International Journal of Innovative Research in Computer Science & Technology (IJIRCST)
ISSN: 2347-5552, Volume-10, Special Issue-12, December-2022
Innovative Projects 2022
Organized by Presidency University, Bangalore, India

A Brief Discussion on Functional Analysis and Allocation

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ABSTRACT:

A key component of systems engineering is functional analysis and allocation, which is essential for the creation and design of complex systems. It entails the methodical dissection of a system into its functional components and the distribution of these components or subsystems to distinct components or functions. The main ideas and advantages of functional analysis and allocation in systems engineering are summarised in this summary. The basic tenets of functional analysis are examined in the first section of this abstract. It talks about the process of defining and determining the tasks that a system must do in order to provide its intended function. To achieve a thorough grasp of the required functionality, this stage entails analysing the system's requirements, user demands, and operating situations. The distribution of functions among various system components or subsystems is the subject of the second section, which focuses on functional allocation. This procedure takes into account a number of variables, such as technological viability, performance specifications, cost effectiveness, and resource limitations. Reliability, maintainability, and safety issues may also be taken into consideration when allocating resources.

KEYWORDS:

Allocation, Functional Analysis, Functional Architecture, Interface Definition.

I. INTRODUCTION

Understanding a system's functional needs and assigning them to particular system components or subsystems is the goal of the crucial process known as functional analysis and allocation in the area of system engineering. It entails dividing up the larger, more complex system functions into smaller, more manageable parts and allocating accountability for carrying out those parts. Functional analysis and allocation's main objective is to make sure that all required system functions are recognised, accurately specified, and assigned to the right components or subsystems. Through this approach, a comprehensive knowledge of the system's functionality and the interactions between its many parts is established. In systems engineering, efficient functional analysis and allocation have various advantages. In the beginning, it promotes system comprehension and aids in stakeholders' knowledge of the capabilities and behaviour of the system. Engineers may find essential dependencies and possible bottlenecks by breaking the system down into functions and assigning them, which results in more robust designs [1], [2].

The following essential phases are frequently included in the functional analysis and allocation process:

Functional Analysis: System engineers conduct this stage to identify and specify the precise functions that the system must carry out based on their analysis of the overall system goals and requirements. To make sure that all pertinent functions are taken into account and accurately documented, this analysis is often conducted in partnership with stakeholders [3], [4].

Functional Decomposition: The next step is to decompose the discovered functions into more manageable, more compact sub-functions. The duties are further divided until they may be assigned to certain parts or systems. The size and complexity of the system under examination determine the degree of decomposition.

Functional Allocation: Following decomposition, the functions are assigned to the correct system components or subsystems. To guarantee that the assigned duties can be carried out successfully and efficiently, this allocation process takes into account elements like the capabilities, traits, and limitations of each component or subsystem [5], [6].

Interface Definition: Definition of the interfaces between the functions assigned and the parts or systems in charge of carrying them out is a part of functional analysis and allocation. For successful communication and coordination between various system parts, well-defined interfaces are crucial.

Verification and Validation: Throughout the functional analysis and allocation process, actions are carried out to make sure that the functions assigned are in line with the goals and needs of the system. This entails determining if the functions assigned are realisable, traceable, and consistent with stakeholder expectations.

System engineers may acquire a thorough knowledge of the functions of the system and how they are allocated across its components or subsystems by doing functional analysis and allocation. This method offers a clear roadmap for assigning roles and ensuring that all functional criteria are satisfied, which supports efficient system design, development, and integration [7], [8].

Effective resource allocation, risk management, and trade-off analysis are also made possible by functional analysis and allocation. System engineers may discover possible bottlenecks, conflicts, or redundancies early in the system development process by explicitly describing and assigning functions. They can then use this information to make choices that will optimise system performance. In a nutshell functional analysis and allocation is a crucial step in system engineering that makes that system functions are clearly defined, broken down, and assigned. By offering a systematic method to comprehend and distribute functional needs across system components or subsystems, it serves as a basis for efficient system design, integration, and development.

II. DISCUSSION

The goal of this systems engineering process activity is to convert the functional, performance, interface, and other requirements that were discovered through requirements analysis into a cogent description of system functions that can serve as a roadmap for the upcoming Design Synthesis activity. The designer must understand what the system must do, how effectively it must accomplish it, and what limitations will restrict design freedom [9], [10].

Functions are organised logically, higher-level functions are broken down into lower-level functions, and performance is distributed across higher- and lower-level functions to achieve this. Functional flow block diagrams and timeline analysis are some of the techniques that were utilised, and the end result is a functional architecture, which is a description of the system that is expressed in terms of its functions and performance metrics rather than in terms of its physical structure. Traceability from requirements to the solution descriptions that result from Design Synthesis is made easier by Functional Analysis and Allocation.

Functions are specific activities (use action verbs) required to carry out the goals of the system. These functions might either be directly specified or inferred from the criteria. In the end, the tasks will be carried out or completed with the aid of tools, persons, resources, infrastructure, software, or a combination of these.

Analysis and Allocation of Functional Data

Higher-level requirements serve as the foundation for developing functional and performance requirements at any level in the system. Architectures are defined at ever-higher degrees of complexity by repeatedly doing functional analysis and allocation to specify increasingly lower-level functional and performance requirements. To assist the integrated system design, system requirements are assigned and described in sufficient depth to offer design and verification criteria.

This top-down method of converting system-level specifications into specific functional and performance design standards entails:

1. Outlining the system's functional components before breaking down the main functions into smaller ones. Identifying the system's required activities at progressively lower levels,
2. Converting more specific functional and performance design criteria or restrictions from higher-level performance needs. Specifically, determining the performance standards for the required functions,
3. Determining and specifying all functional interfaces, both internal and external.
4. locating functional groups to reduce and regulate interactions (functional partitioning);
5. Determining the functional properties of the system's directed or existing components and applying those properties into the analysis and allocation;
6. Analysing every aspect of the life cycle, including the eight fundamental functions, as necessary for the particular project;
7. Carrying out trade studies to identify alternate functional ways to satisfy requirements, and

8. Returning to the requirements analysis stage as required to address functional concerns.

Functional Segmentation

The technique of grouping functions that logically match with the components most likely to be utilised and minimising functional interfaces is known as functional partitioning. Part of functional decomposition involves partitioning. It finds logical clusters of operations that make it easier to employ modular parts and open-system architectures. Understanding how current machinery or components, especially commercial ones, will operate with or inside the system is another benefit of functional partitioning.

Requirements Loop

It is anticipated that a review of the requirements analysis process will be required throughout the functional analysis and allocation phase. The reason for this is the appearance of functional problems that need reexamining the higher-level requirements. The discovery of a new approach to functional sequencing, directed components or standards that produce functional conflict, or—most likely a conflict brought on by requirements that are incompatible with one another are examples of such problems.

The fundamental elements of Functional Analysis and Allocation are shown in Figure 1. The method results in a functional architecture. The functional architecture may be thought of as a straightforward hierarchical breakdown of the functions and their corresponding performance requirements. With the execution of the tasks shown in Figure 1, the functional architecture is developed and made more particular, increasing its level of detail and comprehensiveness. These actions provide a practical architecture with enough specifics to back up the Design Synthesis. Traditional tools that organise the activity and offer documentation for traceability are used to carry them out. There are various tools at your disposal. Traditional tools that depict and describe the main responsibilities of Functional Analysis and Allocation include the following:

1. Functional flow block diagrams that depict the links and sequences of tasks,
2. IDEF0 flowcharts that show how processes and data flow,
3. Timeline analyses that specify the order in which time-sensitive tasks must be performed; and
4. Performance requirement allocation papers that list assigned performance and provide performance requirement tracability.

Functional Architecture

The functional architecture is a top-down breakdown of the performance and functional needs of the system. The architecture will outline not only the necessary functions but also their logical order as well as the performance specifications for each function. It also contains a functional description of the system's available and supplied by the government items.

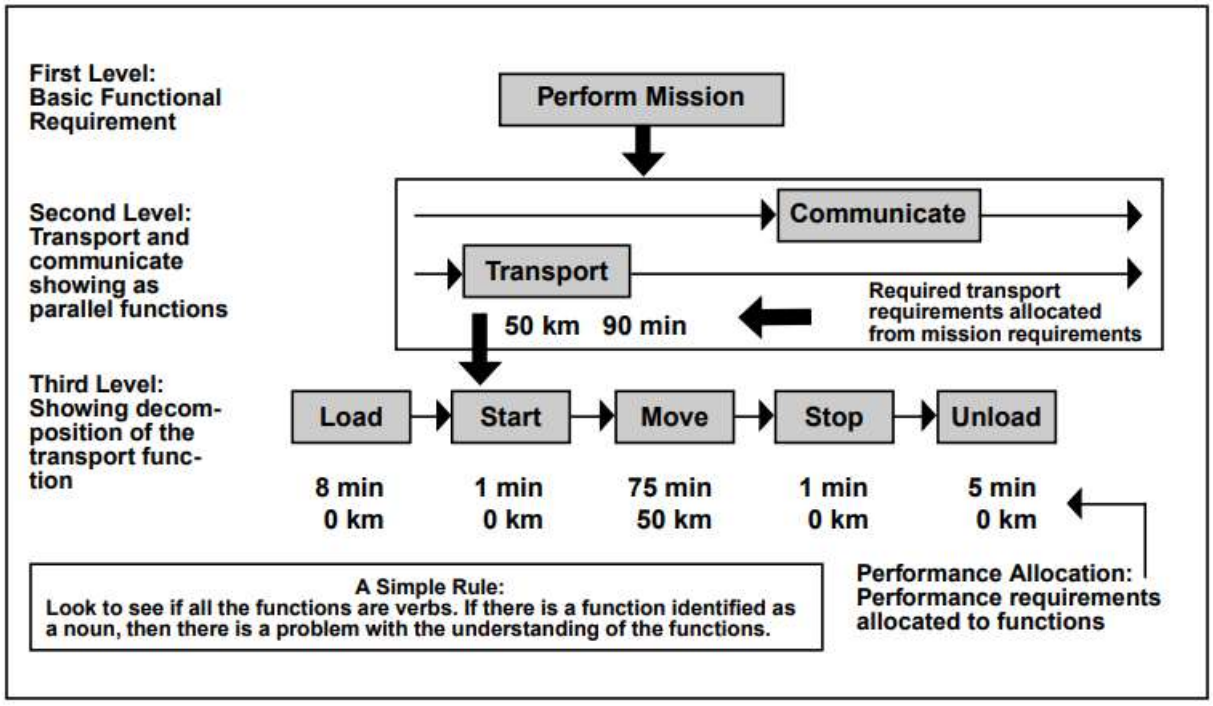

Figure 2: Functional Architecture Example.

Reverse engineering of these existing components could be necessary for this. The comprehensive bundle of documentation created to analyse the functions and assign performance needs is known as the functional architecture, which is the result of the Functional Analysis and Allocation process. It contains all additional documentation created to define the functional features of the system, such as timeline sheets, requirements allocation sheets, IDEF0 diagrams, and functional flow block diagrams. However, the functional design has a fundamental logic that is shown in a rudimentary form in the example of Figure 2. The IPT would typically draw such a simple version of the architecture as the first step in the Functional Analysis and Allocation procedure. The IPT would normally get a grasp of the effort's scope and direction as a result.

Example of a Functional Architecture

The Marine Corps is required to move soldiers across a 50-kilometer radius in squad-level formations. Within 90 minutes of the transport system's arrival, troops must be moved. During the transfer of soldiers, continuous contact is necessary. An initial functional design for this straightforward need is shown in Figure 2.

The results of requirements analysis, or the discovery of higher-level functional and performance requirements, serve as the starting point for functional analysis. Decomposing higher-level functions into lower-level components and then allocating requirements to those components make up functional analysis and allocation.

1. A variety of tools, including functional-flow block diagrams, timeline analysis sheets, needs allocation sheets, integrated definition, and others, are available to facilitate the creation of a functional architecture.
2. Although using the instruments shown in this chapter is not required, the method they stand for is:
   a. Establish task linkages and sequences (functional flow block diagram (FFBD)),
   b. Describe data and process flows using IDEF0 diagrams.
   c. Establish the timeline analysis sheets (TLS) for time-critical tasks, and
   d. Assign performance and create a system for tracking performance needs (requirements allocation sheets, or RAS).

A popular modelling method for the study, development, re-engineering, and integration of information systems, business processes, or software engineering analysis is called Integration Definition for Function Modelling (IDEF0). IDEF0 is used to depict data flow, system control, and the functional flow of life cycle processes, while FFBD is used to depict the functional flow of a product. A broad range of commercial, manufacturing, and other sorts of company processes may be visually represented using IDEF0 at any degree of detail. It encourages uniformity in use and interpretation and offers thorough and accurate explanation. The government and commercial sector have used it for many years, putting it to the test and proving its viability. It may be produced using a range of computer graphics programmes. There are several commercial solutions that are designed to help the creation and study of IDEF0 diagrams and models.

III. CONCLUSION

In summary, system engineering's functional analysis and allocation process is essential to the effective design and implementation of complex systems. Functional analysis and allocation provide an organised method for comprehending and meeting the functional needs of a system by decomposing the overall system functions and allocating them to particular components or subsystems. System engineers may identify and specify the precise activities that the system must carry out via functional analysis, ensuring a thorough grasp of the operational goals of the system. This analysis aids in identifying all pertinent functionalities and creating a solid framework for further design and development work. The process of functional allocation makes ensuring that the right components or subsystems are given the right functions. This method allows for the efficient and effective use of resources since it takes into account things like each component's capabilities, traits, and limitations. Functional allocation enables the coordination and integration of system components by delegating responsibility for certain tasks, allowing the overall system to carry out its intended activities.

The functional analysis and allocation procedure also highlights how crucial interface specification is. System engineers make ensuring that there is effective communication, coordination, and cooperation between the various system pieces by establishing the interfaces between functions and components. This encourages seamless integration and interoperability, which eventually results in a coordinated and peaceful system. Furthermore, functional analysis and allocation make it possible to confirm and validate the functional needs of the system. System engineers may make sure that the assigned functions are in line with the system requirements by conducting thorough verification and validation procedures and correcting any inconsistencies or gaps that

may occur. In the end, functional analysis and allocation provide a methodical way to comprehending, assigning, and managing a system's functional needs. System engineers may optimise system performance, improve resource utilisation, reduce hazards, and accomplish the intended functions by following this approach. As essential building blocks in the system engineering process, functional analysis and allocation set the groundwork for later design, integration, and realisation tasks.

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