Goal-Oriented Metropolis Ecosystem Development

Małgorzata Pańkowska
University of Economics in Katowice, Poland
pank@ue.katowice.pl

Enterprise architecture (EA) modelling is understood as a system of architecture defined in ISO42010 and EA is intended to ensure a holistic view of business organization. This study analyses the goal-oriented approach to EA development. Justification of selection of this topic results from studies on EA modelling methods. Enterprise architects mainly focus on process modelling as well as on the application of UML language. There is still an open question of what the goals of EA modelling are. This paper presents an application of ArchiMate language and i* notation for goal-oriented EA modelling. The paper methodology covers a literature survey as well as a case study presenting ArchiMate and i* models for goal-oriented EA development by example of metropolis system architecture modelling. In this paper, a metropolis is defined as a consortium of cooperative communities and it is considered as a business organization for which the system architecture is modelled. The paper aims to develop the metropolis architecture model consisting of system components, i.e. business issues, data, software and hardware. The metropolis architecture models are provided to support development of a metropolis strategy. The main findings include the identification of business goals and EA goals, goal mapping, and specification of the key performance indicators (KPIS) to control the achievement of the goals.

Keywords: Enterprise Architecture, ArchiMate, i* language, metropolis, Key Performance Indicators
JEL Classification: M15, D83, M381,

Received 2022/11/07 · Revised 2022/12/25 · Accepted 2022/12/27
Published online 2024/03/31 https://doi.org/10.26493/1854-6935.22.5-26

Introduction

Opportunities for the creation of special-goal business organizations increase with Information Technology (IT) development and with economics, political, and social differentiation. Organizations are shaped by the contexts in which they are established. Thus, contemporary organizations reflect the impact of their historical origins in

local or regional communities characterized by growing profitability and competition over the control and distribution of resources. In this paper, business organization is identified with enterprise. However, in some sense, this interpretation is a metaphor. The author does not consider the economic aspects of enterprise existence, but focuses on enterprise structure, resources, requirements, actors, information systems, and ICT networks and devices. In this sense, enterprise architecture is a formal look available to general managers working on the continuous transformations that are necessary to their business. Commonly, architecture is the synergy of art and science for the design of complex structures, such as buildings, houses, roads, or bridges. In this study, enterprise architecture is a practice to design and control an enterprise's structure, processes, applications, information systems and technology. ArchiMate is a language for expression of all of these issues. Firstly, Enterprise Architecture (EA) has been developed for controlled implementation of information communication technology (ICT) and adequately addressing identified requirements (Desfray and Raymond 2014). However, EA is also useful for controlling the management of business organization, implementation of regulations and processes, as well as for internal auditing support.

In this paper, the author will discuss goal-orientation of enterprises, not just enterprise theory. Enterprises are fascinating social units, of many shapes and sizes, but some of their important characteristics are overlooked by the field of enterprise architecture studies. Enterprise architecture researchers have done an excellent job in explaining how IT is aligned with business resources in organizations, but not how organizations came to be that way. In this study, the research gap concerns EA goals identification and modelling with the i* tool for business organization (i.e. metropolis) strategic management. Hence, this study objective is the identification of Metropolis 5.0 enterprise architecture goals and their structuring. The author aims to write about the emergence of enterprise architecture by example of the metropolis, not just its existence. Although EA models are analysed for strategic management support, high quality enterprise architecture should provide opportunities to translate business strategy goals into goals and operations of ICT implementation, deployment, and management. There are many interests, and connected with them are stakeholders, principles, roles and rules steering the daily operations of EA planning. The multi-

plicity of EA frameworks does not make the work easier, because there is a lack of universal patterns and EA practitioners provide their own separate approaches to EA development. However, they agree that the EA model should consist of the business, information, software and infrastructure perspectives (Salmans and Kappelman 2010; Fischer, Winter, and Aier 2010; Zachman 2010). They emphasize that EA enables business and IT alignment, as well as ICT governance and ICT management alignment. The author of this paper, as a follower of ArchiMate modelling, has highlighted specific aspects of EA development in earlier work (Pańkowska and Sołtysik-Piorunkiewicz 2022), which concerns ICT modelling for sustainable development of the metropolis ecosystem.

This study's purpose is to outline the process of modelling EA in the ArchiMate language, identification of goals, and their diagramming in i* language in a case study to reveal a pragmatic application of Key Performance Indicators (KPIS) in EA and to present how these specifications and applications expand the EA model itself. The findings of this study are useful to both IT people and practitioners, i.e. managers at regional governmental institutions, in specification of strategic goals and in passing information from business people to IT professionals and back in an iterative negotiating process on what they expect of future work. This paper encourages practitioners to invest more in project goals identification and proper acquisition of IT resources and, in turn, IT companies are expected to provide suitable sustainable technology.

The methodology of this study includes a literature survey as well as a case study analysis. Therefore, the paper consists of the following parts. The secon section includes a discussion on goal-oriented approaches in the EA domain for identification of information system requirements. The third section presents essential methodology for goal-oriented EA development. The fourth section defines the metropolis model specification and indicators needed in the i* model. Metropolis system architecture developers should focus on the identification of business goals as well as on the specification of ICT goals, and finally on the business and ICT goals' alignment. The fifth section 5 includes conclusions.

Literature Survey

EA management and development are realized to ensure business organization growth and revenue increase, controlled acquisition of resources, successful implementation of managerial and technology inno-

vations, offering different or innovative products and services to clients, cost minimization in the short term, and assurance of business stability in the long term. Business processes, goals, and tasks of stakeholders in enterprise architecture must constantly be aligned with the many regulations, standards, policies and EA principles imposed by public institutions, national authorities, or regional governments. EA business objectives are complex and the objectives' connections are complex as well. As they are changeable, they require continuous verification and validation.

Enterprise architecture is an idiosyncratic holistic plan, which combines business objectives, vision, strategy, and governance principles (Manzur et al. 2015). ISO/IEC/IEEE 42010:2022 defines architecture as 'fundamental concepts or properties of an entity in its environment and governing principles for the realization and evolution of this entity and its related life cycle processes' (International Organization for Standardization 2022). An enterprise is a system of one or more business units supported by ICT solutions. The enterprise boundaries are defined relatively to information workflows among business units, so they are not constrained by the boundaries of a legal organization (International Institute of Business Analysis 2017). An enterprise as a system uses inputs, i.e. resources, in a controlled and goal-oriented way to provide outputs, i.e. products or services in business processes. EA management focuses particularly on planning, organizing, leading, administrating, and controlling, while EA development functions include conceptualization, design, implementation, deployment, evaluation, assessment, and improvement. EA principles are included in business regulations, legal documents, business plans, de facto standards, and governmental decisions. As they are not expressed in a formal language, they can be freely interpreted. Therefore, there is no mechanism for consistency checking between the principles, business goals, assessments, requirements, or values (Marosin, Zee, and Ghanavati 2016). The lack of cohesion can be problematic; however it allows for creativity in business architecture and system architecture development.

EA developers and managers apply the concept of goals. This concept is needed to explain and justify why business is working as well as why EA is developed. There is a need to differentiate business goals and system goals. Business goals are to be strictly included in the enterprise business plan and strategy, while system goals are the goals of EA development. Another issue covers goal achievement measures. Therefore, a

TABLE 1 Goal-orientation in EA – Literature Review

No.	Reference	Findings
1	Truong et al. 2021	Authors propose reasoning process focused on enterprise reengineering, using data mining rules, and strategic goal orientation. They analyse process effectiveness taking into account business intelligence (BI) indicators.
2	Sellitto et al. 2020	Authors integrate EA approach with a goal-oriented development methodology to facilitate implementation of Internet of Actors in Smart Grid, Industry 4.0, and e-Government.
3	Abrahao et al. 2019	Authors compared GRL with i* language, taking into account the quality of goal models, modelling time and productivity. They found i* modelling less laborious.
4	Babar et al. 2019	Authors applied goal-oriented approach to analyse the requirements for designing cognitive systems and cognitive business processes.
5	Gaol, Danny, and Matsuo 2019	Authors develop organization goal-oriented requirement engineering (OGORE) method. They collected business process data, defined KPIS, and elaborated the Goal Tree Model.
6	Marosin, Zee, and Ghanavati 2016	Authors focused on the requirements for improving the development of a framework to formalize EA principles and apply goal-oriented requirements language (GRL).

Continued on the next page

specification of metrics, i.e. key performance indicators, their thresholds and target values, are necessary.

This paper includes a qualitative survey of literature. The research questions (RQS) have been formulated as follows:

- RQ1: How is goal-orientation related to the EA domain?
- RQ2: How to assess goal-achievement through key performance indicators (KPIS) modelling?

Accordingly, this study covers reviews of the following repositories: Scopus, IEEE Xplore, AIS e-Library, Sage Journals, Science Direct, Google Scholar, ProQuest, DBLP Trier University, Emerald Publishing and Taylor Francis Group. The research questions have been analysed through the main keywords. The search keywords were formulated as follows: 'KPI goal-oriented Enterprise Architecture.' The words were connected using the Boolean 'AND' operators. Although, in total, 2796 publications were found, it was necessary to remove duplications as well as publications considering other aspects of EA development not directly connected with Key Performance Indicators (KPIS) or goal-orientation.

TABLE 1 *Continued from the previous page*

No	Reference	Findings
7	Hamm and Kehrer 2015	Authors integrated the collaborative EA concept, goal-driven decision-making, and ArchiMate Motivation extension.
8	Nwokeji et al. 2014	Authors present a technique for checking the completeness of requirements specification in KAOS.
9	Akhigbe, Amyot, and Richards 2014	Authors introduce the EA framework, which exploits business objectives, decisions, and information systems. They apply GRL and consider business goal modelling and KPIS as having impact on EA.
10	Cardoso 2013	Paper concerns the integration of business services, goals, KPI modelling, and business processes. Author proposes the usage of KPI for EA business goals verification.
11	Lee and Song 2011	Authors argue that ArchiMate is not sufficient for requirements identification. They proposed a goal-oriented approach.
12	Ganesan and Paturi 2009	Authors define compatibility of composite enterprise business architecture Framework, Business Motivation Model, Business Rules, and Balanced Scorecard Approach. KPIS link business strategy to business processes, roles, products, and services

In addition, publications limited to KPI applications for business development support and to goal-orientation only in process modelling were removed. Therefore, eventually, just 45 papers were been selected for the final analysis and the most valuable research findings included in 12 papers are presented in Table 1.

Beyond that, some interesting conclusions are presented in other papers. For example, Bernaert and Poels (2011) argue that goals are system properties that are expressed by system stakeholders. They have investigated how the Knowledge Acquisition in autOmated Specification (KAOS) methodology supports small and medium enterprises (SMES) in documenting their entrepreneurial knowledge. Therefore, researchers have formulated a couple of fundamental questions, i.e. know-who, know-how, know-what, and know-why.

The answer to the know-why question is included in the goal model, where goals are presented in a goal diagram. The answer to the question of know-who is in a responsibility model, in which actors are assigned to goals and resources. The answer to the know-what question is included in the concept model, which is applied to describe the objects of computerized information processing, i.e. entities, agents, and associations. Finally,

the know-how question is answered in the business process model, which provides definitions of agent operations and explains the workflows.

ArchiMate has recently been considered as the de facto standard language for modelling EA. ArchiMate models include the business goals combined with stakeholders, processes, products, business values, assessments, and constraints. Abrahao et al. (2019) argue that nowadays, several goal-oriented languages have been developed to present the EA stakeholders' interests. For example, the Goal Requirements Language (GRL) is applied to identify stakeholders' goals in the context of incremental software development. In general, the goal-oriented modelling enables answering the question of why software is constructed. Goal identification should support the evaluation of system requirements' completeness. Horkoff et al. (2019) have noticed that goal-oriented requirements engineering (GORE) creates many different languages of goal modelling, e.g. i* (Yu 1997), KAOS (Dardenne, Lamsweerde, and Fickas 1993), or the textual notation GBRAM (Goal-Based Requirement Analysis Method) (Subhani and Ravikumar 2019). According to Kavakli and Loucopoulos (2005), i* language encourages focusing on understanding the current business organization situations, while KAOS allows for concentrating on relating business goals to system components.

Usage of KPIS in enterprise modelling as well as in architecture frameworks is emphasized in the publications of Cardoso (2013). She perceives the opportunities of KPI application in EA approaches to measure the properties of EA concepts and to evaluate business goal achievement. For her, KPIS are useful if they are specific, measurable, relevant, and actual measures. Mate, Trujillo, and Mylopoulos (2017) define KPIS as metrics of performance of an enterprise relative to its objectives. Thereby, they are enabling corrective action where there are deviations. For years, KPIS have been used by enterprises to monitor performance of business processes and business strategies relative to their objectives. Objectives can be selected, for example, from Balanced Scorecard (BSC) perspectives, i.e. Financial, Customer, Processes, and Learning. Objectives can be considered on different abstraction levels, i.e. the strategic, tactical, or operational level. The scope of KPIS application is quite wide. In general, they are intensity rates or structure rates, which are applied to assess different socio-economic phenomena. Consequently, the KPIS are applied to control the preliminary established values of parameters. Hence, in the case of significant deviation, one can steer tasks or make

decisions concerning human behaviour to return to the required values of the parameters. Otherwise, one can accept the deviations, next monitor, and eventually implement an organizational change in a longer period of time.

Goal-Orientation in Research Methodology

The goal-oriented EA development approach is derived from the ArchiMate Motivation Extension and Business Architecture modelling. This study focuses on EA conceptualization, the identification of stakeholders, and specification of goals. Therefore, the EA conceptualization includes:

- Stakeholder Identification,
- Identification of Stakeholders' Goals,
- Prioritization of Goals,
- Defining Metrics for Goals.
- Beyond that, the further stages in the EA development process cover:
- Defining Threshold Values and Target Values for Metrics,
- Implementation of Metrics,
- Assessment of measuring results,
- Comparison of received results with predefined values,
- Elaboration of recommendations for stakeholders.

As was mentioned earlier, EA development and management are realized for ICT implementation, management and governance. The ICT operational management is realized to keep the existing status of actual computerized information systems, while ICT strategic management is a proactive approach including the anticipation of ICT needs. The long term strategic management process includes EA planning and development, as well as implementation of critical ICT changes. In short term management, the change implementation is limited, and it is identified along with the maintenance of computerized information systems.

However, goals achievement monitoring as well as particular indicators monitoring are the subjects of interest. ICT governance and ICT strategic management require firstly the identification of business goals and business KPIS specification. Modelling these concepts is possible in ArchiMate and i* languages. As the ArchiMate model is rather complex, the most important concepts for strategic ICT management are presented in Figure 1, and next they are extended in Figure 2.

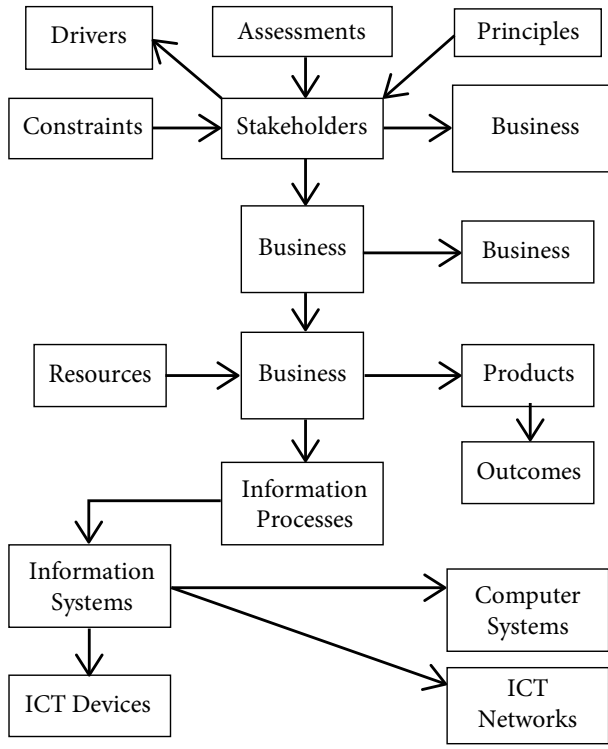

FIGURE 1 ICT Strategic Management Concepts

This study proposes an approach that provides EA stakeholders with an integrated view of strategic business goals, ICT goals, and conceptual KPIs. The main benefit of this approach is that it links the ArchiMate strategic business model to the data for monitoring and assessment. In this study, the i* language is applied as a goal- and actor-oriented tool, which is considered supplementary to other EA modelling notations. In the i* model, the actor is an entity aiming to achieve particular goals through task execution or process realization individually or in collaboration with other actors (Dalpiaz, Franch, and Horkoff 2016). Beyond actors, their tasks, goals, and resources, i* language models include qualities, which are attributes or criteria for the evaluation of achievement of goals. EA developers use the i* goal model to conclude what tasks are assigned to actors, how the tasks are constructed and prioritized, and how the goals are achieved. Unfortunately, the i* language developers have not precisely explained what goals are to be included in models.

In ArchiMate language, goals present a high-level statement of intent of a business organization. However, in EA modelling, there is a need to precisely identify business goals as well as system goals. System goals can be further identified with the achievement of functional requirements, which are described as the necessary capabilities that ICT solutions must have in terms of behaviours and processed data. Beyond the functional requirements, for software and hardware components as well as for ICT services in EA, the identification of non-functional requirements seems to be necessary. Non-functional requirements are named qualities of service requirements (International Institute of Business Analysis 2017). Hence, in this study, the i* language goal-oriented model includes business goals and EA goals, as well as KPIs presenting qualities for businesses, and KPIs for EA.

Case Study

This case study is grounded on the Silesian Province Metropolis. This metropolis is defined as a complex of 41 communities, i.e. towns and villages. Each community has its own business strategy and budget. These communities are closely co-located, hence they have to cooperate to mutually support themselves, protect the environment, and utilize joint resources, which are human, natural, informational, and financial (Ordonez-Ponce 2021). Therefore, beyond issues of governance and management at the community level, there are also problems solved by the metropolis authorities. In this study, the Silesian Province Metropolis is interpreted as an enterprise, for which ICT architecture is to be modelled, because of its particular ICT requirements. The Metropolis Architecture model can be applied to facilitate alignment between the community goals and the metropolis goals in relation to information communication technology (ICT) that supports citizens and visitors in the metropolis. Beyond that, there is the need to consider the alignment between ICT goals and business goals of the metropolis. The alignment is a critical process to support sustainable growth of the metropolis and to improve business services for citizens in their communities.

Naturally, each metropolis is different. They form different constellations of communities, consisting of several equal units, or forming a network around one central point or a few significant points. In any case, their intensive development results from population growth, moving people from villages to towns, reduction of agriculture areas, and

changing green areas into housing and industry areas (Wilson 2020). As with many other metropolises, the Silesian Province Metropolis has problems of transportation, healthcare assurance, natural environment protection, housing, and reduction of green areas because of industrialization (Soyinka and Siu 2018). ICT solutions, particularly the Internet of Things (IoT), cloud computing, and Big Data are expected to support agile management of metropolises. Bokolo (2020) emphasizes the issue of technology for smart cities. He has noticed that Big Data for metropolis management is gaining importance, as the cities deploy ICT architectures supporting the management of energy for electric vehicles and orchestration of the production, consumption, and distribution of energy from renewable sources.

As Industry 4.0 means the application of robots, IoT and advanced analytics of data to facilitate flexible production and Industry 5.0 concerns the collaboration among robots and humans, the concept of City 5.0 means a smart, but sustainable and resilient city (Grabowska, Saniuk, and Gajdzik 2022). The City 5.0 faces many challenges, i.e. stability, safety, healthcare, social services, housing, environment, transportation, employment, culture, and education (Roseman, Becker, and Chasin 2021).

Each metropolis has individual business goals as well as EA system goals. Analysis of metropolis EA can begin from considering the metropolis as an ecosystem, a complex web of symbiotic and cooperative organizations, i.e. cities and communities. Together, they are interrelated through communication and transportation systems. They have common principles and methods that help communities plan and realize their sustainability goals in relation to local business processes and metropolitan information systems. Joint business processes and procedures make the inter-metropolitan information flows easier. Metropolis EA integrates municipalities' information systems of healthcare, energy and water management, and smart parking. However, beyond the integration of local and communal issues, some problems and challenges are assumed to be considered on the upper, i.e. metropolitan, level. These joint problems are as follows: communication and transportation, traffic monitoring, safety and security, accessibility of cultural institutions, investments in higher education, air pollution monitoring, and waste management.

Figure 2 presents the EA model for the Silesian Province Metropolis in ArchiMate language implemented in the Archi 4.10 tool.

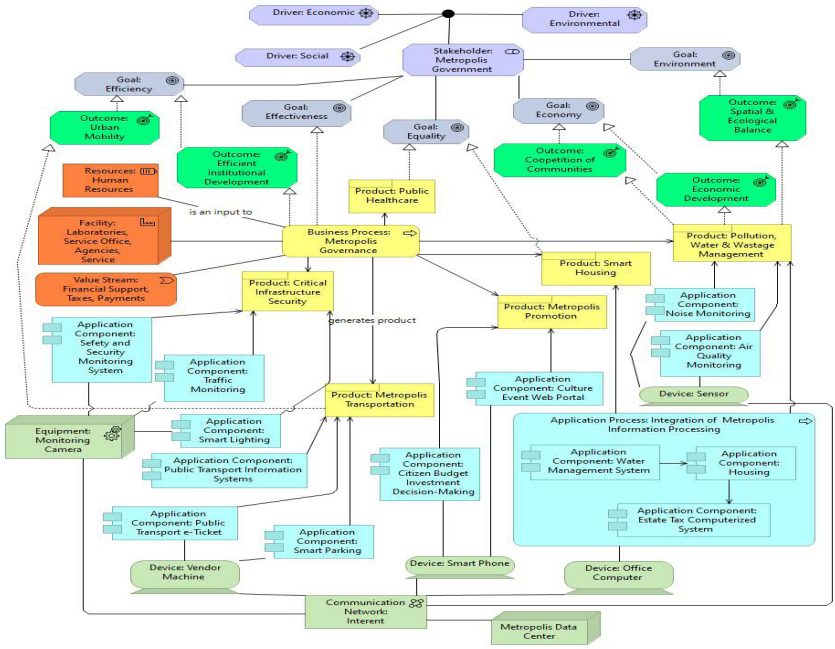

FIGURE 2 EA Model for Silesian Province Metropolis

The ArchiMate model concepts in Figure 2 are derived from Figure 1. Each EA model is an abstract structure of the most important concepts connected through particular relations available in the ArchiMate language. The EA model is applied to facilitate the alignment of metropolis goals, strategic outcomes of the metropolis, and ICT solutions that support stakeholders. The metropolis government is assumed to be the most important stakeholder, although there are also others, i.e. EA developers, business organizations, and public institutions located in the metropolis, as well as individual citizens and visitors. The stakeholders are driven by three types of stimulants, which motivate them to define goals and inputs, plan outputs and outcomes. The drivers are economic, social and environmental. In this model, stakeholders are assumed to have the following business goals: efficiency, effectiveness, equality, economy, and environment. For the business goals' achievement, the metropolis governance process is developed. Human, material, and financial resources facilitate realization of the process. This process's products are public services, i.e. public healthcare, metropolitan security, transportation, pollution monitoring, water and waste management, housing, and metropolis promotion.

The services are supported by ICT solutions, i.e. applications and hardware. In ArchiMate language, a product represents a collection of business services, which are offered by business organizations both internally to that organization and externally to customers and other organizations.

In this model (Figure 2), the product enables the realization of certain outcomes, which identify the results that are assumed to be achieved. In metropolis strategy, outcomes ensure the realization of business goals. In the model in Figure 2, creation of products is possible through the use of business software, i.e. monitoring systems, transportation information system, web portal and others. These software applications are accessible on end users' devices. Data from these devices is stored in a data operation centre. As ArchiMate language models support just the analysis and diagnosis of enterprise on a high abstract level, i.e. strategy level, further detailed planning and design of the system components are realized with the usage of other software development tools and languages, i.e. UML, SysML, etc.

There is a question of what the Metropolis 5.0 is. Therefore, the characteristics of this metropolis are derived from the following standards:

- ISO 37120:2018 Sustainable cities and communities – Indicators for city services and quality of life,
- ISO 37122:2019 Sustainable cities and communities – Indicators for smart cities,
- ISO 37123:2019 Sustainable cities and communities – Indicators for resilient cities.

The metrics presented in these standards are grouped into sub-domains, i.e. economy, education, energy, environment, finance, governance, health, housing, population, safety, solid and water waste, clean water, sport, culture, telecommunication, transportation, urban agriculture and planning. Figure 3 includes characteristics of Metropolis 5.0 selected for the Silesian Province Metropolis. This set of metrics is a sub-set of measures included in the standards, i.e. ISO 37120:2018, ISO 37122:2019, and ISO 37123:2019. The Metropolis 5.0 is characterized as a digitalized, sustainable, and resilient metropolis.

In the identification of characteristics in Figure 3, digitalization means the automation of processes and usage of ICT technologies instead of manual services.

FIGURE 3 Characteristics of Metropolis 5.0

The metrics of the digitalized metropolis concern different technologies used in citizens' daily lives (Hiremath et al. 2013). The sustainable metropolis is oriented towards the performance of services and assurance of a low-carbon economy and renewable sources of energy, as well as social equality, culture and history protection (Adolfsson, Lindblad, and Peacock 2021). Finally, the resilient metropolis is oriented towards survival and prepared to reduce risks of disasters, breakdowns, and failures. The disasters and breakdowns may destroy critical infrastructure in metropolises and may cause environmental degradation, loss of life and health, social inequality, and economic crises. The critical infrastructure covers electricity, water, telecommunication, waste management, sanitation, food and fresh water distribution, and emergency services.

Figure 4 includes the i* language goal-oriented EA model, which is de facto supplementary to the ArchiMate model. The i* language model covers just actors, goals, tasks, and qualities (Centro de Informática

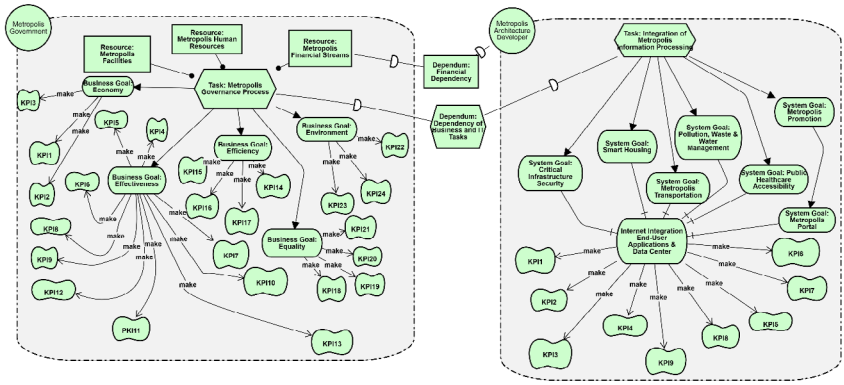

FIGURE 4 Goal-Oriented Model for Metropolis 5.0

of the Universidade Federal de Pernambuco 2021). Business goals have been identified already in the metropolis EA model in Figure 2.

In a goal-oriented model, beyond business goals, there is a place for ICT goals, which are connected with the tasks of the metropolis architecture developer, who is another important actor. The goals identified for actors have been linked with qualities, i.e. KPIS. The specified KPIS for business stakeholders are in Table 2, and KPIS for ICT stakeholders are in Table 3 (International Organization for Standardization 2011; 2017; 2018; 2019a; 2019b; Marr 2012; Adams 2015). There is still the problem that direct mapping of business goals into ICT goals is not possible through i* modelling. In the i* model, these two groups of interests can be combined through the dependency of tasks as well as through financial dependency (Figure 4).

Each group of stakeholders is expected to identify their goals and tasks and processes to ensure goal achievement. Both sides want to achieve a certain consensus and conformity of goals. According to the best practices, the superior role belongs to metropolis government stakeholders, who are expected to formulate ICT governance principles. Hence, the minor role belongs to the EA developers, who are responsible for modelling the ICT solutions enabling the business goals achievement. The EA developers can formulate goals concerning just the quality of ICT and its implementation process. Unfortunately, none of the notations presented in this study enable modelling the hierarchy of dependencies among stakeholders. The only way is to model business processes and consider how each of them can be supported by ICT.

TABLE 2 Metropolis Government KPIs

Category	No	Definition
Economy	KPI 1	'Percentage of labour force employed in ICT sectors as well as in the education and research and development sectors'
	KPI 2	'Annual amount of revenues from the sharing economy as a percentage of own-source revenues'
	KPI 3	'Percentage of public transport services covered by a unified payment system'
Effectiveness	KPI 4	'Number of Internet connections per 100 000 population'
	KPI 5	'Kilometres of public transport system per 100 000 population'
	KPI 6	Percentage of metropolis services accessible online
	KPI 7	'Percentage of the community's population with an online health file accessible to healthcare providers'
	KPI 8	'Percentage of marked pedestrian crossings equipped with accessible pedestrian signals'
	KPI 9	'Number of public library book and ebook titles per 100 000 population'
	KPI 10	'Percentage of community streets covered by real-time online traffic alerts'
	KPI 11	'Percentage of essential service providers covered by a documented continuity plan'
	KPI 12	'Percentage of community electronic data with secure and remote back-up storage'
	KPI 13	'Capacity of designated emergency hospitals per 100 000 population'
Efficiency	KPI 14	Return on Investment for evaluation of the efficiency of an investment
	KPI 15	Percentage of the community's electricity that is produced 'using decentralized electricity production systems'
	KPI 16	'Percentage of households with smart energy meters and smart water meters'
	KPI 17	'Electricity supply capacity as a percentage of peak electricity demand'
Equality	KPI 18	'Percentage of population living below the international poverty line'
	KPI 19	'Number of cultural institutions and supporting facilities per 100 000 population'
	KPI 20	'Percentage of population served by waste water collection'
	KPI 21	'Percentage of public buildings that are accessible by persons with special needs'
Environment	KPI 22	'Percentage of total end use of energy derived from renewable sources'
	KPI 23	'Green area per 100 000 population'
	KPI 24	'Number of real-time remote air quality monitoring stations per square kilometre'

TABLE 3 Metropolis ICT Architecture KPIs

No	Definition
KPI 1	Coherence: 'Degree to which system architecture is logical and consistent'
KPI 2	Usability: 'Degree to which the product has attributes that enable it to be understood'
KPI 3	Compatibility: 'Degree to which two or more components can exchange information'
KPI 4	Security: 'Degree of protection of information and data'
KPI 5	Reusability: 'Degree to which a system repeats the use of any parts of an existing system in a new system'
KPI 6	Adaptability: 'Degree to which a system can effectively and efficiently be adapted for different hardware and software'
KPI 7	Consistency: 'Degree of uniformity, standardization, and freedom from contradiction among the documents or system components'
KPI 8	Correctness: 'Degree to which a system is free from faults in its specification and design'
KPI 9	Modularity: 'Degree to which a system is composed of components such that a change to one component has minimal impact on other components'

Conclusions

The Enterprise Architecture concepts, frameworks and methodologies have been developed for years. The frameworks have various purposes and present different fundamentals and applications. This study focuses on EA goals identification, presentation, and their specified usage for further investigation and development of EA. The survey of literature revealed 45 publications, whose authors emphasized the issues of EA goals and usage of Key Performance Indicators to support those goals' measurement. According to the literature study results, EA goal orientation is combined with goal-oriented development of information systems and goal-oriented requirement engineering, as well as with the application of goal-oriented requirement language and i* notation.

This study covers the author's approach to EA goal identification and goal-oriented EA modelling. This approach is based on ArchiMate Motivation Extension and Business Architecture modelling. The author has identified the ICT strategic management concepts and further proposed a case study application to model the Silesian Province Metropolis as Metropolis 5.0. This research endeavour seems to be beneficial to theorists as well as to practitioners. For theorists involved in EA modelling, this study offers a proposal for the application of ArchiMate and i* languages and tools. The author presents a new direction of ArchiMate application in the Metropolis 5.0 development domain. The study

is also useful for practitioners, as the research covers identification of ICT goals and combining them with measures, i.e. Key Performance Indicators.

In general, EA development is realized as an iterative and incremental process. Continuous changes in ICT as well as political and governmental regulations' renewal lead to changes in the EA model of any business organization. Some technological or political reasons cause smaller changes, but others result in radical modifications of EA. Lately developed Society 5.0 concepts were an inspiration to identify the characteristics of Metropolis 5.0 in this paper and further develop the EA model of Metropolis 5.0. The proposed modelling approach focused on the identification of goals and description of their indicators. For Metropolis 5.0 modelling, the two groups of main stakeholders have been identified. They have different tasks, goals and quality metrics. This paper emphasizes the segregation of goals of particular stakeholders, i.e. business and IT people. The i* model allowed for emphasizing these discrepancies as well as the necessity to align the goals of these two groups. This differentiation cannot be left unsaid because, in practice, each group could dominate the other. Therefore, negotiations and discussions are required to explain priorities of each party and to compromise and reach mutual consensus on the goals.

In this paper, the goal-oriented EA model is supplemented by the i* model to reveal what KPIs can be specified for business goals and ICT architecture goals. This approach should be useful for Metropolis 5.0 EA conceptualization, although the literature study allows for the conclusion that surprisingly many publications on goal-oriented EA or requirement modelling focus on statistical or descriptive literature reviews.

Although the ArchiMate model is rather complex, the most important concepts for strategic ICT management are identifiable in this notation. ArchiMate models as well as i* models are not very popular; therefore, practitioners can have problems in their common application. Both notations have some weaknesses. For example, none of them precisely define types of goals. Both require metamodelling, which would also include other concepts essential for EA development. Usually, they are integrated with business process modelling in Business Process Model and Notation (BPMN). Lack of recognition of the modelling techniques is a real barrier to research and verification in the domain of practice. Beyond that, in business analyses reports, the KPIs are usually presented in descriptive forms, hence additional language would be necessary for

further formalization of KPIs. So far, KPIs have not been widely implemented in EA models, therefore it is a future opportunity to further perfect EA frameworks.

References

Abrahao, S., E. Insfran, F. Gonzalez-Ladron-de-Guevara, M. Fernandez-Diego, C. Cano-Genovés, and R. P. de Oliveira. 2019. 'Assessing the Effectiveness of Goal-Oriented Modelling Languages: A Family of Experiments.' *Information and Software Technology* 116:106171.

Adams, K. M. G. 2015. *Non-Functional Requirements in Systems Analysis and Design.* Cham: Springer.

Adolfsson, P., J. Lindblad, and S. Peacock. 2021. 'Translations of Sustainability in Urban Planning Documents: A Longitudinal Study of Comprehensive Plans in Three European Cities.' *Cities* 119:103360.

Akhigbe, O., D. Amyot, and G. Richards. 2014. 'A Framework for a Business Intelligence-Enabled Adaptive Enterprise Architecture.' In *Conceptual Modelling Lecture Notes in Computer Science,* ER *2014,* edited by E. Yu, G. Dobbie, M. Jarke, and S. Purao, 393–406. Cham: Springer.

Babar, Z., E. Yu, S. Carbajales, and A. Chan. 2019. 'Managing and Simplifying Cognitive Business Operations Using Process Architecture Models.' In *Advanced Information Systems Engineering, 31st International Conference,* CAISE *2019,* edited by P. Giorgini and B. Weber, 643–58. Cham: Springer.

Bernaert, M., and G. Poels. 2011. 'The Quest for Know-How, Know-Why, Know-What and Know-Who: Using KAOS for Enterprise Modelling.' In *Advanced Information Systems Engineering Workshops,* CAISE *2011,* edited by C. Salinesi and O. Pastor, 29–40. Berlin: Springer.

Bokolo, A. 2020. 'Smart City Data Architecture for Energy Prosumption in Municipalities: Concepts, Requirements, and Future Directions.' *International Journal of Green Energy* 17 (13): 827–45.

Cardoso, E. C. S. 2013. 'Challenges in Performance Analysis in Enterprise Architectures.' In *2013 17th* IEEE *International Enterprise Distributed Object Computing Conference Workshops,* edited by E. Bagheri, D. Gašević, S. Halle, M. Hatala, H. R. Motahari Nezhad and M. Reichert, 327–36. Vancouver: Institute of Electrical and Electronics Engineers.

Centro de Informática of the Universidade Federal de Pernambuco. 2021. 'PiStar Tool.' https://www.cin.ufpe.br/~jhcp/pistar/.

Dalpiaz, F., X. Franch, and J. Horkoff, J. 2016. 'iStar 2.0 Language Guide.' *Cornell University,* 25 May 2016. https://arxiv.org/abs/1605.07767.

Dardenne, A., A. van Lamsweerde, and S. Fickas, S. 1993. 'Goal-Directed Requirements Acquisition.' *Science of Computer Programming* 20 (1–2): 3–50.

Desfray, P., and G. Raymond. 2014. *Modeling Enterprise Architecture with* TOGAF*: A Practical Guide Using* UML *and* BPMN. Amsterdam: Kaufmann.

Fischer, C., R. Winter, and S. Aier. 2010. 'What Is an Enterprise Architecture Principle? Towards a Consolidated Definition.' *Computer and Information Science 2010,* edited by R. Lee, 193–205. Berlin: Springer.

Ganesan, E., and R. Paturi. 2009. 'Key Performance Indicators Framework: A Method to Track Business Objectives, Link Business Strategy to Processes and Detail Importance of Key Performance Indicators in Enterprise Business Architecture.' *Proceedings of the Fifteenth Americas Conference on Information Systems,* edited by R. C. Nickerson and R. Sharda. http://aisel.aisnet.org/amcis2009 /736.

Gaol, F. L., J. Danny, and T. Matsuo. 2019. 'Application of Organization Goal-Oriented Requirement Engineering (OGORE) Methods in ERP-Based Company Business Processes.' *Open Engineering* 9 (1): 545–53.

Grabowska, S., S. Saniuk, and B. Gajdzik. 2022. 'Industry 5.0: Improving Humanization and Sustainability of Industry 4.0.' *Scientometrics* 127 (6): 3117–44.

Hamm, T., and S. Kehrer. 2015. 'Goal-Oriented Decision Support in Collaborative Enterprise Architecture.' In *Digital Enterprise Computing 2015,* edited by A. Zimmermann and A. Rossmann, 175–82. Bonn: Gesellschaft für Informatik.

Hiremath, R. B., P. Balachandra, B. Kumar, S. S. Bansode, and J. Murali. 2013. 'Indicator-Based Urban Sustainability: A Review.' *Energy for Sustainable Development* 17 (6): 555–63.

Horkoff, J., F. B. Aydemir, E. Cardosso, T. Li, A. Mate, E. Paja, M. Salnitri, L. Piras, J. Mylopoulos, and P. Giorgini. 2019. 'Goal-Oriented Requirements Engineering: An Extended Systematic Mapping Study.' *Requirements Engineering* 24 (2): 133–60.

International Institute of Business Analysis. 2017. IIBA *Global Business Analysis Core Standard: A Companion to A Guide to the Business Analysis Body of Knowledge (*BABOK *Guide).* Toronto: International Institute of Business Analysis.

International Organization for Standardization. 2011. *Systems and Software* ENGINEERING*: Systems and Software Quality Requirements and Evaluation (*SQUARE*); System and Software Quality Models.* ISO/IEC 25010:2011. Geneva: International Organization for Standardization.

———. 2017. *Systems and Software Engineering: Vocabulary.* ISO/IEC/IEEE 24765:2017. Geneva: International Organization for Standardization.

———. 2018. *Sustainable Cities and Communities: Indicators for City Services and Quality of Life.* ISO 37120:2018. Geneva: International Organization for Standardization.

———. 2019a. *Sustainable Cities and Communities: Indicators for Smart Cities.* ISO 37122:2019. Geneva: International Organization for Standardization.

———. 2019b. *Sustainable Cities and Communities: Indicators for Resilient Cities.* ISO 37123:2019. Geneva: International Organization for Standardization.

———. 2022. *Software, Systems and Enterprise: Architecture Description.* ISO/IEC/IEEE 42010:2022. Geneva: International Organization for Standardization.

Kavakli, E., and P. Loucopoulos. 2005. 'Goal Modelling in Requirements Engineering: Analysis and Critique of Current Methods.' In *Information Modelling Methods and Methodologies: Advanced Topics in Database Research,* edited by J. Krogstie, T. Halpin and K. Siau, 102–24. Hershey: IGI Global.

Lee, H., and Y.-T. Song. 2011. 'Bridging Enterprise Architecture Requirements to ArchiMate.' *Studies in Computational Intelligence* 365:63–78.

Manzur, L., J. M. Ulloa, M. Sánchez, and J. Villalobos. 2015. 'xArchimate: Enterprise Architecture Simulation, Experimentation and Analysis.' *Simulation* 91 (3): 276–301.

Marosin, D., M. van Zee, and S. Ghanavati. 2016. 'Formalizing and Modelling Enterprise Architecture (EA) Principles with Goal-Oriented Requirements Language (GRL).' In *International Conference on Advanced Information Systems Engineering: CAiSE 2023,* edited by S. Nurcan, P. Soffer, M. Bajec and J. Eder, 205–20. Heidelberg: Springer.

Marr, B. 2012. *Key Performance Indicators.* Harlow: Pearson.

Mate, A., J. Trujillo, and J. Mylopoulos. 2017. 'Specification and Derivation of Key Performance Indicators for Business Analytics: A Semantic Approach.' *Data and Knowledge Engineering* 108 (3): 30–49.

Nwokeji, J. C., T. Clark, B. Barn, and V. Kulkarni. 2014. 'Automated Completeness Check in KAOS.' In *Advances in Conceptual Modeling,* edited by M. Indulska and S. Purao, 133–8. Cham: Springer.

Ordonez-Ponce, E. 2021. 'The Role of Institutional Context for Sustainability Cross-Sector Partnerships: An Exploratory Analysis of European Cities.' *Sustainability* 13 (17): 9497.

Pańkowska, M., and A. Sołtysik-Piorunkiewicz. 2022. 'ICT Supported Urban Sustainability by Example of Silesian Metropolis.' *Sustainability* 14 (3): 1586.

Roseman, M., J. Becker, and F. Chasin. 2021. 'City 5.0.' *Business Information System Engineering* 63 (1): 71–7.

Salmans, B., and L. A. Kappelman. 2010. 'The State of EA: Progress, Not Perfection.' In *The* SIM *Guide to Enterprise Architecture,* edited by L. A. Kappelman, 165–87. Boca Raon: CRC Press.

Sellitto, G. P., H. Aranha, M. Masi, and T. Pavleska. 2020. 'Security and Safety by Design in the Internet of Actors: An Architectural Approach.'

In *Subject-Oriented Business Process Management: The Digital Workplace Nucleus of Transformation,* edited by M. Freitag, A. Kinra, H. Kotzab, H. J. Kreowski, and K. D. Thoben, 133–42. Cham: Springer.

Soyinka, O., and K. W. M. Siu. 2018. 'Urban Informality, Housing Insecurity, and Social Exclusion: Concept and Case Study Assessment for Sustainable Urban Development.' *City, Culture and Society* 15:23–36.

Subhani, S., and A. Ravikumar. 2019. 'GBRAM-Based Model for Goal Oriented Requirement Engineering: A Unifying Framework.' *Journal of Emerging Technologies and Innovative Research* 6 (6): 410–6.

Truong, T.-M., L.-S. Le, E. Paja, and P. Giorgini. 2021. 'A Data-Driven, Goal-Oriented Framework for Process-Focused Enterprise Re-Engineering.' *Information Systems and e-Business Management* 19 (2): 683–747.

Wilson, B. 2020. *Metropolis: A History of the City, Humankind's Greatest Invention.* New York: Vintage.

Yu, E. 1997. 'Towards Modelling and Reasoning Support for Early Phase Requirements Engineering.' In *Proceedings of The Third* IEEE *International Symposium on Requirements Engineering,* edited by P. Storms, 226–35. Los Alamitos, CA: Institute of Electrical and Electronics Engineers.

Zachman J. A. 2010. 'Frameworks Standards: What's It All About?' In *The* SIM *Guide to Enterprise Architecture,* edited by L. A. Kappelman, 66–70. Boca Raton, FL: CRC Press.