

# A New Approach to Executive Information Management as Part of IPS<sup>2</sup> Lifecycle Management

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## Abstract

The characteristics of IPS<sup>2</sup> pose new challenges to top managers in IPS<sup>2</sup> enterprises. However, current commercial EIM systems mostly focus on finance and business operations. In this paper introduced is a new approach to Executive Information Management (EIM), based on an IPS<sup>2</sup> Lifecycle Management (LM) system. It offers top managers an integrated IT environment about offered IPS<sup>2</sup>, and thus has the potential to enhance their work. The approach, the IT architecture, and the meta-information model for IPS<sup>2</sup> lifecycle management are explained in detail.

## Keywords

Executive Information Management (EIM), IPS<sup>2</sup>, Lifecycle Management

## 1 INTRODUCTION

The main characteristics of the Industrial Product-Service Systems (IPS<sup>2</sup>), the close interaction between providers and customers and the high change dynamics during the delivery and use phase, pose new challenges to top managers, e.g. more complex decision-making processes and new IPS<sup>2</sup>-related decision tasks in comparison to pure products or services[1]. As top managers' existing experiences cannot be fully used to make IPS<sup>2</sup>-related decisions, they urgently need a suitable Executive Information Management (EIM) system to support their work. Unfortunately, current commercial EIM systems mostly focus on financial information and business operations, and thus cannot fully meet the requirements of top managers in IPS<sup>2</sup> enterprises [2-5]. In these companies, many commercial IT enterprise applications (such as ERP, PDM, SCM, CRM, etc.) are deployed at operational and tactical levels. Only with a few of them special modules are available to meet the information demand of top managers, but these special modules can only integrate and analyze the data, which is stored in single systems. Top managers of IPS<sup>2</sup> providers cannot obtain comprehensive IPS<sup>2</sup>-related information from these single IT systems. Generally, the EIM system for IPS<sup>2</sup> providers should include all IPS<sup>2</sup> data along its entire lifecycle and should provide top managers with the right IPS<sup>2</sup> data for supporting IPS<sup>2</sup>-related decision-making at the right time.

Due to these IPS<sup>2</sup> characteristics mentioned above, the Lifecycle Management (LM) system for IPS<sup>2</sup> has been extended to cover all phases along the IPS<sup>2</sup> lifecycle. Classical PLM systems only cover value-added processes with a focus on product development and manufacturing [6-8]. Thus, the IPS<sup>2</sup>-LM system manages all planning, development, delivery/use and also recycling data of IPS<sup>2</sup> [9, 10]. These data can be used not only for operational engineering tasks, but also for IPS<sup>2</sup>-related decision-making of top managers.

This paper introduces a new approach for an Executive Information Management (EIM), based on an IPS<sup>2</sup> Lifecycle Management system. As an extended part of the IPS<sup>2</sup>-LM system, the EIM module can seamlessly access all IPS<sup>2</sup> data that is stored in the IPS<sup>2</sup>-LM system. In addition, relevant data from ERP, CRM, SCM and other

data sources are also needed. By acquiring, integrating, analyzing and visualizing executive information, the EIM module offers top managers an integrated information environment about IPS<sup>2</sup> for IPS<sup>2</sup>-related decision-making and controlling.

## 2 REQUIREMENT ANALYSIS OF THE EIM MODULE FOR IPS<sup>2</sup> PROVIDERS

### 2.1 Definition of EIM system

The idea of EIM systems was first enunciated by Rockart and Treacy in the early 1980s [11]. The initial definition of an EIM system was an information support system for top managers. The scope of EIM systems has evolved in the last 30 years. The meaning and tasks of EIM systems have been greatly extended. The latest definition of an EIM system was given by Klaus Ballensiefen [3] in 2002:

"An EIM system is a company-specific and dynamic information support system, based on various internal and external data, which is used to supply flexible support information to top managers with a high operating comfort."

According to this definition, an EIM system is not common software, but company-specific or field-specific software. Thus, a careful requirement analysis is the key to its successful development. The first step in developing an EIM system is to take into account the specific information requirements of top managers in various areas [12]. Secondly, executive information is gathered from various sources and conforms to the characteristics of the work of top managers. On a single day, a top manager is involved in a variety of tasks, e.g. meetings, appointments, business negotiations, report-reading and decision-making [13]. These tasks always require an overall support of useful information. Thirdly, EIM systems only provide information support to top managers, but they do not provide decision models. How to use the data and how to make a decision are still the responsibilities of top managers. Finally, the interface of an EIM system must be very intuitive and easy to use.

## 2.2 IPS<sup>2</sup>-related information for top managers of IPS<sup>2</sup> providers

The core problem for a top manager of an IPS<sup>2</sup> provider is how he or she can optimize the structure of IPS<sup>2</sup> and improve customer satisfaction in order to make long-term profits, while in classical industrial enterprises the main goal of top managers is to maximize profit in a financial year. The great change of the main goal leads top managers of IPS<sup>2</sup> providers to pay more attention to IPS<sup>2</sup>-related information. Raw EIM data can be gained inside and outside IPS<sup>2</sup> enterprises, and then processed and visualized to meet the new information requirements of top-managers of IPS<sup>2</sup> providers. The categories of IPS<sup>2</sup>-related data can be defined as follows:

- IPS<sup>2</sup> component data (e.g. up to date status of IPS<sup>2</sup> and different IPS<sup>2</sup> components, data of IPS<sup>2</sup> structure)
- IPS<sup>2</sup> process data (e.g. status of IPS<sup>2</sup>-processes, implementation and release status of IPS<sup>2</sup>, time interval between two releases)
- IPS<sup>2</sup> project data (e.g. allocation of staff in projects or project phases, demands on resources for IPS<sup>2</sup>-projects, schedule of IPS<sup>2</sup> projects)
- IPS<sup>2</sup> staff data (e.g. age, ability, skills, training and performance appraisal of IPS<sup>2</sup> staff)
- IPS<sup>2</sup> customer data (e.g. the number of change requests from customers, application data of IPS<sup>2</sup> by customers)
- IPS<sup>2</sup> IT system data (e.g. investment of IT systems for IPS<sup>2</sup>, number or errors of system downtime)
- IPS<sup>2</sup> external data (e.g. data about competitors, market, economy and politics)

These IPS<sup>2</sup> data can be extracted from different IT systems, which have already been applied in IPS<sup>2</sup> enterprises. But the same type of data can be distributed in different IT-systems, e.g. IPS<sup>2</sup> customer data are distributed and stored in HLB-LM and CRM (Customer Relationship Management). Thus, comprehensive data about a special topic cannot be obtained from a single data source. So, the EIM module for IPS<sup>2</sup> provides a powerful, dynamic data processing module (see chapter 4). It is designed to compress, aggregate and analyze EIM data, which is extracted from different data sources.

## 2.3 Functional requirement of EIM from top managers of IPS<sup>2</sup> providers

Upon extensive research and empirical studies, three main functions have been found to help top managers of IPS<sup>2</sup> providers make IPS<sup>2</sup>-related decisions. They are: IPS<sup>2</sup> monitoring, IPS<sup>2</sup> analysis and reporting.

- IPS<sup>2</sup> monitoring

The aim of IPS<sup>2</sup>-monitoring is to offer top managers integrated information on a dashboard to monitor and control statuses and processes of IPS<sup>2</sup>, IPS<sup>2</sup>-components and other IPS<sup>2</sup>-related resources.

- IPS<sup>2</sup> analysis

The function of IPS<sup>2</sup>-analysis is designed to predict the future development of IPS<sup>2</sup> by means of mathematical methods and based on existing IPS<sup>2</sup> data and important external data. The forecast results will be taken as important references for IPS<sup>2</sup>-related decision-making.

- Reporting

The aim of reporting is to automatically provide top managers with the right reports at the right time according to their demand. Thereby, unnecessary reports are avoided and the time for preparing the reports is greatly decreased.

## 3 IPS<sup>2</sup>-METRIC SYSTEM FOR EIM

As previously stated, on a single day, a top manager may deal with various IPS<sup>2</sup> tasks. The character of these tasks is discrete. There is no or very little relation between them. The paper in hand introduces a metric system (see figure 1) to externalize the information requirement of top managers and to supply exact data to support these discrete tasks. Each information demands of their task can be abstracted to several indicators automatically or manually by their assistants. The EIM module provides them with information support by supplying exact data to IPS<sup>2</sup>-metrics.

On the basis of the categories of IPS<sup>2</sup>-related data, 7 types of IPS<sup>2</sup>-metrics can be distinguished:

- IPS<sup>2</sup> character indicators (e.g. amount of engineering change per IPS<sup>2</sup> module, share of products and services in IPS<sup>2</sup>, share of standard components in IPS<sup>2</sup>)
- IPS<sup>2</sup> process indicators (e.g. processing time of single process step, share of productive process steps in total IPS<sup>2</sup>-LM, reaction time of customer changes)
- IPS<sup>2</sup> project indicators (e.g. adherence to schedule of single project phase, assignment of staff in projects)
- IPS<sup>2</sup> staff indicators (e.g. staff productivity, failures per staff, adherence to schedule)
- IPS<sup>2</sup> customer indicators (e.g. amount of customer satisfactions and reclamations)
- IPS<sup>2</sup> IT system indicators (e.g. downtime of IT systems, availability of IT systems)
- IPS<sup>2</sup> external indicators (about competitors, market, economy, politics, etc.)

According to methods of data processing and data features of indicators, IPS<sup>2</sup> metrics can further be divided into four types:

- Direct indicators

Data of direct indicators (e.g. adherence to schedule, amount of engineering change) is directly stored in clear data sources. After extraction from data sources these indicators can be displayed to top managers in a user-friendly format.

- Statistical indicators

Data of Statistical indicators (e.g. share of products and services in IPS<sup>2</sup>) have clear data sources and can be obtained by calculation with suitable statistical methods.

- Summary indicators

Summary indicators (e.g. staff productivity, availability of IT systems) reflect the status of IPS<sup>2</sup> by point or grade (e.g. 0 to 9), but not the direct description of raw data. The point or grade is given depending on raw EIM data and according to special standards or experiences.

- Event indicators

The term event indicator (e.g. important market change, important events of competitors) describes important events related to IPS<sup>2</sup>. Their abstracts are given directly in EIM. Thus, top managers can easily obtain the context of event indicators.

Hence, each IPS<sup>2</sup> metric has two classification attributes: Classification by data type can fix its data source. Classification by data processing can fix the data processing method of its raw data. According to these two attributes, raw data and processing method of each indicator become clear.

## 4 DATA PROCESSING METHOD OF EIM MODULE

Raw EIM data extracted from various systems can be stored in different formats and may have redundancies,

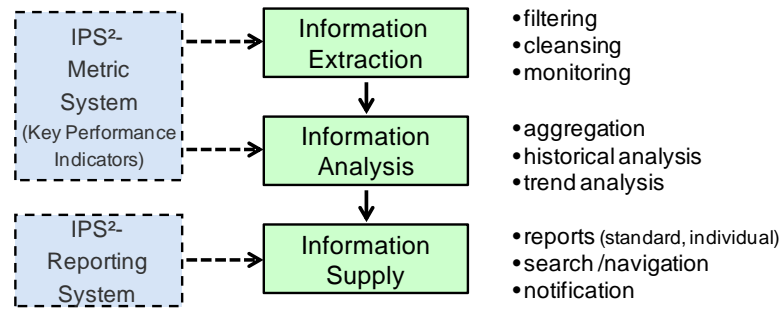


Figure 1: Three-layer structure of data processing method

conflicts, errors, and gaps. The paper in hand introduces a three-layer data processing method designed to process raw EIM data and supply exact data to different indicators with different densities and formats (see figure 1). The three layers are: information extraction, information analysis and information supply.

In the layer of information extraction, data filtering and cleansing are the standard processes to all raw EIM data. They are implemented to obtain cleansed data free of redundancies and errors. As direct indicators do not require further processing, values of direct indicators can be obtained upon information extraction. Most direct indicators related to IPS<sup>2</sup> are used to monitor the situation of IPS<sup>2</sup> and to meet the requirements of the IPS<sup>2</sup> monitoring for top managers.

In the layer of information analysis, choices of method of data processing depend on the attributes of IPS<sup>2</sup>-indicators. For example the value of indicator “share of products and services in IPS<sup>2</sup>” can be obtained by simple statistical methods. The most important duties of information analysis are listed as follows:

- Calculation of values of indicators
- Comparison between actual values of indicators and their given values
- Comparison between actual values of indicators and

existing benchmarks (e.g. of competitors)

- Historical analysis of progresses
- Trends analysis of IPS<sup>2</sup> and IPS<sup>2</sup> processes

These methods of information analysis can process complex data of indicators and realize the function of IPS<sup>2</sup> analysis in the EIM module.

The layer of information supply provides methods of data visualization. The IPS<sup>2</sup>-reporting system is introduced to configure, create and display standard and individual reports, which top managers require. Here, a search/navigation portal can be realized based on processed IPS<sup>2</sup> data, to provide IPS<sup>2</sup> information according to the entered keywords.

## 5 THE IT STRUCTURE OF THE EIM MODULE FOR IPS<sup>2</sup> PROVIDERS

Figure 2 provides an overview of the IT structure of the EIM module, which is an extended part of IPS<sup>2</sup>-LM basic methods.

There are two types of data sources: structured data sources and unstructured data sources. They are defined as follows:

- Structured data sources

Sources for structured data are all sorts of database

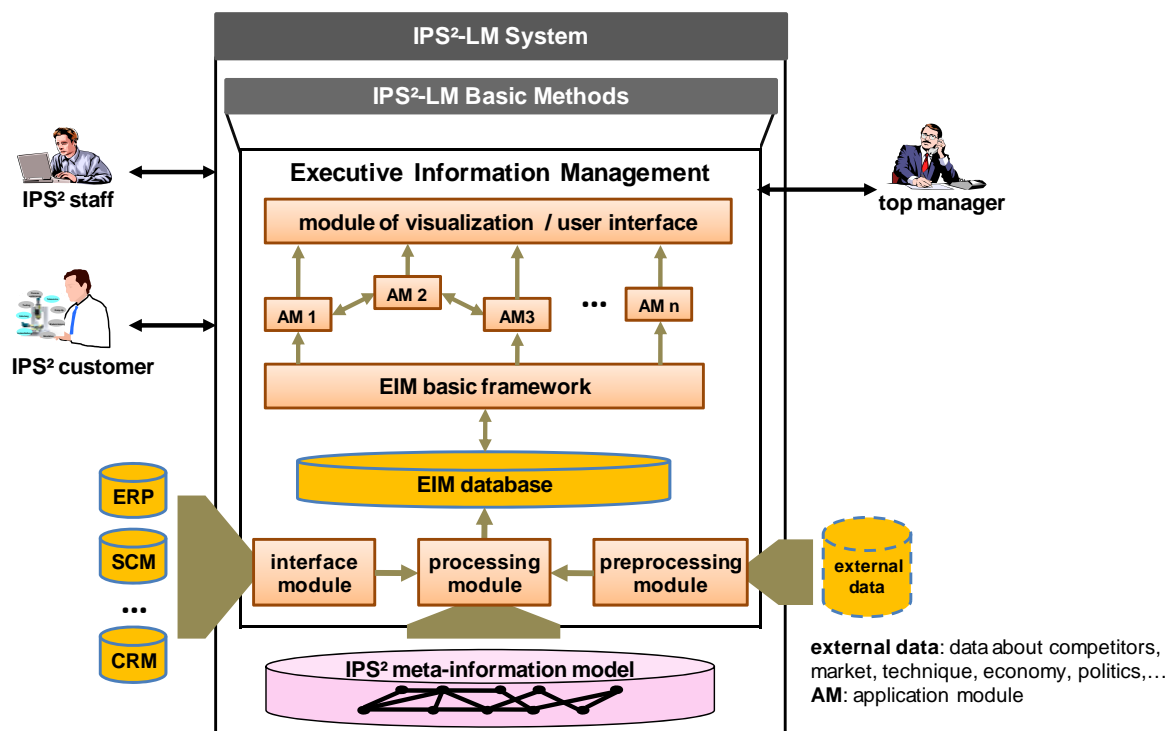


Figure 2: The IT structure of the EIM module for IPS<sup>2</sup> providers

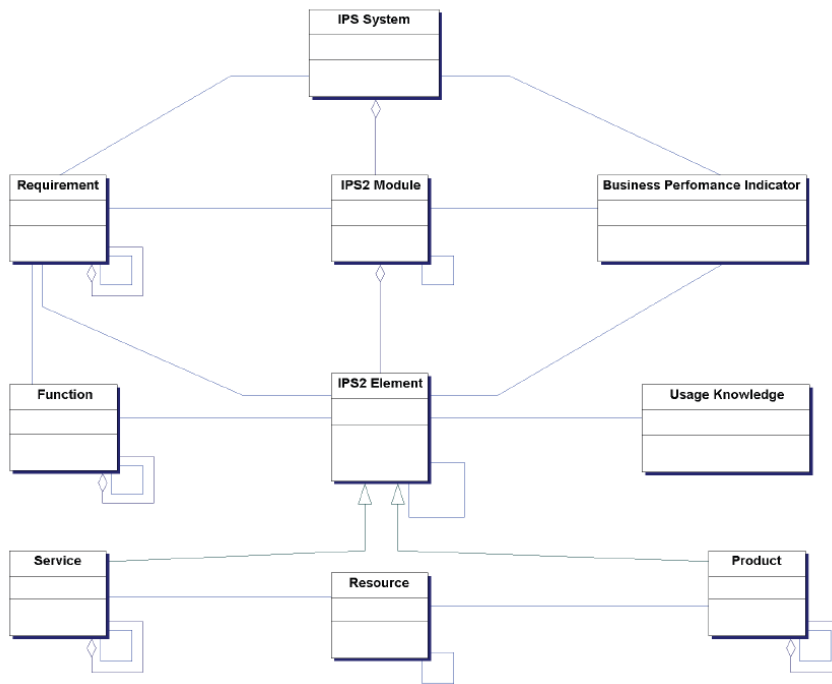


Figure 3: Top level of meta-information model for IPS<sup>2</sup> lifecycle management

systems in IPS<sup>2</sup> enterprises. Databases in IPS<sup>2</sup>-LM, ERP, CRM, etc. are all concrete sources. The extraction of data from concrete sources can be automatically implemented with the help of a special program. In the IT structure, interface modules are designed to process the data from these sources. While the EIM module is an extended part of IPS<sup>2</sup>-LM, data in the IPS<sup>2</sup> meta-information model can be processed directly without the need of an interface module.

- Unstructured data sources

Unstructured data sources exist inside or outside IPS<sup>2</sup> enterprises, but data are not stored in a database system. The process of gaining and handling such data is rather complex. Thus, a preprocessing module is designed to extract and preprocess the data semi-automatically or manually.

While data extracted from different sources have different formats, there are a lot of redundancies, errors, and gaps between them. Thus, the extracted data must be further processed and integrated. For that purpose, a processing module has been designed. The interface module, the preprocessing module and the processing module constitute the information extraction as introduced in chapter 4. After that, an EIM database was designed to store the extracted EIM data. The independent EIM database can highly contribute to the reuse of data and can increase the speed of data access.

In the software structure, the EIM system framework is used to access data in the EIM database and to manage all application modules. Application modules are designed to realize one or several IPS<sup>2</sup> indicators. Each application module can be adjusted, modified, added and deleted dynamically to meet the new requirements of IPS<sup>2</sup> indicators for top managers. On the other hand, an application module can be designed that is based on a different application module or that uses the results of other function application modules. The interface module is designed to realize the user-friendly interface and to visualize the result in property format. In general, the EIM software framework, all application modules and the module of visualization realize the function of information analysis and information supply.

User groups are another essential part of a system. Here, top managers constitute the most important user group, but there are other important user groups. They are IPS<sup>2</sup> staff (e.g. IPS<sup>2</sup> project managers, IPS<sup>2</sup> developers, IPS<sup>2</sup> service engineers) and IPS<sup>2</sup> customers. Although they have not enough authority to access the EIM module directly, they can access IPS<sup>2</sup>-LM with respective authorities. As a part of IPS<sup>2</sup>-LM, EIM module can exchange data with IPS<sup>2</sup>-LM seamlessly. So IPS<sup>2</sup> staff and customers can gain EIM data by the transport of IPS<sup>2</sup>-LM. Then the decisions made by top managers in EIM module can reach managers, IPS<sup>2</sup> developers and engineers in IPS<sup>2</sup> enterprise and also IPS<sup>2</sup>-customers via the IPS<sup>2</sup>-LM software.

## 6 META-INFORMATION MODEL FOR IPS<sup>2</sup> LIFECYCLE MANAGEMENT

Upon extensive research and empirical studies, most raw IPS<sup>2</sup>-related data are stored in the IPS<sup>2</sup> meta-information model, and required by most IPS<sup>2</sup>-related indicators. So IPS<sup>2</sup> meta-information model is very important to the EIM model and is introduced in this chapter.

For the lifecycle management of IPS<sup>2</sup> a meta-information model has been developed within the research project Transregio 29 "Industrial Product-Service Systems – Dynamic Interdependency of Product and Service in the Production Area". It is based on the UML (Unified Modelling Language) object-oriented notation. Figure 3 shows the top level structure of the IPS<sup>2</sup> meta-information model. In order to make the model more simple, obvious classes for data management and subclasses of each main class have been omitted.

Each IPS<sup>2</sup> is represented by the class IPS\_System, which consists of several IPS2\_Modules. In turn, IPS2\_Module is composed of different IPS2\_Elements, which may be Services or Products. The class IPS2\_Element is an abstract class that is never instantiated. In order to support the IPS<sup>2</sup> engineering process, a few classes are introduced: Resource, Function, Usage\_Knowledge, Business\_Performance\_indicators and Requirement. These five classes can be associated with individual IPS\_Systems, IPS2\_modules, Services, and Products. A

comprehensive description of IPS<sup>2</sup> classes and relations mapping in the meta-information model has already been presented in a previous paper [15].

## 7 CONCLUSIONS AND OUTLOOK

The new approach to the EIM module presented above is based on a variety of empirical studies that were conducted with several IPS<sup>2</sup> providers. In the EIM module, the IPS<sup>2</sup> metric system and data processing methods ensure the supply of executive information and its correctness. A dynamical system structure of the EIM module ensures sufficient flexibility to meet flexible information requirements of top managers. As a part of IPS<sup>2</sup>-LM system, it reduces the difficulty of developing the EIM module. The integration of the EIM module can extend the use range of the IPS<sup>2</sup>-LM system from engineers to top managers.

Though an EIM system can provide all IPS<sup>2</sup>-related information to top managers, other managerial tasks are not considered, e.g. HR management, strategic planning and investment. Fortunately, the dynamical IT structure ensures the extension of the EIM module. Other functions and information can be added and improved during its use phase. The ultimate goal is to develop a comprehensive IT environment for top managers in IPS<sup>2</sup> enterprises.

## 8 ACKNOWLEDGMENTS

We express our sincere thanks to Deutsche Forschungsgemeinschaft (German Research Foundation) for financing this research within the Collaborative Research Project SFB/TR29 on Industrial Product-Service Systems – dynamic interdependency of products and services in the production area.

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