navigation attributes*).
- **Master Data:** is data that remains unchanged over a long period of time and contains information that is always needed in the same way.

- **Hierarchy:** is created for a characteristic and provide a structure for the characteristic's values like attributes.

3.2.2 Advanced DataStore Objects

An Advanced DataStore Object (ADSO) is a data storage object that serves as a flexible and powerful option for storing and managing data within the data model. ADSO is the primary persistent object used in data modelling for transactional and historical data. In the previous versions of BW, these structures are generally called InfoCubes. One of the advantages that the new ADSO have introduces is the ability to change their settings without the risk of losing records within them. In addition, they are able to maintain the consistency of the data even if the type of data they contain is changed.

ADSO is a data structure composed of three tables populated and used according to the type of cube selected:

- **Inbound Queue:** in general this table contains all the new data for which saving inside the cube has been requested. After activation, this data is moved to the second table.
- **Active Data:** represents most of the central data persistence tables in SAP BW/4HANA. Contains activated data after a load request. During data activation, a data consistency check is made by issuing a warning in case of an error.
- **Change Log:** tracks all changes to the data within the ADSO. It is also useful for the selective deletion of data.

In the system, they are distinguished using a specific suffix and prefix to the technical name of ADSO. For example, in FG's project, we have an ADSO called "MCBP2URP" that tables are defined as "/BIC/AMCBP2URP1" for "Inbound Queue" table, "/BIC/AMCBP2URP2" for "Active Data" table and "/BIC/AMCBP2URP3" for "Change Log" table.

The creation of an ADSO needs the definition of the attributes that make up the records ADSO can contain. An ADSO is generally shaped by InfoObjects that can be seen as columns in SQL language. In the alternative, Fields can be used instead of IO, but the latter is preferable to ensure data consistency across layers. ADSO also needs the selection of keys to identify unique records. They can be set manually or automatically according to the kind of ADSO the developer wants to implement.

The following are the different types of ADSO available in SAP BW/4HANA:

- **Standard ADSO:** it consists of all three tables and allows reporting, that is, displaying data to users, from the active data table. Allows Delta extraction of records and other options such as the ability to update or not active data with the same key. It is generally the most widely used type of ADSO.
- **Staging ADSO:** the main table is the Inbound Queue from which the data is also extracted. There are also other settings which enable reporting and the Active data table.
- **Data Mart ADSO:** It provides data extraction and reporting from both the Inbound Queue and the Active data table. It is possible to load through Delta extraction and in addition all dimensions are in key

- **Direct Update ADSO:** It consists only of the Active data table which is updated directly on each upload request. It also allows reporting.

3.2.3 Composite Provider and Queries

Composite Providers is a data modeling object that acts as virtual data providers that combine data from various underlying InfoProviders, such as InfoObjects, ADSO, or other Composite Providers. It allows to combine data from different sources via set operations like union and joins. It's worth to note these operations are performed "on the fly" in SAP HANA. In this way, it is possible to emulate an ADSO that contains the downstream information of the operations without the need to duplicate the data. In addition to basic operations, Composite Providers support aggregations and calculations on the data, allowing users to perform calculations or summarize data at different levels of granularity. This enables users to derive meaningful insights from the consolidated data.

Cause the nature of Composite Provider, data can't be manipulate directly from the user through the queries. For this purpose, an additional modeling object is used over the Composite Provider to allow planning operation to user. This component is called **Aggregation Level** and define the level of detail at which data is stored and analyzed within an InfoProvider. They determine the specific characteristics and key figures that make up a unique combination of data points.

Once data source is defined, it can queried through the appropriate modeling object called Query in SAP BW/4HANA. It is a powerful tool that allows users to interact with the data stored to retrieve specific information

and perform various analytical operations. Starting from the InfoProvider under the query, developer can use the InfoObjects provided by underlying layer to make a request to the database. Developer can define the following set of InfoObjects in the Query Designer:

- **Query Elements:** Define the query elements, such as characteristics, key figures, variables, and calculated key figures. Characteristics represent the descriptive attributes of data, key figures represent the measurable quantities, variables allow for dynamic input parameters, and calculated key figures enable the creation of new calculated values. They are provided from the underlying layer by the InfoProvider.
- **Query Structure:** Arrange the query elements in a meaningful structure. Determine the rows, columns, and pages of the query, which define how the data will be displayed in the query output. Another possibility is to insert an element as navigable characteristic. It is not immediately visible in the result of query but can be use by user if needs to see data with its detail.
- **Query Filters:** Apply filters to restrict the data set returned by the query. Filters allow you to focus on specific subsets of data based on predefined conditions, such as time periods, product categories, or geographical regions.
- **Query Variables:** Define variables to enable dynamic input parameters in the query. Variables allow users to provide input values at runtime, such as selecting a specific time period or choosing a particular product. A specific type of variable is called Customer Exit. That

defines the value of a characteristic without the interaction of the user, but produces a value according to an algorithm designed by the developer. In this project, this component matters to pass parameters to isolated functions in a process chain.

3.2.4 Planning Sequence

A Planning Sequence is a logical sequence of planning steps that guide users through the process of creating and updating planning data. It provides a framework for executing planning operations, such as data entry, aggregation, calculations, and validations, in a structured manner. Technically speaking, planning sequences allow saving groups of planning functions in a sorted sequence and executing groups of planning functions sequentially with the purpose to manipulate and store data. However, in this work, we use a single approach based on one or two at most sequences of a single step that processes a Planning Function.

The Planning Function is an essential component of the planning process and represents a specific operation or action that can be performed. It needs two component to be created: an active aggregation level as a data source and a filter that is required in runtime because the filter determines ad lock the data that the function is performed for. After meeting requirements, a planning function can be created and associated with a Function Type that defines which algorithm to use and which parameters pass to the function. The developer can decide to use a standard function type provided by SAP or make a new one by writing a custom class. The latter is the most used type in this project since many processes need to include particular data

manipulations.

3.2.5 Process Chain

In SAP BW/4HANA, a Process Chain is a tool used for automating and orchestrating a sequence of processes or activities within the data warehouse. It provides a framework for executing and monitoring various tasks, such as data extraction, transformation, loading, and other related operations. Through the use of process chains, developers can automate complex process flows using event-controlled processing and centrally control and monitor them.

Process chains are based on the following principals:

- **Openness:** the abstract meaning of process as any process flow with a defined start and end enables openness with regard to the type of process that can be integrated into a process chain. The principle of openness is applied to process chains so that user-defined programs and processes can be implemented.
- **Security:** ensures a high level of security in the process flow through ad-hoc background management.
- **Flexibility:** the subsequent process is responsible for getting all the information it needs from the predecessor processes so that it can run correctly.

These chains supports various types of processes that can be included in the workflow. These can include data extraction from source systems,

data transformation, data loading into target InfoProviders, data activation, process chains calling other process chains, planning sequences and more.

3.2.6 HANA Calculation View

A HANA calculation view is a type of modeling artifact that allows for complex calculations and aggregations to be performed on data stored in the system. It is a key component of the SAP HANA database and serves as a virtual data provider, enabling users to define and execute calculations on data from various sources. Calculation views are simple and yet powerful because they mirror the functionality found in both attribute views and analytic views, and also other analytic capabilities.

Use calculation views when your business use cases require advanced data modeling logic, which cannot be achieved by creating analytic views or attribute views. For example, you can create calculation views with layers of calculation logic, which includes measures sourced from multiple source tables, or advanced SQL logic, and much more. A calculation view can include any combination of tables, column views, attribute views, and analytic views. You can create joins, unions, projections, and aggregation levels on its data sources. Developer can create two kind of calculation views that differ from type of scripting: graphical or script-based calculation views.

We can summarize the main purpose of a calculation view is to provide a consolidated and transformed view of data that meets specific reporting or analytical requirements. It allows users to create complex analytical models that can be used for ad-hoc analysis, reporting, or data visualization purposes.

4 Management Closing and Consolidation processes

In this chapter we explain how we approach to solve the requirements defined during the analysis phase, showing how data flow, data model and calculations are technically migrated from the old to the new version.

In particular, the following sub-sections mention how access to application is managed (see Chapter 4.1), how data move through the process (see Chapter 4.2), the design of the application's procedure (see Chapter 4.3) and the "allocation engine" and the "revaluation of Cogs" processes (see Chapters 4.4 and 4.5). These last two topics represent the main computation in the application and were the focus of my entire internship in PwC.

Note that, as I write, the application is still in development phase and that means possible changes may be applied in the near future if new requests occur.

4.1 BPC Securities

SAP BPC 11.1 manages security system through Team, Task access, and Data access. Teams are groupings of multiple users on which the same levels of security are applied. Users of the same team will then have access to the same tasks and the same portions of data. Each team is associated with:

- One or more data access profiles to define which data is accessible to that team and how to access it.
- One or more roles that define the tasks to be performed and the avail-

able features.

In this way it will be possible to protect sensitive data by making it available only to users who belong to the relevant area of competence.

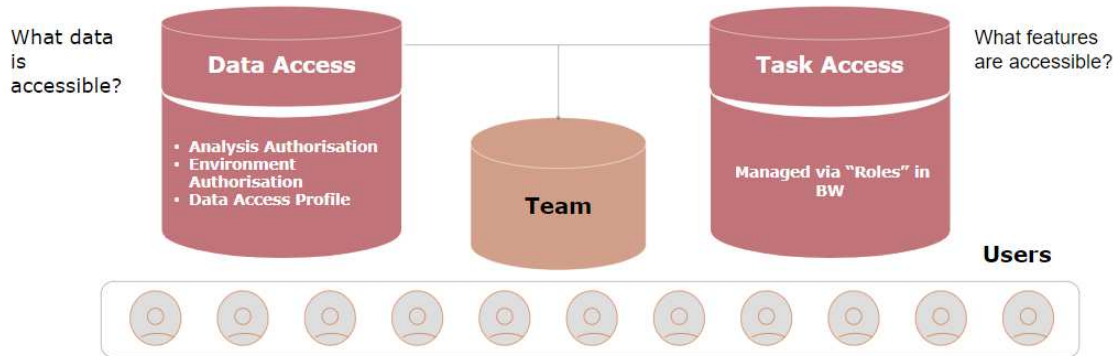


Figure 4: Overview of BPC 11.1 security schema

4.2 Actual Management Data

At the beginning of collaboration between PwC and FG, one of the first objective to reach was the simplification of old structure of data warehousing system through the update to SAP BW/4HANA. We can resume the structure and the data flow at starting point of this work as shown in Figure 5. Two flows travel from SAP ECC to BW/4HANA which carry actual data from CO and CO-PA modules and budget from OPEX application in ECC. Overlooking the flow for Cost Center Analysis that is focused on OPEX Planning, in this chapter we want to describe the data structure and flow of the Actual Management that define the underlying data basis for the following applications.

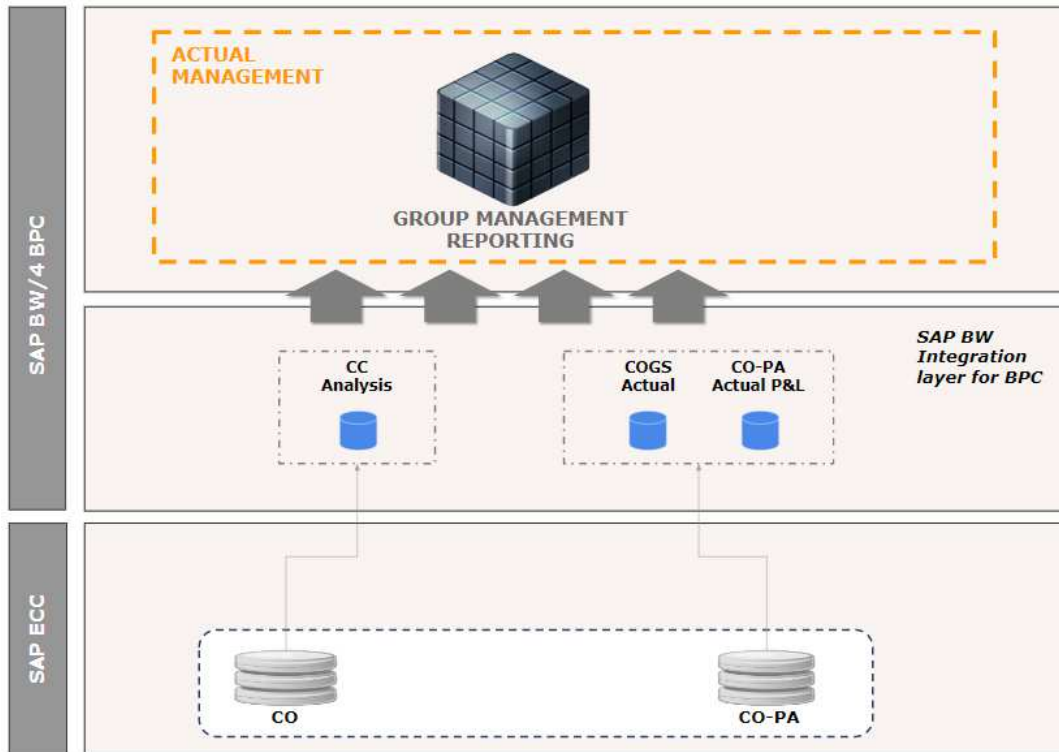


Figure 5: Overview of data flow of current system.

4.2.1 Data Model

The identification of correct dimensional model is fundamental to carry out the best design of data flow. We want to dedicate this section to list the dimensions that are significant for actual management and cogs analysis. All these data will be transported and stored as defined in the next chapter.

Dimension	Description	Technical Name
Fiscal Year / Period	Technical timing dimension	0FISCPER
Fiscal Year Variant	Technical timing dimension	0FISCVARNT
Period	Technical timing dimension	0FISCPER3
Fiscal Year	Technical timing dimension	0FISCYEAR
Amount Currency	Currency dimension	0CURRENCY
Value Type		MIVTYPE
Company	Legal Entity	MICOMPCOD
Controlling Area		MICO_AREA
Cost Center	Details of data for cost center	MICOSTCEN
POS	Store dimension	MIWWNPO
Group Cost Center	Details of group's cost center	MIWWRCE
Division		MIWWDVP
Country	Geographical dimension	MICOUNTRY
Sub Area	Geographical dimension	MIWWNSA
Geographic Area	Geographical dimension	MIWWNAR
Season	Season timing dimension	MISEASON
Trading Partner		MIVBUND
Customer		MICUSTOMR
Type of Contract	Identify type of contract	MIWWNTC
Channel		MIWWNCN
Brand	Product dimension	MIWWPBR
Main Line	Product dimension	MIWWPML
Model		MIWWPMO
Collection		MIWWPCO
Cost Element		MICSTELMN
Reference Document Number		MIRBELN

Value Field	Field of CO-PA	MICODCCVV
Tech Account	Account dimensions (includes 3°, 4° and 5° level account)	MI1LEVCOD, MI2LEVCOD, MI5LEVCOD
P&L Line	P&L dimension filled by combination between Group Cost Center, Value Field and Company	MIPL_LINE
Version	Allocation version	MIVERSIO
Category	Version of data (Budget, Actual)	MIFYCATEG
Amount	Amount Key Figure	MIAMOUNT
YTD Amount	Amount Key Figure	MIAMNTYTD

Table 2: List of the principal dimensions and their technical names used in the applications. Colored rows are exclusive dimensions: yellow for the allocation engine and cyan for the COGS revaluation.

Dimensions represents information that can be usually categorized in three macro groups: temporal data, amount data and business data. Furthermore, technical dimensions are also included since we need to distinguish different state of data computed along the process and to perform allocations.

Between the two application of this project, most of dimensions are shared since they contains the information asked by companies' controllers to write up documents for the closing. However, the revaluation process has more dimensions about products and sales documents because needs the details about the cost of produced and sold models to perform the computation. On the other hand, the Urgent Allocator of the allocation engine require a proper

dimension, named Version, to distinguish the results of allocation between company level and group level.

4.2.2 Data Flow

First step of the retrieving of data from ERP system is to ingest the CO-PA data, setting up a basic source for the closing of FG. The path starts filling the MDCO0PAI that data are elaborated along the DTP execution computing *document currency conversion* and the *value fields* based on Standard Cogs. Note that, the shape of the incoming data has inline value fields which doesn't get along with the HANA optimized column-based logic. For this reason, we need to transpose the value fields values transporting the dataset into the final aDSO named MCCO1PAA. In addition to transposing operation, the traveling data are also altered as follows:

- Change of catalog and currency rates via an application based on MDCO0LIS
- computation of signs of amounts in according to costs and revenues
- assignment of Partner Division MIWWDVPP

A graphical representation of flow until Profitability Analysis table is shown in Figure 6. There is an additional table for profitability analysis, named MCCO1PAD, which contains more details than MCCO1PAA because from the application's flow doesn't need all the dimensions to provide useful information.

From the MCCO1PAA, the following tables are implemented to host the applications for closing and their reports. The table MCCO2PAA is

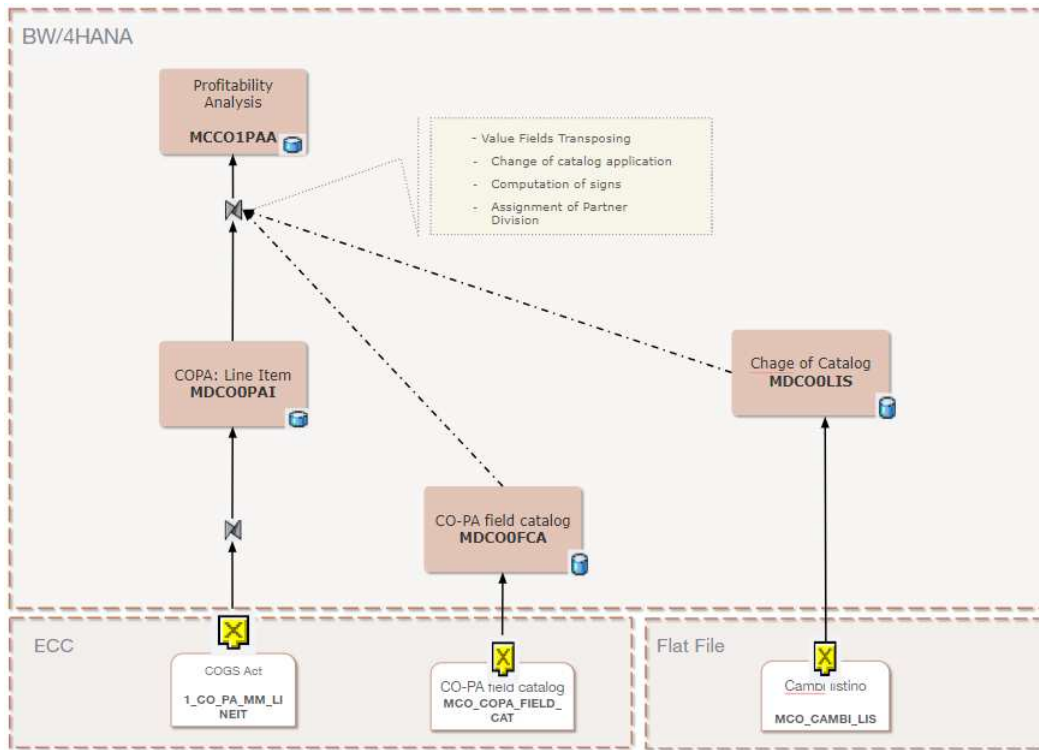


Figure 6: Diagram of data flow from ECC to Profitability Analysis aDSO.

the backup point for the entire applications that contains the data from MCCO1PAA and the MCCO1CGA. The latter contains the actual Cogs amounts revaluated in old system with a transformation between the MCCO1PAA and an aDSO called MDMA0CGA, filled from a flat file with actual values. Data from these tables converge then to a structure named MCBP2URG which works as backup dataset. Its data are sent then to MCBP2URA aDSO as basis for allocation engine. The elaborated results of allocations are also stored in the MCBP2URA, so that it can be used as the only source for planning and reporting. Along common data flow, P&L line information are joined to the MCCO1CGA and the MCBP2URG through a DTP sched-

uled during the night and the budget data are provided from MDSO_BDGA aDSO which receives data from the budgeting applications. The described can be summarized as shown in Figure 7.

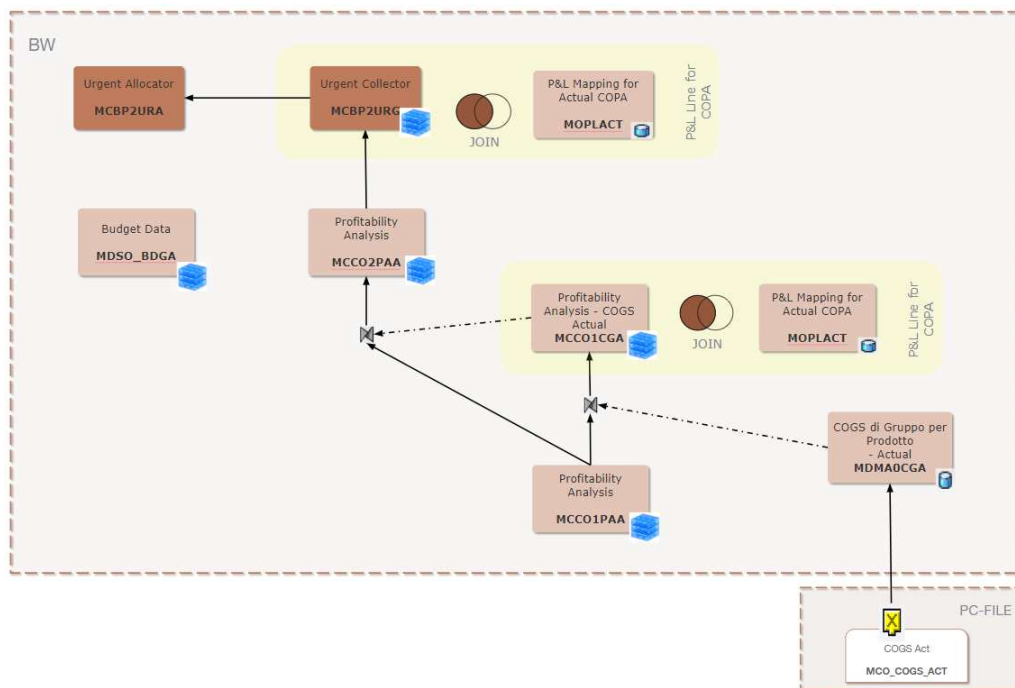


Figure 7: Diagram of data flow from Profitability Analysis to Urgent Allocator.

The flow finishes in management reporting layer composed of the Composite Providers for report and in planning layer where Aggregation Levels allows to input data. These software objects will be described directly on the next chapter 4.3 along with reports.

However, during the design phase of new request "Actual New", it arises a necessity to remodel the data structures in order to not interfere the closing period during the development of the new features. Thus, several aDSO and InfoProviders were implemented to create a parallel data flow of independent

data from current companies' data. Data will be redirected at the release of "Actual New" through proper modifies at view level, as shown in Figure 8.

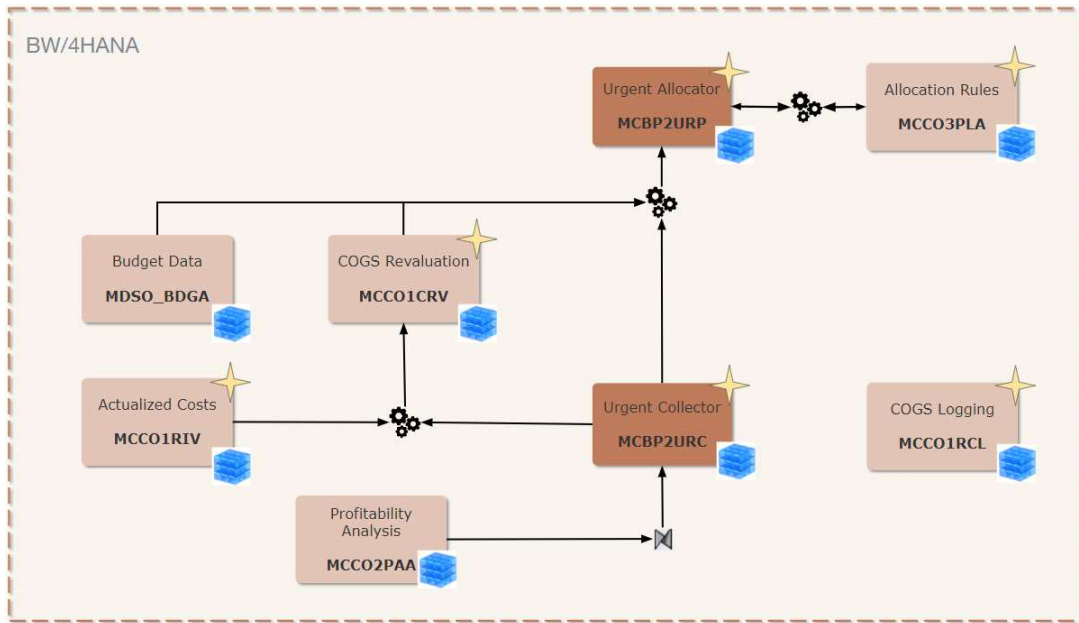


Figure 8: Diagram of new data flow from Profitability Analysis to Urgent Allocator.

In the following list, the produced edits are described:

- implementation of two HANA Calculation View for actual (CV_PL_LN_MAPPING_ACT) and budget (CV_PL_LN_MAPPING_BDGA_CC) **real-time P&L line**. This feature will allow to map new P&L lines and to edit existing ones without reloading Actual data. The one-to-one mapping is generated between the object MICPL_LN and the combination of Company, Group Cost Center, 4° Level Account and Cost Item. These objects are integrated in the flow joining them with the aDSO that provides the input data for applications in the Composite Providers of reporting.

- The virtual P&L line feature requires structural modify to get the necessary data to execute the computation. For this purpose, new aDSO MCBP2URC was implemented as replacement for Urgent Collector MCBP2URG, adding MICODCCVV and MI4LEVCOD. Other dimensions was inserted to divide the local data from consolidated ones (MISCOPE) and to distinguish data flows at technical level (MIDTSCON).
- We decided to create a new Urgent Allocator MCBP2URP as replacement of MCBP2URA where only allocation data are stored. In this way, we maintains separated allocation data from the "raw" actual data from MCBP2URC, improving the **integrity**. Further aDSO named MCCO3PLA is implemented to store the rules of the allocations.
- Auxiliary aDSO was implemented for revaluation of Cogs. The MCCO1RIV contains the actualized amounts and the MCCO1CRV contains data of revaluation of company and group. The latter is the table that will replace the MCCO1CGA at the release of this proect. The results of revaluation are distinguished by MIDTSCON InfoObject, assigning "COGS" for company's Cogs and "COGS_G" for group's Cogs. It will also contain the adjustments for CO-PA which are distinguished in according to the method used to perform the upload: "INPADJ" if values are inserted manually, "IMPADJ" if they're inserted automatically from a flat file.
- The key figure for amounts was replaced with a float ones, i.e. MIFAMNT and MIFAMTYTD, in order to get better precision during the allocations.

- After definition of new tables, we also need adapt the higher level of Providers to reach the parallelism between old and new flow. Thus, we copy the existing Composite Providers modifying the underlying data sources and we create new ones to specific purposes. Table 3 describes the modifies applied of the structures.

AS-IS Struct	Type	TO-BE Struct	Modifies	Reports
MOPLACT	Composite Provider	MMOPLACT	add real-time P&L and Value Fields	Check P&L Line mapping
MMCO1PAC	Composite Provider	MMCO1ACA	add real-time P&L	Actual Cogs Group
MMCO1PAA	Composite Provider	MMCO1PAG	add real-time P&L	Profitability Analysis
MMCO1CHK	Composite Provider	MMCO2CHK	add real-time P&L	Check CO vs COPA
HMCCO2PAA	Composite Provider	HMCCO2PAG	add real-time P&L	Pre-allocated P&L reports
MMCBP2URA	Composite Provider	MMCBP2URP	add real-time P&L	Post-allocated P&L reports
MMCBP2URA	Composite Provider	MMCBP4URP	aggregation of sources without real-time P&L. Used for planning	Calculation of allocations
MMCBP2URA	Composite Provider	MMCBP2URP	aggregation of sources with real-time P&L lines. Used for reporting	Reporting for allocations
AMCBP2URA	Aggregation Level	AMCBP4URP	based on MMCBP4URP. Used for planning	Calculation of allocations

Table 3: List of the virtual providers modified for Actual New.

Note that, for planning and reporting layer of allocation engine are implemented two distinct path because SAP doesn't allow to plan data using a Composite Provider that contains a Calculation View. For this reason, the MMCBP4URP is built over the only aDSO without the real-time P&L Lines. In the Figure 9 are shown how the structures are built.

4.3 Management Closing BPF

It is a simple feature but also very significant to assist the user during the process, since they had to use a text file to keep track of all the steps for closing and consolidation. The following lists represent the **Business Process Flow** models of the two main steps of management closing and business

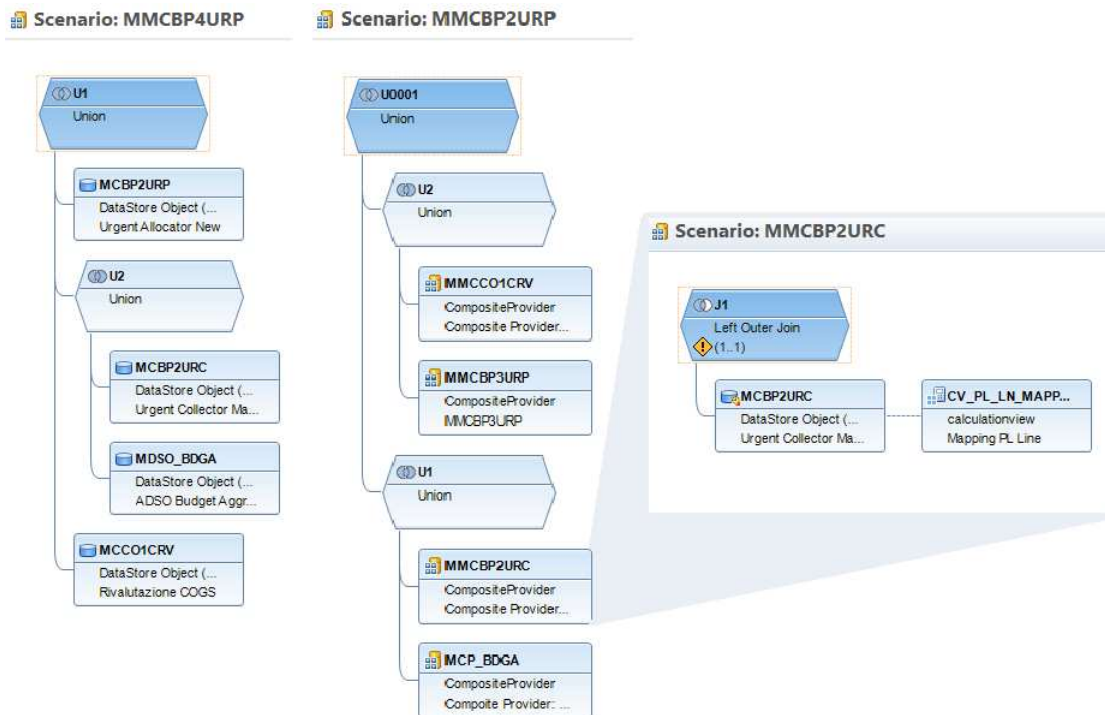


Figure 9: Internal structure of Composite Providers used for the allocation application.

consolidation. The first-mentioned model will be copied into three similar BPF's instances in according to the companies' kind (see Figure 10).

We can summarize the process of companies' managers into three macro steps:

- *Revision of ECC data:* users have to check actual and budget data that come from ERP system along the CO and COPA flows. Several reports are available for users since each of them may use a specific set of data or may arrange data with precise shapes to analyze the business state. Most used steps are the ones show P&L lines in the financial statements' structure and the one allows to analyze the profitability of

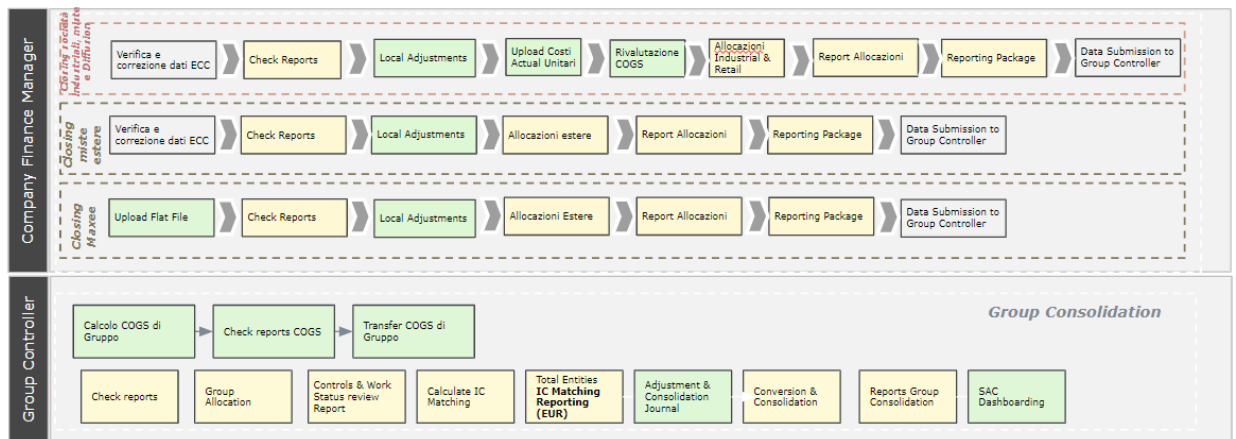


Figure 10: Overview of macro steps in the future live BPF. Management closing BPF is implemented for Industrial and Diffusion companies, Foreign companies and Maxee.

business.

- *Adjustments*: users are able to insert data freely, correcting values along the process. This step includes the revaluation of COGS since it can be as an adjustment at cost level.
- *Allocations*: it includes the allocation engine for redistribution of amounts for certain dimension and its reporting.
- *Final reporting and submission*: users check amounts along all the process and validate them before to submit to group controller. In this phase, reports have the same purpose of the first ones but showing new elaborated data.

About the group process, the controller doesn't have a determined path to follow and includes the same features of companies' BPF. However, elaborated data from these steps are managed and stored on a different layer

starting from an input set composed of all information from companies.

4.4 Allocation Engine

The **allocation engine**, also known in FG as "distribution engine", is a fundamental tool of closing process which allows to enhance the details of costs, distributing a certain amount to a dimension in according to the percentage calculated from a requested set of records, called **driver**.

The allocation process occurs in stages with the use of multiple working versions WK:

- The actual data uploaded from CO-PA has no version assigned.
- Most of the items already arrive with the maximum detail from the CO-PA. In some cases (discounts, credit notes, etc.) the cost items do not report the maximum desired detail and therefore must be allocated.
- The system does not allow allocation according to revenues as the amount of data to be processed is too high; therefore there is a **custom driver** workbook through which it is possible to define fictitious P&L Lines.
- The allocation engine is responsible to copy the input data assigning the version WK1 and to allocate the selected dimensions. The entire allocation engine thinks from a YTD perspective (on YTD amount).
- The version of WK1 is defined as copy of the Actual data with the maximum level of granularity, on which the first allocation is applied.

The user of this version is the local controller during the management closing in each company.

- The version of WK2, initialized on WK1, manages the assignment of dimensions which are interesting to HQ level and it is executed by group controller in business consolidation phase.

The necessary information to execute correctly the engine are divided in two sets: *"to allocate" data* and *driver*. The Table 11 lists all the dimensions and their technical names which are requested to filter the initial datasets.

After collection of necessary data, the first step of allocation engine is to copy the data to be allocated assigning the next working version. We distinguish this function and call it **create working version** since it is executed before the true allocation action allowing the user to check the correctness of the operation. The next step is the allocation of amounts in according to a sequence of rules, each of that specifies a dimension to allocate. The available dimensions to be allocated are the ones that may be not assigned along data flow or have a particular necessary to be reassigned for specific parameters:

- Brand
- Main Line
- Type of Contract
- POS
- Customer

- Country

The user can decide to allocate the selected dimension either for the "not assigned" amount or for all the values, overriding even allocated amounts. For a better explanation of the process, we provide the following example:

Consider we are the user responsible for the management closing of the company M001. We want to allocate the amount of dimension Brand for a certain set of parameters, e.g. INDUSTRIAL division, fiscal year 2021, period 11 and so on. The records of data to be allocated may be as indicated in Table 4.

Brand	Amount
BR01	10
BR02	20
BR03	30
#	50

Table 4: Data to be allocated. Remember that "#" means "not assigned".

Now driver data get into the game. In according to the wanted proportions, we insert our custom driver (see Table 5) for the same parameters of to-be-allocated data so that we have a correspondence between the two datasets. We named it "DRV01" as value of MIPL_LINE dimension in the proper workbook. From these data, the allocation engine will calculate the percentage of distribution.

At this time, we can allocate the amounts in two ways: to allocate only the "not assigned" values or to consider all the amounts and override them.

PL Line (Custom)	Brand	Amount	Percentage
PLDRV01	BR01	200	50%
PLDRV01	BR04	200	50%

Table 5: Driver's data inserted by the user

These scenarios are shown in Tables 6 and 7.

Brand	Amount	Cancellation	Allocation	New Amount
BR01	10	0	25	35
BR02	20	0	0	20
BR03	30	0	0	30
BR04	0	0	25	25
#	50	-50	0	0

Table 6: Case 1: allocation of the "not assigned" amounts

Brand	Amount	Cancellation	Allocation	New Amount
BR01	10	-10	55	55
BR02	20	-20	0	0
BR03	30	-30	0	0
BR04	0	0	55	55
#	50	-50	0	0

Table 7: Case 2: allocation of the overriding all the brands

The allocation can be set up in a way that the percentages' set of the selected dimension is computed in according to additional dimensions which are fixed as "parity", i.e. the engine performs more redistribution of a certain

amount for each combination of parity dimensions. An example follows to explain a simple use case:

As previous example, we choose to allocate the Brand in according to the same generic dimensions. In this case however we want to allocate with parity on Country dimension. The Table 8 shows the records increasing the granularity of amounts.

Country	Brand	Amount
IT	BR01	20
IT	BR02	20
IT	BR03	30
IT	#	40
EN	BR01	30
EN	BR02	20
EN	BR03	30
EN	#	80

Table 8: Data to be allocated. The values of highlighted rows will be allocated computing the percentage depending on custom driver with correspondent value of the country.

Selecting a "not assigned" allocation type, we will allocate the highlighted values for the percentages calculated respect to the level of detail country-brand. Inserting custom driver as the one listed in Table 9, we obtain two distinct set of percentages.

Executing the engine, the result of computations will be as the one in the Table 10. The result of the override allocation is calculated as in the previous example.

Country	Brand	Amount	Percentage
IT	BR01	200	50%
IT	BR04	200	50%
EN	BR01	800	67%
EN	BR05	400	33%

Table 9: Data to be allocated.

Country	Brand	Amount	Cancellation	Allocation	New Amount
IT	BR01	20	0	20	40
IT	BR02	20	0	0	20
IT	BR03	30	0	0	30
IT	BR04	0	0	20	20
IT	#	40	-40	0	0
EN	BR01	30	0	53.333	83.333
EN	BR02	20	0	0	20
EN	BR03	30	0	0	30
EN	BR05	0	0	26.667	26.667
EN	#	80	-80	0	0

Table 10: result of allocation with country as parity dimension.

The previous allocation executions for a single dimension are considered as only one rule and each of them must consider as input and driver data the new data computed from the previous rule. In this manner a sequence of allocation's rules define the result of the overall allocation process.

An additional action is also performed automatically from BW system. It

consists of dimension's value derivation from a mapping aDSO or InfoObject's attributes, depending on the new allocated dimension. This function is been tuned through the characteristic relation on the Urgent Allocator aDSO and it is useful to enrich amounts for reporting. The derived dimensions are retrieved as follows:

- (MDCO0MB) Main Line -> Brand
- (MDCO0BA) Brand -> ASA
- (MICOUNTRY) Country -> Sub-Area
- (MIWWNSA) Sub-Area -> Geographic Area
- (MIWWNTC) Type of Contract -> Channel
- (MIWWNPO) POS -> Sign

Implementation

The old allocation engine consists of an AFO workbook which gather all the functions to carry out the computation and the reports to see the results. The Excel workbook is composed of two sheets: the first is the main section which contains a real-time report of allocated data and the buttons to trigger the "create working version" and the allocation for each dimension and type of allocation; the second sheet has an auxiliary purpose of showing which driver is elaborated from the selected prompts.

After the user opens the workbook, a prompts appears and asks to insert the values to fetch the data to allocate and the driver's data. A long prompt is shown and the user have to fill it with the necessary information. In this

moment, the user decides the underlying datasets for "to allocate" and driver. Note that it is possible to choose multiple values for each dimension and set driver's dimensions as "parity" with special master data value "ZZ".

In this system, after the creation of working version through a Planning Sequence, a rule is selected pressing the corresponding button which triggers a standard Planning Function. This action must be repeated dimension by dimension without a proper rule saving system, making the whole system scarcely usable.

For this reason, the new engine provides an **allocation's rules system** which automate the allocation process. Through a new workbook, the user can define a set of records identified by a unique datasource, e.g. RULE000001, RULE000002 and so on. The latter is useful at the end of the process to store the result of allocation related to each rule.

The engine is in the AMCCO3PLA_DIST_ENG workbook which contains three sheets. The most important is the one called "Allocazioni" and it has the rules' query in planning mode. At this point, the supervisor of the allocation can insert manually rules to define the filter of the data to allocate, the driver and the settings of allocations. These data are stored pressing "Save" button into the MCCO3PLA aDSO. Generally, the user will input a set of data which is composed by four main subsets:

- *Generic Dimensions*: define the perimeter of domain. They are entered via prompt pop-up at the opening of workbook.
- *"To Allocate" Dimensions*: filter data to be allocated respect the selected dimension.

- *Driver Dimensions*: filter data of driver. These columns can assume a special value "PP" that indicates the "parity" property. Among them, "Category" and "Version" are the only mandatory dimensions that can't assume "all data" value indicated as "XX".
- *Allocation's Settings*: indicate information about the rule. Then, the user is obligated to fill the following dimensions:
 - Allocation Cycle (MICICLALL): descriptive data used by user to keep track of which category the rule belongs (e.g., profit, discounts, revenues, etc.)
 - Rule's ID (MIDTSCON): datasource's dimension that is helpful to distinguish data in the aDSO. Rules must be unique respect a key composed by settings and "to allocate" dimensions.
 - Type of Allocation (MIALLTYPE): identify which value has to be considered for allocation. With "N" only "not assigned" values of selected dimension is considered; otherwise with "O" all values are taken and overridden.
 - Dimension To Allocate (MIINFOBJ): indicates the dimension to be allocated.

In the Table 11 the dimensions of the datasets are indicated and associated to their technical names. Note that, a dimension is "general" if the datasets share the same InfoObject, Indeed, we had to create new InfoObjects which derive the characteristics of original ones because BW/4HANA does not allow to select two value for two distinct purposes.

Dimension	"To Allocate" Param	"Driver" Param
Company *	MICOMPCOD	MICOMPCOD
Category *	MIFYCATEG	MICATDRV
Fiscal Year *	0FISCYEAR	MIYEARDRV
Period *	0FISCPER	0FISCPER
Division *	MIWWDVP	MIWWDVP
Version *	MIVERSIO	MIVERDRV
P&L Line *	MIPL_LINE	MIPLDRV
Cost Center	MICOSTCEN	-
Season	MISEASON	MISEADRV
Trading Partner	MIVBUND	MIVBUDRV
Brand	MIWWPBR	MIBRDDR
Country	MICOUNTRY	MICOUDRV
Type of Contract	MIWWNTC	MITCODRV
POS	MIWWNPO	MIPOSDRV
Main Line	MIWWPML	MIMLIDRV

Table 11: List of the dimensions and their technical names used in the new allocation engine. * indicates mandatory dimensions.

In the main sheet, there's a button which triggers the Planning Sequence ZPS_AMCBP3URP_ALLOC. This component contains the set of software object to execute the application. The code in Listing 3 is the main function of the class called by the previous Planning Sequence. The main steps of this algorithm can be summarize as follows:

1. *Setup*: initial phase where datasets (i.e. AMCBP3URP, AMCBP4URP and MCCO3PLA) and variables are prepared to be elaborated for each rule :RULE_I in a while loop. Data is filtered through a proper method initializing an internal varibale, called :DATA_IN. Since the AMCBP3URP lean on the MNCBP3URP Composite Provider, in this step we need to calculate the P&L lines for the input data (actual and budget) by joins with proper calculation views.
2. *Get "To Allocate" data*: first, data are filterd from :DATA_IN variable in according to the dimension to be allocated and the type of allocation ('Not Assign' or 'Override'). Then, the resulting dataset is joined with the current rule on "to allocate" parameters in :FLT2_REC. Through the use of "XX" value, we can easily indicate to get all the values of a dimension.

```

1  if( :ALL_DIM = 'MICOUNTRY' ) then
2    FLT1_REC = select FISCVARNT, FISCYEAR, INFOPROV, MICOMPCOD, MICOSTCEN, MICOUNTRY,
        MICO_AREA, MICURTYPE, MICUSTOMR, MIDTSCON, MIFYCATEG, MIFYSCATE, MIPL_LINE, MISEASON,
        MISOURCE, MVBUND, MIVERSIO, MIWWDVP, MIWWDVPP, MIWWNFO, MIWWNIC, MIWWPER, MIWWFML,
        CURRENCY, UNIT, SUM(MIAMNTYID) as MIAMNTYID, SUM(MIAMOUNT) as MIAMOUNT, SUM(MIFAMNT) as
        MIFAMNT, SUM(MIFAMILYID) as MIFAMILYID, SUM(MIQNTYID) as MIQNTYID, SUM(MIQUANT) as MIQUANT
3    from :DATA_IN where ( :ALLTYPE = 'N' and MICOUNTRY = '' ) or ( :ALLTYPE = 'O' )
4    group by FISCPER3, FISCVARNT, FISCYEAR, INFOPROV, MICOMPCOD, MICOSTCEN, MICOUNTRY,
        MICO_AREA, MICURTYPE, MICUSTOMR, MIDTSCON, MIFYCATEG, MIFYSCATE, MIPL_LINE, MISEASON,
        MISOURCE, MVBUND, MIVERSIO, MIWWDVP, MIWWDVPP, MIWWNFO, MIWWNIC, MIWWPER, MIWWFML,
        CURRENCY, UNIT;
5  elseif( :ALL_DIM = 'MICUSTOMR' ) then
6    ...
7  elseif( :ALL_DIM = 'MIWWNFO' ) then
8    ...
9  elseif( :ALL_DIM = 'MIWWNIC' ) then
10   ...
11  elseif( :ALL_DIM = 'MIWWPER' ) then
12   ...
13  elseif( :ALL_DIM = 'MIWWFML' ) then
14   ...
15  end if;
16  FLT2_REC = select distinct FISCPER3, a.FISCVARNT, FISCYEAR, INFOPROV, a.MICOMPCOD, a.MICOSTCEN, a.
        MICOUNTRY, a.MICO_AREA, MICURTYPE, a.MICUSTOMR, rule.MIDTSCON, a.MIFYCATEG, MIFYSCATE, a.
        MIPL_LINE, a.MISEASON, CONCAT( 'CICL', RIGHT(CAST(rule.MICICLALL as VARCHAR( 10 ) ), 2)) as

```

```

MISOURCE, a.MIVBUND, a.MIVERSIO, a.MIWDV, MIWDV, a.MIWNFO, a.MIWNIC, a.MIWFBR, a.
MIWFML, CURRENCY, UNIT, MIAMTYID, MIAMOUNT, MIFAMNT, MIFAMTYID, MIQNTYID, MIQUANT
17 from :FLT1_REC as a join :RULE_I as rule
18 on a.FISCPER3 = RIGHT( rule.FISCPER, 3 ) and a.FISCVARNT = rule.FISCVARNT and a.FISCYEAR = LEFT
    (rule.FISCPER, 4) and a.MICMPCOD = rule.MICMPCOD and a.MIWDV = rule.MIWDV
19 and (( rule.MIPL_LINE = 'XX' ) or ( rule.MIPL_LINE <> 'XX' and rule.MIPL_LINE = a.MIPL_LINE ))
20 ***** More conditions for each dimension in the rule
21 and (( rule.MICUSTOMR = 'XX' ) or ( rule.MICUSTOMR <> 'XX' and rule.MICUSTOMR = a.MICUSTOMR ));

```

Listing 1: Retrieving of data to be allocated taking into account the selected dimension and the type of allocation

3. *Get Driver*: from the internal table of initial dataset of drivers :DRIVER_SRC, a join is performed with the parameters in the rule taking into account the "parity" value. If the rule specifies a different value than "XX", then the dimension loses its details. In this way, we can identify which dimensions have importance for the rule. After the join, the resulting records are grouped into :GRP_DRV to reduce the size of table.

```

1 DRIVER = select a.FISCPER, a.FISCPER3, a.FISCVARNT,
2     case when rule.MIYEARDRV <> 'PP' then 'XX' else a.FISCYEAR end as FISCYEAR,
3     'XX' as INFOPROV, ' ' MI4LEVCOD, ' ' MICODCCVV, a.MICMPCOD
4     case when rule.MICODDRV <> 'PP' then 'XX' else a.MICOSTGEN end as MICOSTGEN,
5     a.MICO_AREA , a.MICTGRY,
6     case when rule.MICATDRV <> 'PP' then 'XX' else a.MIFYCATEG end as MIFYCATEG,
7     a.MICURTYPE, 'XX' as MIDTSCON, 'XX' as MISOURCE, a.MIWDV, ' ' MIWVRCE
8     case when rule.MICUSTDRV <> 'PP' and :ALL_DIM <> 'MICUSTOMR' then 'XX' else a.MICUSTOMR end,
9     case when rule.MIPLDRV <> 'PP' then 'XX' else a.MIPL_LINE end as MIPL_LINE,
10    case when rule.MISEADRV <> 'PP' then 'XX' else a.MISEASON end as MISEASON,
11    case when rule.MIVBUDRV <> 'PP' then 'XX' else a.MIVBUND end as MIVBUND,
12    case when rule.MIWDVDRV <> 'PP' then 'XX' else a.MIWDV end as MIWDV,
13    case when rule.MIPOSDRV <> 'PP' and :ALL_DIM <> 'MIWNFO' then 'XX' else a.MIWNFO end,
14    case when rule.MITCODRV <> 'PP' and :ALL_DIM <> 'MIWNIC' then 'XX' else a.MIWNIC end,
15    case when rule.MICODRV <> 'PP' and :ALL_DIM <> 'MICOUNTRY' then 'XX' else a.MICOUNTRY end,
16    case when rule.MIBRDDRV <> 'PP' and :ALL_DIM <> 'MIWFBR' then 'XX' else a.MIWFBR end,
17    case when rule.MIWLDRV <> 'PP' and :ALL_DIM <> 'MIWFML' then 'XX' else a.MIWFML end,
18    case when rule.MIVERDRV <> 'PP' then 'XX' else a.MIVERSIO end as MIVERSIO,
19    a.CURRENCY, a.UNIT, a.MIAMOUNT, a.MIAMTYID, a.MIFAMNT, a.MIFAMTYID, a.MIQNTYID, a.MIQUANT
20 from :DRIVER_SRC as a join :RULE_I as rule
21 on a.FISCPER3 = RIGHT( rule.FISCPER, 3 ) and a.FISCVARNT = rule.FISCVARNT and a.MICMPCOD = rule
    .MICMPCOD and (( rule.MIPLDRV = 'XX' ) or ( rule.MIPLDRV = 'PP' ) or ( rule.MIPLDRV = a.
    MIPL_LINE ))
22 ***** More conditions for each dimension belonging to filters

```

```

23 and (( rule.MICUSIDRV = 'XX' ) or ( rule.MICUSIDRV = 'PP' ) or ( rule.MICUSIDRV = a.MICUSTOMR ))
;

```

Listing 2: Retrieving of data to be allocated taking into account of the selected dimension and the type of allocation

4. *Calculate percentages*: an if statement checks the dimension to be allocated in order to calculate the total amount, aggregating the driver's data without the considered dimension. Then, the percentages are computed joining :GRP_DRV and a specific table that contains the total amount of dimension to allocate. The percentage variable is join with :FLT_REC, obtaining the allocation result in :ALLOC_REC variable. Lastly, a cancellation is performed from :ALLOC_REC_STR that contains the real allocated data since :FLT2_REC may not join with driver for all the data.

```

1 ALLOC_REC = select a.FISCPER3, a.FISCVARNT, a.FISCYEAR, INFOPROV, a.MICOMPCOD, a.MICOSTCEN,
2 case :ALL_DIM when 'MICOUNTRY' then b.MICOUNTRY else a.MICOUNTRY end as MICOUNTRY,
3 a.MICO_AREA, a.MICURTYPE, a.MIVERSIO, a.MIWDV, MIWDV;
4 case :ALL_DIM when 'MICUSTOMR' then b.MICUSTOMR else a.MICUSTOMR end as MICUSTOMR,
5 a.MIDTSCON, a.MIFYCATE, MIFYCATE, a.MIPL_LINE, a.MISEASON, a.MISOURCE, a.MIBUND,
6 case :ALL_DIM when 'MIWNFO' then b.MIWNFO else a.MIWNFO end as MIWNFO
7 case :ALL_DIM when 'MIWNIC' then b.MIWNIC else a.MIWNIC end as MIWNIC
8 case :ALL_DIM when 'MIWPER' then b.MIWPER else a.MIWPER end as MIWPER
9 case :ALL_DIM when 'MIWPL' then b.MIWPL else a.MIWPL end as MIWPL,
10 a.CURRENCY, UNIT, (a.MIAMNIYID * b.PERC) as MIAMNIYID,
11 0 MIAMOUNT, 0 MIFAMNT, (a.MIFAMIYID * b.PERC) as MIFAMIYID, 0 MIQNTYID, 0 MIQUANT
12 from :FLT2_REC as a
13 join :PERC as b
14 on a.FISCPER3 = b.FISCPER3 and a.FISCVARNT = b.FISCVARNT and a.MICOMPCOD = b.MICOMPCOD and
15 a.MICO_AREA = b.MICO_AREA and a.CURRENCY = b.CURRENCY and
16 (( b.FISCYEAR = 'XX' ) or ( b.FISCYEAR <> 'XX' and a.FISCYEAR = b.FISCYEAR )) and
17 ***** Join conditions of not selectable dimensions for allocation
18 (( b.MIWDV = 'XX' ) or ( b.MIWDV <> 'XX' and a.MIWDV = b.MIWDV )) and
19 ((( b.MIWPER = 'XX' ) or ( b.MIWPER <> 'XX' and a.MIWPER = b.MIWPER )) and ( :ALL_DIM
20 <> 'MIWPER' )) or ( :ALL_DIM = 'MIWPER' )) and
21 ***** Join conditions of selectable dimensions for allocation
22 ((( b.MIWPL = 'XX' ) or ( b.MIWPL <> 'XX' and a.MIWPL = b.MIWPL )) and ( :ALL_DIM
23 <> 'MIWPL' )) or ( :ALL_DIM = 'MIWPL' ));

```

Listing 3: Retrieving of data to be allocated taking into account of the selected dimension

and the type of allocation

5. *Update inputs*: before to restart the loop, driver and "to allocate" data must be updated for the next rule. The output data are stored in the :E_VIEW variable into the new Urgent Allocator MCBP2URP with the proper values of rule ID and version.

We can see the data at this point looking the report in the "Check Allocations" sheet.

However, even if old allocation engine is hard to use, it may be useful to observe real-time allocation on the fly. That is why we decided to carry out the migration of application.

It should not be used with the new engine because they use different logics which were not analyzed to work together properly. While the new application use RULE* mechanism with MIDTSCON dimension, the old one doesn't distinguish any datasource, thus all input values would be allocated.

To achieve the migration, we have taken care of the following changes:

- **InfoProvider migration for Planning Function and Queries**: we have adapt objects which were based on the old data providers to the new one, i.e. from *AMCBP2URA* to *AMCBP4URP*.
- **replacement of old "Create Working Version" Planning Sequence**: it would be difficult to handle two code with same result and performance. Thus, it is convenient to adapt the new function to old workbook's logic, creating a new Planning Sequence *MPS_AMCBP4URP_OLD_WK* associated to a new Function Type, called *AMCBP4URP_OLD_WK*, which diverges only for the input parameters.

Furthermore, we had to modify the parameter's variable of dimension MICOUNTRY in all the Planning Function mentioned above in order to solve an high priority issue that causes a bad allocation on Country dimension.

At the end of the process, two reports are available to check the correctness of allocation. The first report MMCBP2URP_CHECK is the same of the main workbook, while the second one, named MMCCO2PLA_Q001 allows to check which data create the driver for a specific rule. Since driver data are not stored in an ad-hoc aDSO but it is an intermediate table of the allocation calculation, we use a Composite Provider MMCCO2PLA that queries data to HANA directly through a Calculation View called CV_ALLOC_DRIVER_RECORDS.

Results and Future Works

The old allocation engine works properly but the process have always had room of improvement on some matter. The new engine indeed is now able to fill gaps about the timing of computation and user interaction.

Regarding the computation, it did not have large issues but it has with the introduction of real-time P&L Line. Indeed, this feature is provided joining the actual and budget data from the beginning of data flow with the resulting set of combination produced by a Calculation View. The outcome is a set of 241.242.960 rows that join may cause a slowing down of total computation. However, we were able to obtain the same timing of the old engine, i.e. around 4 seconds, filtering properly the table of real-time P&L Lines with all the possible combinations in the input data.

About the procedure, since the new allocation uses a different logic, most

of users got confused during the first introduction of the application. In particular, they struggled to understand that the definition of a rule includes several steps that would be performed in the old engine. For this reason, we had to organize meetings with each supervisor for each company in order to test different scenarios of old engine in the new one. The following observations are the result of this sequence of tests and the timing outcome are resumed in the Table 12.

The old engine allows to perform a single allocation filling the prompt windows of the workbook and clicking on a button associated to the dimension to allocate. The first step is onerous since the prompt has around 20 input fields shown in a small area and more than one dimension may be changed. This action is also redundant because must be carried out anytime the user wants to change the parameters that define the domains of "to allocate" and driver data. For example, during our tests using a real-case set of rules for the new engine, all the 200 rules have had different parameters of the domains. Assuming the allocation's computation is negligible, if we consider the best case where for each rule a single parameter changes and to complete the entire step the user needs 10 seconds, thus the user should complete this step 200 times after around 30 minutes.

This operation is translated as writing of a single rule in the new allocation engine. Moving all the process at Excel's sheet level, it's easier and faster to define the allocation's steps to reach the desired result. Considering the previous example, the 200 rules has been inserted in the table in around 15 minutes taking advantage of copying and pasting tools in Excel environment. However, in this case the computation affects the timing since the

system executes all the rules at once, by a single call. During the tests, the computation has lasted around 1 minute and 50 seconds each time.

Different action must be performed from the user when more dimensions are allocated for the same domains of data. In this case, the old engine requires a single click on a button while the new one requires to copy a new line with different value under the "to allocate dimension" column. However, this case is less probable than the first one, thus it does not influence the overall performance of the process.

At the end, the best improvement on the interaction process is about the re-computation of all allocations. While the user must performed all the single allocation from the beginning in the old engine, in the new one, thanks to storing of rules, the user must only edit the desired rules and launch the computation. In this way, the user can perform this action in a few minutes in contrast to the 30 minutes at least to carry out all the rules manually.

Allocation of a company (N = 200 rules)		
Tasks	Old Engine	New Engine
Computation timing for N allocations	-	1 min 50 sec
Definition of a single allocation	≈ 10 sec	≈ 10 sec
Definition of N allocations	≈ 30 min	≈ 15 min
Total Timing to Complete Process (definition + computation)	≈ 30 min	≈ 17 min
Remake of Allocation Process	≈ 30 min	≈ 3 min

Table 12: Summary of result about user interactions timing.

This scenario is further assisted by the new logic through which the user can see the results of each rule inserting in the reports the datasource's dimension and can find easily the points in which apply the desired changes.

4.5 Revaluation of Cogs

FG has requested to migrate the application from the ERP system to BW/4HANA because the entire process are being migrated and the performance is very poor. Thus, from a manual performance of Cogs' revaluation, FG wants to realize an automatized solution where the only user's interaction is the execution of processes led by a BPF, offering completely autonomy to users.

Through this process, FG's companies are able to recompute standard costs of good sold with actual unit cost value in order to assess their own financial performance. Cost of goods sold (Cogs) is the cost of acquiring or manufacturing the products that a company sells during a period, so the only costs included in the measure are those that are directly tied to the production of the products, including the cost of labor, materials, and manufacturing overhead. In other words, Cogs includes the direct cost of producing goods or services that were purchased by customers during the year.

In the BW system, these information are found along the COPA's data flow from ECC and are represented by amounts or quantities through the dimension MICODCCVV that represents the structure of costs and revenues required to carry out costing-based profitability analysis. The Tables 13 and 14 shows the Value Fields associated to standard and actual Cogs that are used during the process. The ones associated to quantities are not important to list since it is important only the sum of them to get the total amount of sold products.

The revaluation is composed by three sequential steps: upload of actualized costs, revaluation of Cogs of companies and revaluation of Cogs of

Standard Cogs Company		
Value Fields	Description	Rule
VV200	Cogs - Raw Material	From "Raw Material" from Standard BW
VV225	Cogs - Clothing Purchase	From "Clothing Purchase" from Standard BW
VV210	Cogs - Mods - Facon	From "Mods" from Standard BW
VV205	Cogs - Outside Works - Facon	From "Outside Works" from Standard BW
VV220	Cogs - Fixed Rates	From "Fixed Rates" from Standard BW

Actual Cogs Company		
Value Fields	Description	Rule
VV255	Cogs - Industrial Cost Variance	Sum between the inverse of previous VV255 value and (actualized cost * quantity)

Table 13: List of the MICODCCVV Cogs of companies

group. At the beginning, the user inserts manually or through a flat file the data about the actualized Cogs. Unlike the previous version, the new application enables this task only to supervisors of each business, providing later the actualized costs of each company to the revaluation of group without additional importing. The requested input data must contain details about *Fiscal Year* (0FISCYEAR), *Vendor Company* (MISOCIETA), *Company of Cost* (MISOCIETC), *Model* (MIWWPMO) and *Amount* (MICOSTIND). In this case, the application doesn't use the main dimension MICOMPCOD for the company codes, but a descriptive code (e.g., MM, MR, DT, etc.) associated to a small set of companies for that the revaluation takes place.

Standard Cogs Group		
Value Fields	Description	Rule
VVC01	Cogs - Raw Material	From "Raw Material" from Standard BW
VVC02	Cogs - Clothing Purchase	From "Clothing Purchase" from Standard BW
VVC03	Cogs - Facon	From "Facon" from Standard BW
VVC04	Cogs Total - Fixed Rate	From "Fixed Rate" from Standard BW
VVC05	Cogs Total - Industrial Cost	Calculated as sum of the previous ones

Actual Cogs Group		
Value Fields	Description	Rule
VVC06	Cogs - Industrial Cost Variance	Under specific conditions, it is calculated as inverse of VVC05
VVC15	Cogs Total - Industrial Cost	Under specific conditions, it is calculated as Industrial Cost * Quantity

Table 14: List of the MICODCCVV of Cogs group

After the upload, the revaluation is performed. The calculation must be distinguished between company and group scenarios because the second one follows an ad-hoc logic:

1. For each company, the actualized costs are calculated only for the total amount and its variance. In fact, the process consists of the cancellation of current values and the computation of actualized cost in VV255.
2. For group, the algorithm aims to calculate the actualized costs in according to a specific sequence of companies that defines the priority

for the revaluation of a model. Before the revaluation, the standard costs are computed linearly, matching the input amount with the list of unitary actualized costs for year, provider and model. In the design documents, there is a code that is used later as check parameter if the record doesn't match with previous condition, but it is not taken back for the current implementation. Then, revaluation starts performing a cancellation of all imports with VVC05 which are in the list of actualized costs per year and model. After the cancellations, the algorithm computes the total actualized Cogs for the companies which don't belong to Diffusion division and have a Value Field different than VVC05, i.e. previous values of VVC15 or quantities for actualization. Thus, two nested loops are performed iterating the year up to two previous years and following a previously defined sequence of companies. In the body of loop, the input record is searched in the list of unitary actualized costs in according to year, provider, sequence's company and model. At the end of this loop, another one is performed with the same conditions except for the provider value which must be equals to "DT". The following tables 11 and 12 shows the algorithm described above.

At current state of implementation, these procedure are represented partially because there's a period of discussion to decide whether change or not the logic behind revaluation. For this reason, we simplify the calculation of Standard, retrieving data directly from Profitability Analysis cube (MCCO1PAA), and we discard the revaluation for the previous years. In the following Listing

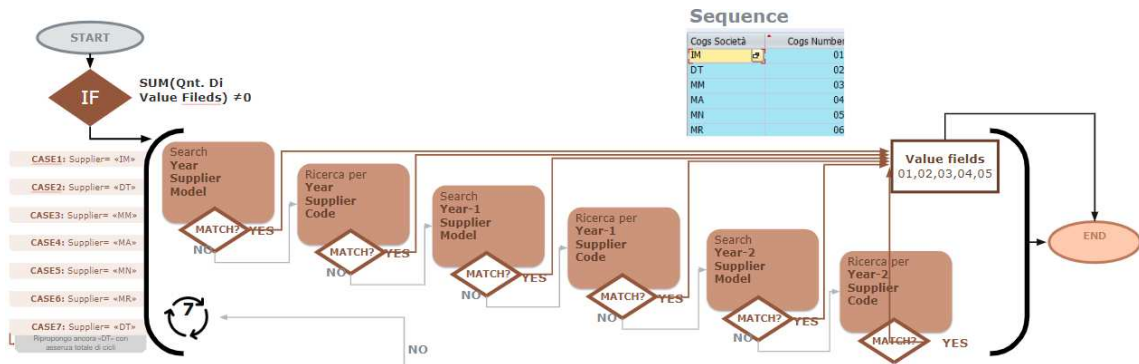


Figure 11: Flow diagram of revaluation of group Cogs

Implementation

For algorithm migration, the goal was to convert the logic of process written in ABAP to a SQL procedure. SQL helps us to organize the algorithm, making a cleaner and more compact code.

At current state of implementation, these procedure are represented partially because there's a period of discussion with users to decide whether change or not the logic behind revaluation. For this reason, we simplify the calculation of Standard, retrieving data directly from Profitability Analysis cube (MCCO2PAA), and we discard the revaluation for the previous years.

Considering the code of Cogs of group, we sketch out the process' steps as follows:

1. *Setup*: unitary actualized values are initially filtered in according to the sequence of companies defined in the table /BIC/PMICOGSNUM.
2. *Computation of standard costs*: compute of standard costs for group, applying a cancellation on already existing ones and copying the stan-

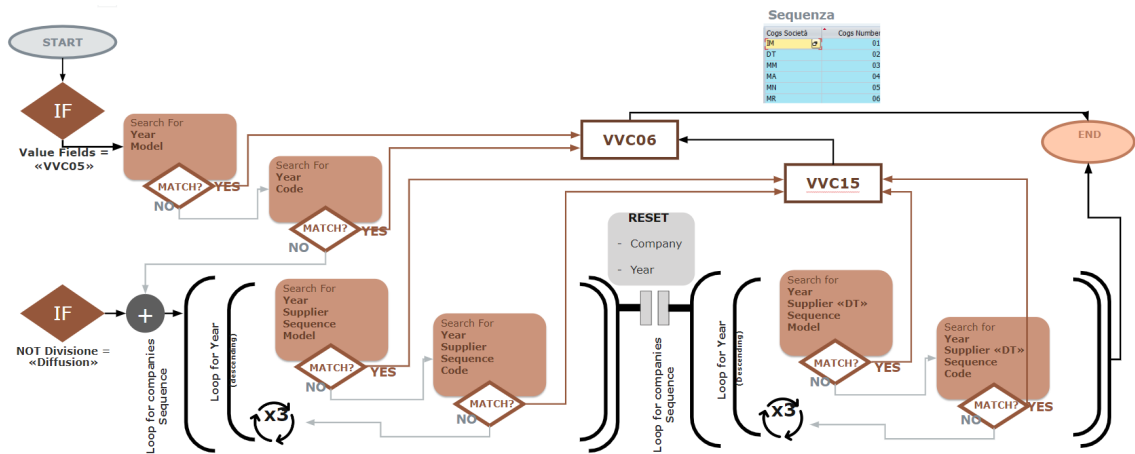


Figure 12: Flow diagram of revaluation of group Cogs

standard costs of companies to the corresponding group's Value Fields. Then, the total cost, i.e. VVC05, is computed aggregating the previous calculated amounts.

3. *Revaluation of group's cogs*: start the procedure of revaluation with the conditions shown in the Figure 12. First, we fetch the data related to total costs VVC05 and the quantities VVC9**, indicate with a mark DIFFCOMP if the company belongs to Diffusion division. After that, the cancellation of total costs is stored on total variance VVC06 and the total cost VVC15 is computed in according to the division, the year and the model. In case of not diffusion companies, the positivity of fixed costs is considered, but since the value is not inputable in the list of actualized costs then the condition will be always true.
4. *Cleaning*: it is a small important part of code where we reset all the possible variable because the we ran into a memory issue which blocked

the Planning Sequence.

Further the implementation algorithm, we had to combine the right software objects to solve three requirements that have arisen during the development of the application:

- When a calculation is triggered from an AFO sheet, the entire Excel software of the user remains halted until the end of the job. It can be a problem since the revaluation may need several minutes to finish so that user would be unable to carry on.
- Necessity to manage the synchronization of access to the aDSO of Cogs data because errors may occur whether a company starts the execution of revaluation while another calculation is being performed.
- Revaluation of group process computes the amounts for each selected periods and then these values must be aggregated to define the amount Year-To-Date for the next periods. It means the calculation must generate at most 16 records for each period producing a quantity of records that is not manageable from a Planning Sequence in BW system.

To overcome these issues, we avoid to use a set of Planning Sequence launched in AFO roughly, but we choose to employ a Process Chain object through which the revaluation is executed synchronously in background. In fact, BW manages these chains as its own process' job and using a queue system that allows to keep track of the requests for execution. The queue, however, is not visible externally and it may cause user errors and complaints, e.g. user could launch countless requests to system because no UI

element notifies him that the process is running. For this reason, we design and implement a **logging system** useful to track the running revaluation.

The logging system is the components via which the user interact with the revaluation. It is based on keeping track of the status of each request, storing the log in MCCO1RCL aDSO with the details shown in Figure 13.

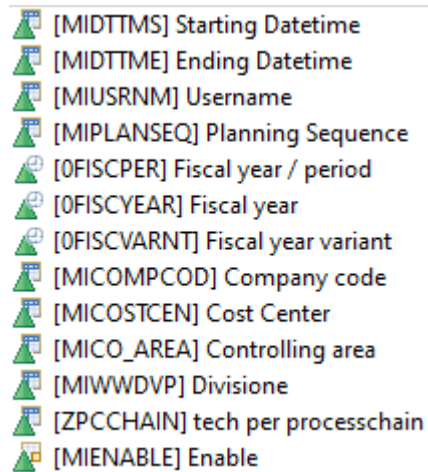


Figure 13: Structure of MCCO1RCL aDSO for storing of logs.

The MIENABLE InfoObject represents the status of the process that will be updated along the process chain: "1" process is running, "2" process was completed successfully and "-1" process failed. MIUSRNM, ZPCCHAIN and MIPLANSEQ are metadata of chain that indicate the user, the initial Planning Sequence and the Process Chain. They are extremely useful during errors' recognition phase since BW doesn't automatically handle these information. The remaining dimensions are defined by user to select the domain of the revaluation. Note that, this system is used from both company and group users with the only difference in the logging report since revaluation

group doesn't need to specify to which company, cost centers and divisions run the calculation.

In the Figure 14 the objects and the interactions between each other are shown. The procedure is triggered from the user clicking on Excel sheet's button that launches two planning sequence sequentially. The first initialize the log of the request storing partial information as starting timestamp, domain of revaluation, name of process chain and name of following planning sequence. These information are shown immediately on the workbook through the query of logs. Then, the second executes a standard Planning Function that launches the Process Chain. From this point of the procedure, a sequential set of planning sequence will be executed that can't receive the input parameter from the AFO sheet. For this reason we implement ad-hoc Planning Sequences with fixed parameters and Customer Exit variables. The latter are especially helpful to fetch information of running process from logging system.

Then, the Process Chain will execute the revaluation and the calculation of YTD amounts sequentially. In case of group's revaluation, an additional step is implemented because the resulting data must be aggregated to the set of WK2 data of allocator since they are necessary for the end of closing process. After steps about computations, two distinct functions of the logging system will be called whether all calculations were completed successfully. These two Planning Sequences will update the ending timestamp and the status of process' log. At the end of the chain, if a request exists in the queue then it will be executed.

As said previously, the revaluation of Cogs of group needs less input

parameter and it consumes more hardware resources respect to revaluation of Cogs of companies. Moreover, Cogs of group must be copied to WK2 version in order to enter to the Consolidation data flow. Thus, we decided to implement two distinct process flows with two similar chains (M_PC_RIV_COGS_S and M_PC_RIV_COGS_G). Group's chain is distinguished since YTD calculation of group's Cogs is split into 17 sub-steps, one for each period from 000 to 016, and contains unique Planning Sequence for copy of data into WK2 version.

Results and Future Works

During the development phase, we have dealt with performance issues since a large volume of data is used during the computation. This has also been the factor of the old application in ECC system that have led an execution time of 3 days at most for the revaluation of group's Cogs. Fundamental help is given by the Process Chain that manages high amount of data conveniently. Further, the necessity of hardware resources for computation doesn't let us to perform tests in DEV environment cause resources limitations. Thus, we execute the application on TEST environment that has 1.269,5 GB of allocated memory of which only 800 GB are available.

Since the official tests are not started yet, we have had only one case on which try the application. The company M013 have provided a list of actualized costs long 62.033 records for revaluation of models that costs are associated to the fiscal year 2022. The company M013 represents on average company about data quantity, so the following results may be considered as a truthful case. We have performed a revaluation filtering only the mandatory

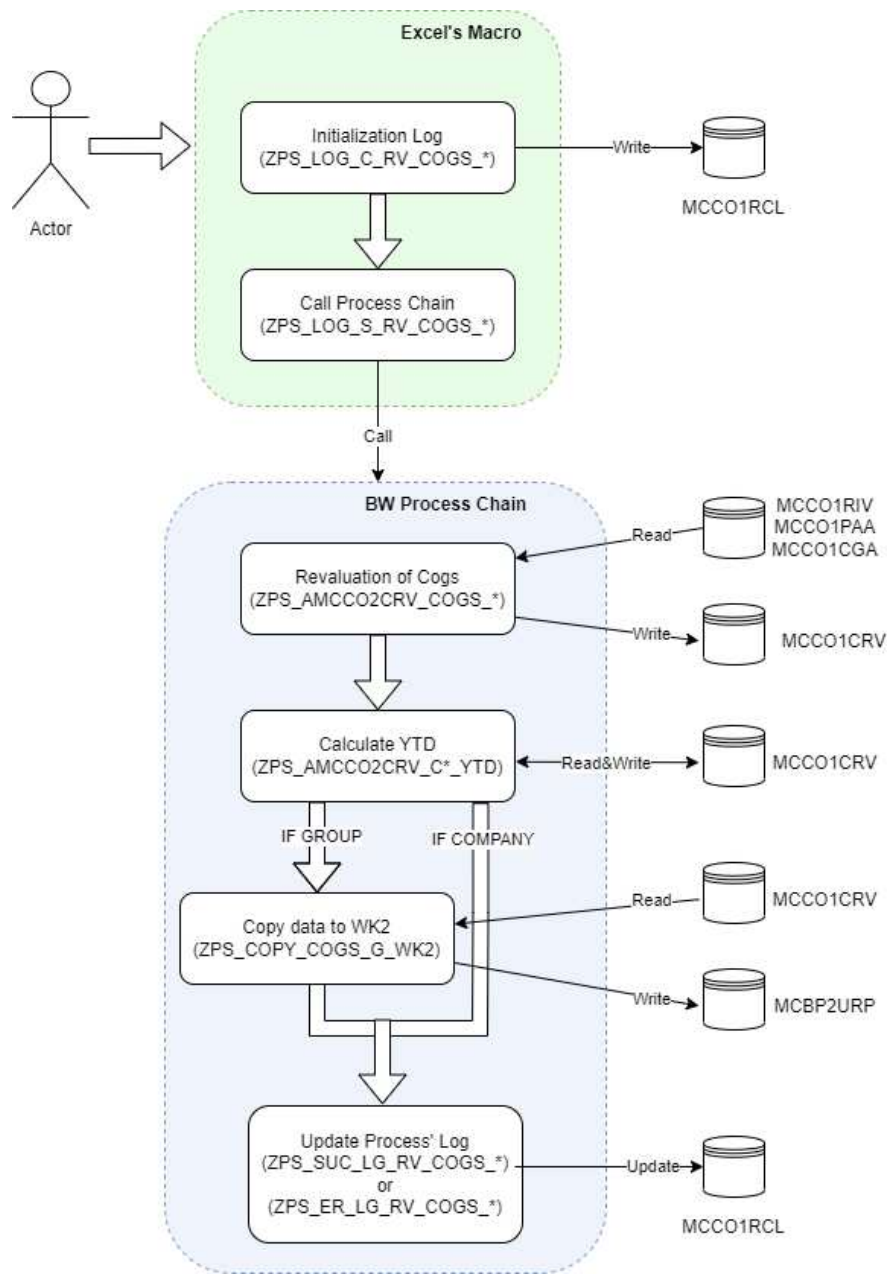


Figure 14: Diagram of actors and interactions in the process of revaluation of Cogs. The symbol * in nomenclature is a placeholder that has to be replaced with "S" for company's elements and with "G" for group's elements.

input parameters, i.e. company M013 and fiscal year 2022, avoiding to specify the optional ones in order to simulate the worst performance case for this company. In other words, the test runs on all the 17 periods (from 0 to 16) and all cost centers each of which is related to a division. The parameters of performance are resumed in the Table 15. Note that, stats of applications are shown as elaborated records during the Planning Sequence, whereas the overall stats consider all the steps (i.e., reading, writing and updating) and the elaboration of delta records for previous stored data. We can see that the total amount of time is widely acceptable for the purpose of the single company, providing to the user the time to check and to retrieve along the same day. The time makes longer if we consider that multiple users want to launch the revaluation for each the 30 company. In this case, the last execution in the queue may start after 7 hours. However, it is not a problem since the companies begin the closing sufficiently early.

About the revaluation of cogs of group, the process needed more attention in design phase since the volume of data is huge. In fact, if they were not managed adequately, the process would have blocked the entire server for an undefined period. For this purpose, the Process Chain and the subdivision of tasks is fundamental to the correct operation of the application.

At the current state of application, we have been able to make an approximately test on all 30 companies of group only using the actualized Cogs above. It is only a starting point to evaluate the overall performance of the application since a larger dataset of actualized Cogs may be uploaded. The Table 16 resume the statistics about performance of the calculation over an entire fiscal year composed of 17 periods.

Company's Cogs (M013; 2022; 17 periods; 200 CdC)		
Actualized Cogs		62.033 rec.
Revaluation Planning Sequence	Input Data	3.014.526 rec.
	Output Data	3.007.540 rec.
	Exec. Time	423 sec
Year-to-date computation	Input Data	7.265.250 rec.
	Output Data	86.430.136 rec.
	Exec. Time	426 sec
Overall Best Time (one process)		≈ 15 min
Overall Worst Time (30 processes)		≈ 7 hours
Overall Approx. Used Memory		≈ 7,09 GB
Overall Approx. Storage Size		≈ 2,80 GB

Table 15: Stats of company's cogs revaluation.

The listed parameters are fetched for an ideal execution where the user launches the application for the first time for a specific fiscal year. The server was not overloaded by application and don't show any freezing behaviour. In case of repetition of execution, however, the use of memory and storage may increase doubly and may cause stability issue for server since the system must manage the previous stored data applying a delta operation.

Altogether, the performance of the two variances are far better respect to application in ECC and, with the implemented auxiliary features, the process will be easily done by user whose experience will improve considerably in terms of time and load.

Only a little improvement to group's application should be done in order to improve the usage of the hardware resources. We are able to divide the

Group's Cogs (30 companies; 2022; 17 periods)		
Actualized Cogs		62.033 rec.
Revaluation Planning Sequence	Input Data	338.517.541 rec.
	Output Data	729.207.948 rec.
	Exec. Time	2.188 sec
Year-to-date computation	Input Data	890.574.785 rec.
	Output Data	9.796.322.642 rec.
	Total Exec. Time	2.236 sec
	Average Exec. Time	139,8 sec
Copy to Allocator WK2	Input Data	15.218.112 rec.
	Output Data	15.218.112 rec.
	Exec. Time	328 sec
Overall Best Time (first exec.)		≈ 50 min
Overall Worst Time (overwrite exec.)		≈ 1 h 20 min
Overall Approx. Used Memory		≈ 24,49 GB
Overall Approx. Storage Size		≈ 10,05 GB

Table 16: Stats of company's cogs revaluation.

computation further through other steps in the Process Chain and using the package feature efficiently. So that, the instability about high volume of data will be erased avoiding to cause unexpected block of server during the use of application. The time execution may increase, but making no trouble since the difference would be slight. Another option would be the reduction of the load of data selecting a subset of dimensions to elaborate, but this must be done working together with FG's user to understand what are the not fundamental information for the closing.

5 Conclusion

In conclusion, this work has demonstrated the significant improvements that can be achieved in the EPM system through the utilization of SAP BW/4HANA and BPC 11.1. The integration of these technologies has proven to enhance the efficiency and usability of various business processes, resulting in tangible benefits for FG's companies.

The implementation of the allocation engine proved to be successful in delivering a streamlined workflow to users, despite initial training challenges and the potential disruption to their established processes. The decision to introduce a novel approach was not without risks, as it required a significant shake-up of the users' workflow. However, by incorporating the storage of rules and eliminating the need for repetitive instructions, the allocation process was significantly optimized. This resulted in increased efficiency, time savings, and an overall enhanced user experience.

The COGS revaluation application successfully tackled technical challenges and delivered a robust solution. By migrating the application to the data warehouse software suite, it became possible to effectively manage large volumes of data while ensuring smooth user workflows and preventing server overload. The application's utilization of the Process Chain component further optimized its performance. Although lower-level tools such as jobs and events were available options since they are easier to manage on our terms, we chose not to implement them due to limited expertise in the technology, which could have resulted in delays to the planned schedule. An additional enhancement was achieved through the import of adjustment COPA, empowering users with greater independence as they no longer need to rely on the

competence center for data uploads and no longer have to wait for overnight process chain runs to access the required data for closing.

While acknowledging the encountered limitations during the design phase, including technical and methodological challenges, it is evident that the technical and design decisions made have resulted in significant outcomes that have satisfied FG's companies. This assertion is substantiated by the positive feedback received from users through a survey conducted to assess the new processes. The survey revealed excellent results, with 9 out of 11 users expressing satisfaction with the new applications. They specifically highlighted the streamlined workflow of the allocation process and the improved performance of COGS revaluation. It is worth noting that the remaining users did not provide an evaluation as they had not sufficiently tested the applications. These findings underscore the importance of selecting appropriate software solutions, such as SAP BW/4HANA and BPC, for achieving effective EPM processes.

Looking ahead, further research could explore additional optimization techniques and delve into the specific impacts of these solutions on different industries or business scenarios. The findings of this study emphasize the value and potential of leveraging SAP technologies to improve data management, streamline processes, and enhance overall performance in the realm of enterprise performance management.

In conclusion, this work underscores the significance of using SAP BW/4HANA and BPC 11.1 to drive efficiency and usability enhancements in EPM processes. By adopting these technologies and making informed design choices, businesses can achieve improved outcomes, optimized workflows, and a more

seamless user experience.

References

- [1] *All you need and wanted to know about SAP BPC 11 on BW₄/HANA.* URL: <https://www.element61.be/en/resource/all-you-need-and-wanted-know-about-sap-bpc-11-bw4hana>.
- [2] *Assurance Services.* URL: <https://corporatefinanceinstitute.com/resources/accounting/assurance-services/>.
- [3] *Bilancio gestionale e civilistico: quali sono le differenze?* URL: <https://www.saep.it/magazine/bilancio-gestionale-e-civilistico-quali-sono-le-differenze/>.
- [4] *Budget definition.* URL: <https://www.accountingtools.com/articles/what-is-a-budget.html>.
- [5] Dan. *Cost Center.* URL: <https://strategiccfo.com/articles/accounting/cost-center/>.
- [6] Diann Daniel. *SAP ERP Central Component (SAP ECC).* URL: <https://www.techtarget.com/searchsap/definition/SAP-ERP-Central-Component-SAP-ECC>.
- [7] Jason Fernando. *Cost of Goods Sold (COGS) Explained With Methods to Calculate It.* URL: <https://www.investopedia.com/terms/c/cogs.asp>.
- [8] Jason Fernando. *Profit and Loss Statement Meaning, Importance, Types, and Examples.* URL: <https://www.investopedia.com/terms/p/plstatement.asp>.
- [9] *Financial Budgeting.* URL: <https://planful.com/financial-budgeting/>.

[10] *Tax services*. URL: <https://www.pwc-tls.it/en/services/tax-services.html>.