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За зміст статті відповідальні автори.

Редакційна колегія

С.О. Шейко, *к.т.н., доц.,* ХНУРЕ, Україна (головний редактор)
В.М. Безрук*, д.т.н., проф.,* ХНУРЕ, Україна
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О.М. Цимбал, *д.т.н., проф.,* ХНУРЕ, Україна

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.

Відповідальні за випуск: *С.О. Шейко, канд. техн. наук, доц., І.Д. Горбенко, д-р техн. наук, проф.*
Технічний секретар: *О.С. Полякова.*

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O. PLOKHA, Ph.D, D. HOLUBNYCHYI, Ph.D, L. ZNAKHUR

MODELLING OF AN IT ENTERPRISE MANAGEMENT INFORMATION SYSTEM: CONCEPTUAL FOUNDATIONS AND STRUCTURAL-FUNCTIONAL MODEL

Introduction

In the current context of globalisation and the accelerated transition to Industry 4.0, the information technology (IT) sector is the main driver of the digital transformation of the economy [1]. According to Gartner (2023), based on a survey of chief executive officers regarding the effectiveness of internal processes, the proportion of companies that recognise the inadequacy of their own internal management tools stands at 67 % [2]. At the same time, IT enterprises themselves operate in a highly dynamic, stochastic environment characterised by a high level of uncertainty and dependence on intellectual capital [3]. Research into management practices in the IT sector reveals a certain paradox: whilst developing high-tech solutions for external clients, the internal business processes of many IT companies often remain fragmented, decentralised and based on heuristic approaches to management [4]. A study by McKinsey (2022) confirms that up to 70 % of medium-sized IT companies simultaneously use between 5 and 12 unconnected management tools, giving rise to the so-called ‘system zoo’ phenomenon and leading to losses in operational efficiency of up to 20–30 % [5].

Under such conditions, the implementation of integrated management information systems (MIS) becomes an objective necessity for ensuring the viability and competitiveness of the enterprise.

The purpose of this paper is to develop a structural and functional model of an integrated management information system (MIS) for an IT enterprise, based on the principle of functional completeness of the system and aimed at eliminating the fragmentation of business processes. To achieve this aim, the following tasks are addressed:

To conduct a systematic review of existing frameworks and identify their limitations with regard to the comprehensive management of an IT enterprise.

To formalise and operationalise the principle of functional completeness of the system as a key architectural criterion.

To develop a structural-functional model of the MIS with a formal description of inter-system relationships.

Identify the conditions for application, limitations and directions for the further development of the model.

1. Research analysis

The conceptual foundations for the design of management information systems (MIS) were laid in classical works on organisational theory and systems analysis. Henri Fayol [6] formulated a five-function model of management (planning, organising, motivating, controlling and coordinating), which still serves as the theoretical basis for most management structures.

Subsequently, W. Edwards Deming [7] developed this approach into a cyclical model of continuous improvement (PDCA), which has now been adapted in the Agile and DevOps methodologies. The design of Management Information Systems (MIS) for organisations is also discussed in the works of Henry Mintzberg [8], who classified organisational configurations and defined the role of information systems in providing coordination mechanisms. Research by Thomas Davenport [9] and Daniel O’Leary [10] laid the foundations for understanding ERP systems as integrating platforms.

In Ukrainian academic literature, the management of IT enterprises is examined in the works of V.S. Ponomarenko [11], N.I. Klymova [12] and other researchers. However, a comprehensive approach to MIS modelling, specifically designed for the IT industry, remains underdeveloped.

A comparative analysis of leading industry frameworks (ITIL v4, COBIT 2019, SAFe 6.0, PMBoK 7) and corporate platforms (ERP, PSA) has enabled us to quantitatively confirm significant functional gaps in existing approaches [13–15]. To ensure the model's formal scientific rigour, a method for the formal description of inter-system relationships was applied.

2. Presentation of the main material and substantiation of the obtained research results

To gain a structured understanding of the 'blind spots' in existing approaches and platforms, a comparative analysis of leading frameworks was conducted, calculating the Functional Completeness Index (FCI).

The principle of functional completeness is traditionally formulated descriptively [16]. This study proposes its operationalisation via the FCI, which is a normalised quantitative metric that measures what proportion of a reference (ideal) management system is covered by a particular framework, platform or developed MIS.

Unlike qualitative expert assessments, the FCI ensures the reproducibility and comparability of results, which is a prerequisite for the informed selection of architectural solutions.

The index is calculated as the ratio of the sum of the actual scores across all criteria to the total number of evaluation criteria:

$$FCI = \frac{\sum_{i=1}^{n} F_i}{w}$$

where Fi – represents the implementation rating for the *i-th* criterion, discretely rated as {0; 0.5; 1.0}; w – the total number of evaluation criteria (w=9 in the base version of the model); $FCI \in [0;1]$, where 0 indicates a complete lack of functionality, 0.5 indicates partial coverage, and 1 indicates full coverage of all criteria.

To interpret the obtained FCI values, it is proposed to use the following threshold scale: with FCI ≥ 0.85, the system is characterized by high functional completeness and is ready for implementation; the range of 0.70–0.84 indicates an acceptable level of completeness that requires refinement of individual modules; values within 0.50–0.69 indicate critical gaps that require significant expansion of the functionality; finally, FCI < 0.50 indicates functional incompleteness of the system and the need for its conceptual rethinking.

The comparative analysis of existing IT management systems is presented in Table 1.

Table 1

Comparative analysis of existing IT department management systems

Evaluation criterion	ITIL v4	COBIT 2019	SAFe 6.0	PMBOK 7	ERP (SAP/Oracle)	PSA (Kantata)
SDLC Management	Partially	Absent	Fully	Partially	Absent	Partially
Project Financial Accounting	Absent	Absent	Absent	Partially	Fully	Fully
Human Capital Management	Absent	Absent	Partially	Absent	Partially	Partially
Strategic Planning	Absent	Fully	Partially	Absent	Partially	Absent
Risk Management	Partially	Fully	Partially	Fully	Absent	Absent
BI & Analytics	Absent	Partially	Absent	Absent	Fully	Partially
Marketing Management	Absent	Absent	Absent	Absent	Partially	Absent
Security Management	Fully	Fully	Absent	Absent	Partially	Absent
IT Industry Specifics	High	High	High	Medium	Low	High
Functional Completeness Index (FCI)	0.41	0.38	0.44	0.39	0.52	0.56

The analysis of the table 1 clearly shows that none of the existing frameworks achieves a coverage ratio exceeding 56 %. This quantitatively confirms the existence of «gaps» in existing approaches and justifies the need for an integrated model.

At the same time, it should be emphasised that the basic formula has an inherent methodological limitation: it assumes a priori that all nine criteria are of equal value in terms of their strategic management impact, which does not always correspond to the actual priorities of a particular organisation.

Thus, for an IT outsourcing company, managing the full software development life cycle (SDLC) is strategically far more critical than managing marketing, whereas for a product-based IT company or a SaaS platform, these priorities will differ significantly. Ignoring this differentiation can lead to distorted evaluation results: a system with well-developed but secondary functionality will receive an artificially inflated FCI compared to a system that effectively covers critically important but narrow areas of management.

Given this limitation, a promising direction for the development of the proposed metric is the transition to a weighted version of the FCI, which involves introducing individual weighting coefficients wi for each criterion:

$$FCI_{weighted} = \frac{\sum_{i=1}^{n} w_i \cdot F_i}{\sum_{i=1}^{n} w_i}, \quad where \sum_{i=1}^{n} w_i = 1$$

The weighting coefficients wi are calibrated using expert assessment (in particular, the Delphi method), taking into account the type of IT enterprise (outsourcing, product-based, SaaS, start-up) and its strategic priorities.

The phenomenon of fragmented management tools has been studied in the works of J. Ross [13] and P. Weil [14]. A typical medium-sized IT company (50–200 employees) uses a vast stack of unrelated tools (Fig. 1).

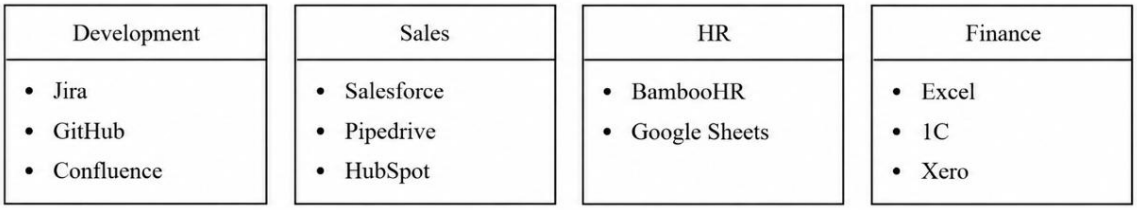


Fig. 1. Typical architecture of a «systems zoo» in an IT company

This architectural approach gives rise to several significant organizational and management problems, which adversely affect the effectiveness and reliability of an IT company.

Data duplication and inconsistency. Using several independent information systems often requires the same data to be entered manually into multiple applications. For example, information about customers, staff, projects, financial transactions or operational activities may exist simultaneously in project management systems, CRM platforms, spreadsheets, accounting applications and other specialised tools. Such duplication increases staff workload and creates the risk that different systems will contain different versions of the same information. As a result, the organisation may lack a single, consistent source of data, which reduces the reliability of analysis results and complicates the preparation of management reports.

Delays in management decision-making. When information is spread across disparate and poorly integrated systems, consolidating it often requires additional manual work. Analysts and managers must gather data from different applications, resolve discrepancies, convert the information into a common format and prepare summary reports. This process is time-consuming and makes decision-making dependent on the availability and workload of individual staff members.

Increased information security risks. The use of numerous independent and inadequately controlled digital tools expands a company's information security perimeter. Confidential corporate information may be copied, transferred or stored in applications that have not been formally approved, assessed or integrated into the enterprise's security architecture. This creates additional risks associated with unauthorized access, accidental disclosure, loss of information, inadequate access controls and inconsistent data protection mechanisms.

The emergence of «shadow IT». Fragmentation of the IT environment may prompt employees to independently select and use digital tools that are not officially authorized by the organization. Such practices, commonly referred to as shadow IT, arise when existing corporate systems do not adequately support employees' operational needs or when alternative applications are perceived as more convenient and effective. According to a source cited in [15], up to 42 % of employees at IT companies use unauthorized tools to carry out their work tasks. Although such tools may temporarily boost individual productivity, their uncontrolled use can lead to duplication of functionality, fragmentation of data storage, security vulnerabilities, difficulties in auditing information flows, and additional support costs.

To address these issues, an architectural approach is proposed, based on the fundamental principles of systems theory, in particular the principle of functional completeness of a system. According to this principle, a system must contain all the elements necessary to perform its intended functions, whilst avoiding unnecessary or redundant components. In other words, every structural element of the system must have a clearly defined functional purpose and contribute to the achievement of the system's overall objective.

If a significant element is removed, the system loses part of its functional capabilities and may no longer fulfil its intended purpose. A structural-functional analysis allows the composition of each subsystem to be described and its functions to be defined (Fig. 2).

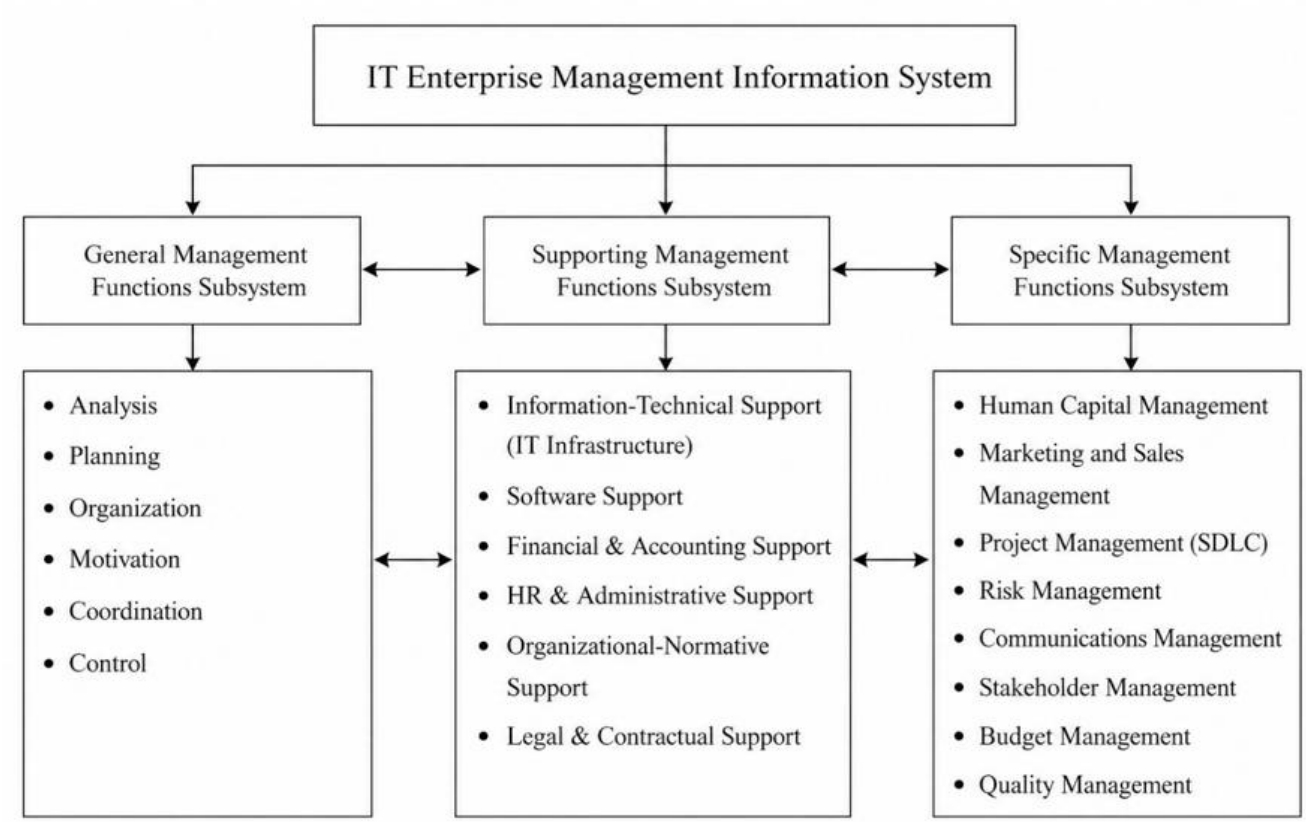


Fig. 2. Structural-functional model of an IT enterprise management information system

A detailed description of each subsystem is provided in Tables 2–4.

The general management functions subsystem reflects the classic management cycle (Deming/PDCA) [7], adapted to the rapid pace of development in the IT industry, ensuring the continuity of company management (Table 2).

Table 2

Detailed description of general management functions

Function	General Content	IT-Specific Features	Implementation Tools
Analysis	Data collection and evaluation	Analysis of team velocity, technical debt, and labor market trends	SWOT, Burndown charts, Competitor Analysis
Planning	Setting objectives and paths to achieve them	Product roadmaps, sprint planning, and resource capacity planning	OKRs, Gantt charts, Sprint Planning, Capacity Planning
Organization	Structuring and role allocation	Forming cross-functional teams, defining boundaries of responsibility	RACI matrices, Org Charts, Team Topologies
Motivation	Stimulating goal achievement	Preventing burnout, grading systems, and career development	KPI bonuses, stock options, Individual Development Plans
Control	Verifying compliance with plans	Code quality control, deadline compliance, and financial monitoring	SonarQube, Jira, Tempo, Budget dashboards
Coordination	Synchronizing inter-departmental actions	Aligning development teams, sales, and technical support	Daily Stand-ups, Scrum of Scrums, Confluence

The management functions support subsystem provides the technical, operational and legal framework without which automation and effective management are impossible (Table 3).

Table 3

Detailed description of support management functions

Function	General Content	Implementation Tools	Responsible Role
Information Technology (IT Infrastructure) Support	Hardware resources, cloud platforms, networks	AWS / Azure / GCP, Helpdesk (Zendesk)	IT Operations Manager
Software Support	OS, IDE, DBMS, version control systems, CI/CD	GitHub / GitLab, Jenkins, Docker	DevOps Engineer
Financial & Accounting Support	Bookkeeping, Cash Flow, taxes	1C, Xero, QuickBooks	CFO / Chief Accountant
HR & Administrative Support	Employee database, leave tracking, recruiting (infrastructure)	HRM (BambooHR, Workday), ATS (Greenhouse)	HR Director
Organizational & Regulatory	Regulations, security standards, NDA, corporate policies	ISO 27001, SOC 2, Internal Wiki	CISO / Legal
Legal & Contractual Support	Client contracts, software licenses, IP law	CLM systems (ContractPodAi), legal support	General Counsel

The specific management functions subsystem covers specialised business domains that are critical to the success of an IT company in the market (Table 4).

Table 4

Detailed description of specific management functions

Function	General Content	Key Processes	Tools
Project Management (SDLC)	Full-cycle management: presales → development → release → support	Sprint Planning, Release Management, Post-mortem	Jira, Azure DevOps, Linear
Budget Management	Cost calculation, margin control under T&M / Fixed Price / Dedicated Team models	Timesheet validation, Invoice generation, P&L per project	Harvest, Toggl, Kantata
Risk Management	Technical risks (tech debt, dependencies) and business risks (scope creep, client churn)	Risk Register, Mitigation Planning, Risk Review	Jira Risk Board, Monte Carlo simulation
Communications Management	Internal (cross-team) and external (client-facing) communications	Status Reports, Client Demo, Escalation Process	Slack, Zoom, Loom, Notion
Stakeholder Management	Managing relations with clients, investors, executive management, and end-users	Stakeholder Map, Expectation Alignment, Executive Reviews	Salesforce, HubSpot, Miro
Human Capital Management	Attraction, development, and retention of engineering talent	Performance Review, Skills Matrix, Career Path, Burnout Prevention	Lattice, 15Five, LinkedIn Talent
Marketing & Sales Management	Lead generation, employer branding, sales pipeline management	Lead Generation, Employer Branding, Presale Process	HubSpot CRM, LinkedIn, Google Analytics
Quality Management	Quality assurance across all SDLC stage	Test Planning, Automated Testing, Code Review	Selenium, TestRail, SonarQube

Based on classical methodological approaches to the design of organizational and economic systems [17, 18], the proposed methodology structures the development of an MIS into 5 sequential and interrelated stages. Each stage is characterized by clearly defined inputs, expected outcomes and formal transition criteria, ensuring methodological consistency, traceability and completeness throughout the entire design process.

Stage 1. Defining the MIS architecture and structural configuration.

Inputs: Strategic business objectives and the results of the analysis of the organizational structure and «As-Is» processes.

Outputs: The conceptual MIS architecture and corresponding data flow diagrams.

Pass criterion: Formal approval of the proposed architecture by all key stakeholders, confirming its alignment with organizational objectives and business requirements.

Stage 2. Decomposition into general and supporting subsystems.

Inputs: Approved conceptual architecture and business process register.

Output: A detailed structural decomposition of the MIS into general and auxiliary subsystems, presented in Tables 2-4.

Pass criterion: The structure of the subsystems complies with the mutually exclusive and collectively exhaustive principle, ensuring that the functions of the subsystems are neither duplicated nor omitted.

Stage 3. Allocation of functions and organizational responsibilities.

Inputs: The defined subsystem structures and the enterprise's organizational structure.

Outputs: A RACI matrix defining the allocation of responsibilities, as well as the corresponding access rights and functional authorizations within the IS.

Pass criterion: Every identified function and process must have a clearly designated responsible owner, whilst no organizational role must remain unassigned or functionally ambiguous.

Stage 4. Verification of functional completeness.

Inputs: The RACI matrix and the baseline functional register.

Outputs: The calculated FCI and a documented set of identified functional gaps requiring rectification.

Pass criterion: The developed MIS must achieve a minimum FCI value of ≥ 0.85. If this threshold is not met, an approved corrective action plan aimed at addressing the identified functional gaps must be developed before proceeding to the implementation phase.

Stage 5. Implementation as part of the digital transformation strategy.

Inputs: A validated MIS model, an approved budget and defined technical specifications.

Outputs: A deployed, integrated and operational IMS environment that aligns with the organization's digital transformation objectives.

Pass criterion: Successful implementation is confirmed by achieving a target FCI ≥ 0.90, demonstrating a high degree of functional coverage and alignment between the implemented IS and the organization's operational requirements.

The proposed five-stage sequence ensures a controlled transition from strategic and organizational analysis to system architecture, functional decomposition, allocation of responsibilities, verification and implementation. The use of clear transition criteria at each stage provides a quality control mechanism and prevents structural, functional or organizational shortcomings from carrying over into subsequent stages of IS development.

Conclusions

A systematic comparative analysis of leading industry frameworks (ITIL, COBIT, SAFe, PMBOK) and ERP/PSA platforms shows that none of them achieves an FCI higher than 0.56 relative to the complete register of an IT enterprise's management needs. This quantitatively confirms the existence of a systemic «information gap» and justifies the need for an integrated model.

A formalised Functional Completeness Index (FCI) is proposed as a measurable criterion for verifying developed ISUs. Establishing threshold values for different types of IT enterprises allows a shift from subjective assessments to quantitatively justified architectural solutions.

The 5-stage model for developing MIS provides a repeatable, structured methodological path from conceptual design to deployment, with clearly defined input, output and control criteria.

Limitations of the model: 1) dynamic environment: the model represents a static snapshot at the time of design. It requires regular audits and reviews every 12–18 months to adapt to rapid market changes; 2) the human factor: a mathematically and structurally sound model does not guarantee successful implementation. Organisational culture and change management remain critically important and lie outside the technical scope of system design.

Prospects for further research: 1) development of a dynamic version of the model with mechanisms for automatically recalculating weighting coefficients and the FCI when strategic objectives change; 2) empirical testing of the model on a sample of 20–30 Ukrainian IT companies to compare operational indicators before and after the implementation of a management information system (MIS); 3) exploring the possibilities of integrating generative AI components to automate analysis and forecasting functions within the management information system (MIS); 4) adapting sector-specific profiles of the model for specialised IT sub-sectors, such as cybersecurity, educational technology and financial technology.

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Відомості про авторів:
Плоха Олена Борисівна – канд. екон. наук, доцент, Харківський національний економічний університет імені Семена Кузнеця, доцент кафедри інформаційних систем; Україна; e-mail: olena.plokha@hneu.net; ORCID: https://orcid.org/0009-0004-4789-9858
Голубничий Дмитро Юрійович – канд. техн. наук, доцент, АТ "Інститут Інформаційних Технологій", Харківський національний економічний університет імені Семена Кузнеця, Україна; e-mail: dmytro.holubnychyi@hneu.net; ORCID: https://orcid.org/0000-0002-6873-7004
Знахур Людмила Володимирівна – старший викладач кафедри інформаційних систем; Харківський національний економічний університет імені Семена Кузнеця; Україна; e-mail: liudmyla.znakhur@hneu.net; ORCID: https://orcid.org/0000-0002-0043-5050

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