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Research Article

Intelligent Management Frameworks for Global Cooperation

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This paper presents the definition, use, and evaluation of intelligent management frameworks for global cooperation. The research work brings new concepts and ideas to design new management models and artificial intelligence solutions in sustainable environments. An intelligent management framework is a flexible and efficient vertical association of models, architectures, and processes. It is a mixed (architectural and methodological) association of services and procedures across IT departments of global organizations. The paper presents a general top-down approach to design these frameworks for global, cooperative models of intelligence. The approach includes five levels of abstraction and three refinement techniques. These elements are used to design an evaluation case study with global services and process-oriented cooperation for current sustainable targets in education. In our future work, we will implement these management solutions for government organizations currently involved with digital transformations.

Keywords: artificial intelligence; global cooperation; intelligence; sustainability; management frameworks

1. Introduction

This paper presents our current investigations to address *intelligent management* from a *globally oriented perspective*. We design and evaluate new *management frameworks* based on intelligent models for sustainable global organizations. More particularly, the paper brings four main contributions to knowledge in the modeling and building of global management:

- The exploration of relevant research *concepts* like "sustainability" and "cooperation."
- The presentation of some concrete ideas to *globally cooperate* using adaptable, natural techniques and systems.
- The use of our *models and abstractions* (initially introduced in [1]) to derive new management frameworks supporting *global, cooperative intelligence* [2].
- The design evaluation of our *management frameworks* in sustainable organizations working in education.

We present our intelligent management frameworks (IMFs) as open, flexible mechanisms for global directions in sustainable organizations. Further, we analyze intelligent cooperation using an evolved version of a *top-down design approach* (inspired in our previous work [3]) based on five abstractions and three refinement techniques. Here, our abstractions point to the modeling of abstract levels of global, cooperative intelligence. And they focus on organizational aspects of development like, for example, "service." The refinement techniques facilitate the design of lower-level structures and mechanisms in the organizations. Indeed, we have defined several model enhancements for moving from one abstraction to another, according to some preselected aspects of design (e.g., "process" or "architecture").

The new abstractions incorporate what we have called Global Services and Process-Oriented Cooperation (GS&POC) models as core, flexible designing elements. A GS&POC model incorporates intelligent services (based on knowledge and behavior structures), architectures, and processes mainly inspired by the latest Information Technology Infrastructure Library (ITIL v4) process standards. Intelligent services are identified first. Then we move down to design GS&POC models by means of identifying, integrating, and/or adapting the architecture and processes to compute and/or methodologically deliver the services. The IMF vertically associates these architectural and procedural bases of GS&POC.

Sustainable Development Goals (SDGs) currently involve large organizational and technological innovations. They integrate many relevant social aspects for sustainability. However, new global solutions are needed for effectively managing human, natural, and technological resources for this. Indeed, progress must be made toward *sustainability management* and the achieving and assessment of the SDGs using specific indicators across many sectors.

We have investigated this major problem and concentrated our efforts on searching for management solutions in the global cooperation of education-related sectors (e.g., government or research). We have designed an IMF case study for solving managing issues in sustainable educational organizations.

Furthermore, this year, we have moved into the practical evaluation of our IMF by running several investigations and publications. In this recent research work, we have provided substantial demonstrations on the flexibility and feasibility of our management framework to develop intelligent, cooperative Digital Library Systems (DLSs) for government organizations currently involved with digital transformations. These investigations show how our IMF proposal provides significant benefits in the integration and management of new cooperative processes and new artificial intelligence (AI)–driven services within DLSs. Finally, in these investigations, we are using qualitative analysis methodologies aimed at capturing participant perceptions regarding the applicability of our IMF with these systems. These participants are being selected from a targeted sample of professionals in government IT departments, digital transformation offices, and AI-related policy and infrastructure roles.

The paper is structured as follows. Section 2 presents our main research goals. In Sections 3 and 4, we summarize our ongoing investigations and preliminary research work toward sustainable organization management in education. Section 5 describes the initial foundations of our frameworks. In Section 6, we describe our top-down approach to design IMFs. The core features of our IMFs are described in Section 7. Section 8 presents our evaluation case study with SDGs. In Section 9, we assess this case study. Conclusions and future work are presented in Sections 10 and 11, respectively.

2. Research Goals

Our main objective is investigating *global cooperation* by means of defining and evaluating a top-down approach to designing IMFs for new global intelligent systems in sustainable education. Other, more explicit goals are:

1. Presenting our ongoing investigations around current global cooperation and sustainability (Section 3).
2. Summarizing, reviewing, and evolving our preliminary research work to model and build global intelligent systems supporting high-level cooperation (Section 4).
3. Presenting our more concrete ideas to integrate global intelligence, cooperation, and management (Section 5) as the initial foundations of our frameworks.
4. Presenting our top-down approach to design IMFs as open, direct, and dynamic combinations of services, architectures, and processes (Section 6).
5. Defining the IMF frameworks based on this design approach (Section 7).
6. Evaluating the design of an IMF framework in sustainable education organizations (Section 8).
7. Assessing our design evaluation case study (Section 9).
8. Planning our future investigations to continue evaluating our IMF frameworks in real, global organizations (Section 11).

3. Ongoing Investigations

From a general perspective, we investigate global cooperation and how to resolve current management issues in sustainable organizations within educational environments.

3.1. Sustainability Management. A major current, global problem is sustainability. Public and private organizations across the world must become *active agents for sustainable development*. They must solve global issues (like poverty, hunger, or education for all) and plan targets for future generations. And little has been done in terms of *global solutions* to help these organizations to become sustainable and to manage this sustainability.

Current organizational sustainability requires new, revolutionary social and technological performance. It requires many changes in organizational targets, structures, principles, priorities, and values; it requires new strategies and new management solutions for the relationships that take place inside the organizations and with other organizations. Indeed, the new organizations must be socially responsible for future generations using new local and global partnerships and management.

Human resource management is vital for organizations and governments which intend to become sustainable. Activities and principles of this management must develop new talents needed for their globalization. However, "it is becoming increasingly more difficult to find competent, motivated workers who have good attitudes and work ethics" [4]. We believe that it is necessary to promote moral and ethical global solutions to stimulate, support, and manage staff development in *superior frames of intelligence*;

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in global, cooperative frames of cognition where individual development must be placed in lower abstractions and collective development in higher abstraction.

3.2. Education and Cooperation. Current global development of societies underlines the importance of education. Indeed, education is "one of the main drivers of the progress of a country" [5].

Nowadays, educational organizations in global environments require new *collaborative actions* for providing *quality and efficient educational services* to all. "The population does best if individuals cooperate" [6]; "cooperation is a key aspect of social evolution" [7]; "humans cooperate to build societies" [8]; "close cooperation between many entities for the benefit of public interest is one of the most important determinants for public sector organizations" [9]; "cooperation improves performance" [10]. Indeed, some educational systems are now capable of delivering some integrated services and collaborate for student satisfaction. These systems allow education professionals to make better system supported decisions for the learning of their students. For example, Moka and Refanidis [11] designed a system to automatically schedule the educational activities of a student. Using this, the student can take "informative decisions" to attend to learning objects. More recently, in [12], a collaborative online learning environment improves students in group's attitudes involving social interactions.

The educational sector also needs a *global environment* where professionals and students can cooperate using global educational services. "Digital tools, online platforms, and collaborative technologies" are transforming the educational environments into a "globalized and interconnected domain" [13]. And for this end, we believe that it is important to design management mechanisms that create new global educational services and efficiently maintain these for our future generations. Indeed, sustainable education must preserve the quality and efficiency of appropriate global solutions across current organizations. And the support of government institutions and their management actions are "essential success factors," promoting international cooperation around the world and increasing general awareness using social networks and media [14].

Further, the educational sector must contribute to the establishment of *global citizens* through the design of new studies dealing with social and ethical responsibility; new studies dealing with principles of "respect, equity, justice, honesty, and transparency" for human resource management.

3.3. Global Cooperation and Related Studies. Global cooperation is "difficult to achieve" [15]. Social, cultural, and language differences between humans and systems may cause major difficulties. And we cannot observe our biology to understand and support our true "cooperative nature." Biological models, like neural networks, are not sufficient [15]. We need looking into human relations, global behavioral capacities, and moral thinking. We need numerous individuals globally acting together to produce relevant shared outcomes. Indeed, global cooperation requires that humans learn special, global capacities to construct positive collective actions. These abilities involve, for example, establishing shared objectives (like SDGs) and performing collaborative activities. Further, this cooperation requires specific *regulations* to appropriately coordinate all this positive global activity.

Cooperation has been studied by many researchers in Human-System Integration, Human-Machine System, and Human-Machine Teaming. For example, in [16], Hoc proposed the next definition for cooperation: "Human and machine are in a situation of cooperation if: (a) each of them strives toward goals although interfering with the goals of the other (at least based on resources or procedures), and (b) they try to manage such interference to make easier the activities of the other." The first point highlights common objectives like SDGs. But this common goal could be the same for cooperation and for competition. Thus, we need appropriate frameworks to guarantee that our IT supports the positive objective of cooperation. We need management frameworks guiding the design of computational models able to support positive collective actions. However, more investigations will be required to connect with the positive nature of our actions (see also [2]).

3.4. Technologies and Services. "No nation, great or small, in the world today and tomorrow can secure its future alone" [17]. The global network of relationships is growing between individuals, organizations, and states. Companies and organizations at large produce new *global services* to increase prosperity for all citizens. And current technologies are important to facilitate this globalization. However, technologies can also cause "new spikes in inequality" [18].

"Today's business is strongly influenced by globalization" [19]. "Managers and employees are exposed to global strategic decisions and cross-cultural interactions" [19]. Companies "operate in a complex environment" [20] characterized by the global economy and the integration of new IT based on current AI technology. They need "gathering, analyzing, and delivering" global information to help grow business and markets. And these global data are largely obtained using the web. However, the web needs more intelligence [21] and there are developing fields like "web intelligence" [22] to perform global services in the connected world.

The first organizations based on global services used "knowledge networks" built upon professionals managing "domains of knowledge" [23]. Since 2013, the world turned in an economy "driven by services" [24]. And "success in global service innovation required companies to develop capabilities that support increased relationship intensity and interactions" [25].

The knowledge management systems provide useful, global information to employees. They allow capturing, creating, and disseminating a "great deal of information" [26]. For example, Chioreanu et al. [27] designed an information monitoring platform for the industrial robot's field. This architecture generally supports the management

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of industrial robotic systems based on IT services. It provides customizable services for cooperation among all the actors involved in the robotics sector.

3.5. AI and Management. More general management systems have also been implemented with recent AI technologies. For example, Qiaohong et al. [28] presented a middleware architecture for an intelligent management system. And this is an important basis for low-level software platforms. But intelligent management ideas need to be combined with current AI technology as an important part of the management practice [29]. In doing so, Information Communication technologies and recent Machine Intelligence techniques will be able to support new management behaviors. However, we must be careful that there is no complete replacement in this management.

The integration of AI systems within societies has many legal limitations and several jurisdictions have begun to propose AI regulations, for example, in Europe. As we shall see, the proposed framework starts at high-level abstractions where these limitations are widely considered. For example, it is important to underline the fact that we do not manage general purpose AI systems. The term "global" is used here to mean "global cooperation" as the ultimate objective. Further, we look at ethical and moral concerns that are also important in current AI regulations. In this sense, it is important to underline the following facts.

- We design "system behavior" instead of having access and/or control of "human behavior."
- Human process managers control system behavior design within our architectures (see also [30]).
- We propose high-level management (in process orientation) that supervises major processes (activities) around the models, services, and architectures of the framework. And this high-level management must not be replaced by machines.

Multiagent systems have been proposed for providing "computer supported cooperative environments" where "coordination, negotiation, and communication among various organization units" are required [31]. Agent-based models have also been used as computational models to "explore group behavior" in [32]. Tello-Leal et al. [33] also presented an "agent-based platform." This allows "collaborations among heterogeneous and autonomous healthcare organizations focusing on the process-oriented integration."

More generally, AI technology is currently used in public service organizations to improve policy decision making and to enhance public service delivery for citizens [34]. Further, AI applications are very successful for internal management issues [35] like cybersecurity or financial management. The existence of high-quality datasets as well as fast machine learning algorithms allow the successful completion of all these tasks with large amounts of data. However, recent studies like [36] underline the fact that there are also major risks in the AI technology adoption in governments.

This year, we have concluded some investigations on the design of intelligent software architecture for cooperative DLSs extensively used in governments and related organizations. With this research work summarized in [37], we have demonstrated how these systems require new architectural modeling techniques to incorporate new cooperative actions as well as new AI-driven services (mapped to concrete AI applications) implementing decision support and recommendation processes. Further, in [37], we have provided an evaluation case study for our software architecture to achieve SDG4, ensuring inclusive and equitable education worldwide.

3.6. ITIL Processes and AI. A process model shows "cause-effect relationships"; it shows "how the business entities are affected by the process actions" [38]. "A collaborative process defines the global view of the interactions between organizations to achieve common business goals" [33]. It focuses on "the coordination of activities to improve the management of resources and services" [33]. Process managers in the public sector need "cooperation skills to be able to build and to sustain relationships with citizens" [9]. However, this cooperation does not seem to be supported by current standards in process-oriented management.

IT Service Management (ITSM) has been used as a general framework to "implement and manage quality IT services" provided by "an appropriate mix of people, processes, and IT" [39]. It is concerned with the planning, organization, offering, deployment, and maintenance of IT services instead of IT technologies. More recently, ITSM has been adopted in combination with advancing AI technologies like, for example, chatbots in customer services [40], simulating the way humans would behave as conversational partners offering the IT services.

ITIL is a collection of best practices in ITSM; it provides a general framework for robust ITSM; it is a global process-oriented standard used in the development and governance of IT infrastructures. ITIL helps to create and maintain successful IT systems that "add value" to companies and organizations [27]. ITIL provides IT services with "better performance and quality" [41]. Further, ITIL helps to evaluate current knowledge built with social networking from the service management viewpoint [42].

With the advances of AI, the latest version of ITIL (ITIL v4) is being used in large environments with machine learning techniques. These investigations enable real-time decision making in complex markets. Further, they improve organizational responses by managing large data volumes (from the web) as currently required. However, the integration of ITIL v4 with current generative AI findings and with global, cooperation-oriented processes has not been clearly established and need to be investigated. Indeed, most ITIL tools support the work of individual actors rather than supporting the cooperation among "all the parties involved in the processes" [43]. With other words, "ITIL lacks cooperative perspectives" [44].

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4. Preliminary Research Work

Our preliminary research work establishes the use of intelligent models and abstractions as initial foundations for our new global approach to AI [2]. This new approach can help in the modeling and building of new computational models supporting global cooperation and, consequently, sustainability. In this section, we adapt and evolve this work for the management issues that we explore later in this paper.

4.1. Intelligent Models and Abstractions. So far, we have presented three main types of models: "generic models"; "computational models"; and "operative models" (see Figure 1). As we describe in our recent publication [1], we consider these as intelligent models since they are mainly inspired by knowledge-based and behavior-based foundations of AI. Further, our generic models focus on cooperative intelligence, our computational models incorporate AI-driven services, and our operative models use concrete AI technologies like chatbots.

In this paper, we introduce a new type of model: the "management model." As we shall see, the more we refine our generic models, the more we can achieve lower management abstractions to combine models of intelligence (not only computational intelligence) or adaptive models of intelligence. This refinement includes some concrete mechanisms (like learning, adaptation, or decision making) and/or procedures (like process activities) to really facilitate and support (never replace) management in future sustainable environments.

For example, a management model for a sustainable organization could be a globally evolved version of a knowledge management solution for an IT department. As a first global approximation, this type of management might be like a new computational model where the manager behaves as a kind of "stereotype" using knowledge. But this is not the global solution that we propose. We believe in "people and management" as a human solution based on global capacities; as a solution specially dedicated to improving thinking and behaviors; and as a set of open, natural procedures that help driving people (in their life, in their careers) toward sustainability.

Figure 1 illustrates our preliminary intelligent models and some relevant associations among them. In general, we can achieve computational models of intelligence from very generic abstractions based on organizational entities and their cooperative, manageable links. A more complete computational model supports generic abstractions of intelligence using concrete AI techniques and software engineering methods. And this computational model can facilitate the design of a subsequent management model. Indeed, we can design management solutions based on the support of computational intelligence. However, this is not required; we can achieve our management models without the support of any computation and/or architectural design. This last modeling technique represents a methodological solution. Further, we can use our management models to guide the lower-level design of our computational and/or operative models. Similarly, we can define operative models (very close to current technologies and standards) without management. We can integrate our technological solutions into computational models. The most appropriate design for a global organization might depend on the higher organizational entities and their associations.

We are currently investigating the role and efficiency of these models to intelligently cooperate with humans and systems in sustainable environments. Indeed, we are running several interpretations and uses as cornerstone pieces of what global, cooperative intelligence could be [2]. For example, we are beginning to develop new models of intelligence focusing on:

- The modeling of global sustainable environments.
- The meaning of open, natural management.
- The modeling of moral, principled behaviors.
- The design of cooperative system behaviors.
- The design of flexible, collaborative system actions.
- The design of process-oriented cooperation.

In this paper, we organize and evolve some of these aspects. We investigate new global abstractions using three core designing elements: *services*, *architectures*, and *processes*. And a GS&POC model, as we describe later, summarizes some of these investigations. More generally, the paper brings five explicit *abstractions* to support intelligent cooperation from a globally oriented management perspective.

As we shall see, we also propose several *refinement techniques* for adapting (and evolving) each of these abstractions to our *cooperative objectives*, either locally (to improve local developments of intelligence) or globally (to solve the most helpful intelligence). All these abstractions are related throughout our general design methodology. We methodologically produce flexible and efficient abstractions across the organizations. And, following this methodology, it is possible, for example, to design very technical solutions for final operative models. Indeed, the last two abstractions that we present in this paper allocate a "methodological model" next to a "technological model." The methodological model is mainly focused on the procedural part of the cooperative processes. The technological model is built upon the selection, distribution, and/or integration of currently available technologies like AI.

These refinement techniques introduce *levels of detail* to support superior, generic models of cooperative intelligence. Indeed, we support top, global cooperation in terms of *collective system actions* producing "global effects" like *collective goals* [45]. Further, these refinement techniques introduce *levels of interaction*, since cooperation arises from "interaction structures" [6].

4.2. Global AI. We investigate new *computational solutions* to support our intelligent models (including the management model) in the context of what we have called Global AI [2]. This new approach helps to improve human behaviors and thinking, supporting cooperative models of *global, true, natural intelligence*, as we describe in [2].

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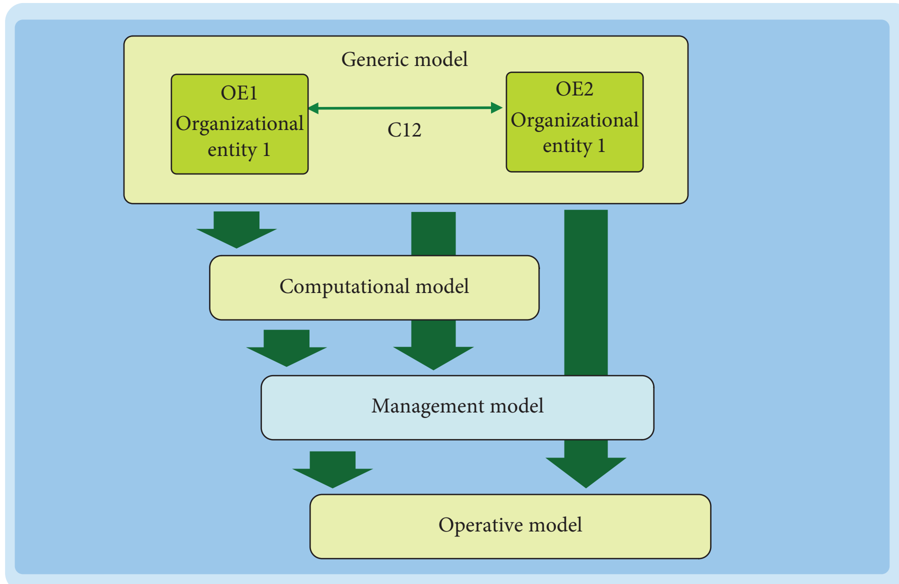

Figure 1: Models of intelligence: generic models, computational models, management models, and operative models.

We work on the theoretical (not so much practical) integration of Knowledge-Based and Behavior-Based approaches to AI. And we have established new concepts, ideas, and general solutions to define this new, globally oriented approach to AI based on system cooperation.

In [2], we concentrate most of our efforts in the modeling of intelligent cooperation based on new global capacities, sustainable thinking, and moral behaviors. We model new integrated systems of humans and machines from a new, globally oriented perspective instead of just building the models from either the behavior approach (as initially introduced in [46]) or the physical symbol system (as widely applied in classical AI) or the most recent data-driven methods (like machine learning or deep learning) or the latest evolutions of knowledge approaches based on generative AI [47]. Then we design computational intelligence solutions to support this global view of intelligence. For example, in this paper, we present new, open management frameworks, architectural designs [37], and methodologies that can be adapted to any scenario such as a global, sustainable organization or a company, as we describe in Section 8. Further, we design some flexible and efficient low-level elements (e.g., global networks of system behaviors, knowledge registries, etc.) to computationally support our most generic, conceptual abstractions, giving new engineering insights into our Global AI approach.

The investigations that we present in [48] focus on the design of learning-oriented solutions for educational environments. This research work provides a complete architectural design for scientific behavior and knowledge, to convince people to share well-structured knowledge, and collaborating with each other in an intelligent, open, and globally efficient way. In practice, this type of investigations allows us exploring the design of new architectural solutions for intelligent eLearning systems between research centers, universities, government organizations, sociocultural entities, and industries. Further, we investigate intelligent software platforms [37] to be able to support our high-level abstractions of intelligent cooperation with physical and/or virtual models of computational intelligence.

In these learning-oriented designs, we suggest modeling generic eLearning environments and mapping these into computational interactions while adapting high level architectures. Further, we apply some classical AI principles to analyze generic eLearning environments as knowledge-based systems. And we exploit some behavior-based insights to design intelligent system actions for final, operative platforms. This largely hybrid approach helps us approximate workable integration among knowledge and system behavior from a computational (mainly virtualized) perspective.

Now, in this paper, we extend some of these initial ideas toward a more concrete foundation of our global approach to AI. Basically, we integrate what we believe in as the *unique, global, superior intelligence* [2] that surrounds us, with new abstractions and management techniques to support human behaviors and thinking. In essence, we explore the term intelligence and point to new balanced principles of ethical and moral development for people and organizations toward global cooperation.

More particularly, this paper presents the fundamentals of a general methodology to design a management framework for global, cooperative models of intelligence. We introduce an overall top-down approach to design IMFs in global environments. And, in this approach, we combine services, architectures, and processes, moving from high levels of cooperative intelligence to highly objective models of management and computational solutions to support these.

The approach incorporates several of our models (e.g., computational models) and refinement techniques (like service-oriented refinement) to generally characterize

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organizational/cooperative system behaviors and lower-level actions. More generally, we use this top-down approach to design/evolve some cooperative abstractions. These facilitate, mainly, the identification and overall description of:

- *Global management frameworks* based on intelligent services, high-level architectures, and cooperative processes.
- *AI models* supporting organization, enterprise systems, and management interactions.
- *Active models of intelligent management* that integrate operative global/local services, architectures, and processes.

All these models and frameworks represent the result of several years of investigations in AI and innovative solutions for enterprise systems and IT management. Further, we have created all our abstractions and techniques following some of our initial ideas in behavior systems (like [3]), AI solutions (e.g., [2]), and intelligent software architectures (like [37]).

5. Global Intelligence, Cooperation, and Management

We understand *intelligent cooperation* as a *global integrated system* where all the participants can cooperate with each other having the most appropriate models for thinking and moral/ethical behaviors. And to achieve this, we propose a global top-down methodology that helps to identify and refine the most suitable services, architectures, and processes supporting and managing new open, natural organizations (see Figure 2).

This top-down approach facilitates the creation of computational and operational models to support global behaviors and thinking so that everybody in these organizations can develop more cooperative intelligence.

The core principles of this new approach refer to the unique, superior intelligence that needs to be transferred to our organizations [2]. And we would like to solve current management issues by means of supporting such superior intelligence with our models and frameworks. Further, we want to communicate major principles and laws from this superior intelligence to really help people understand and drive their life and careers toward globally oriented, sustainable development. Therefore, in our research work, we start the modeling and building of our solutions considering these principles and laws.

We define our models as open, natural *ecosystems of organizations* that need cooperating with each other. Indeed, our final objective is to be able to extract and define GS&POC models for concrete management frameworks. More particularly, we use generic models to analyze high level intelligence and service-oriented designs to develop lower-level architecture. Further, we evolve these into methodological aspects of design to finally achieve the core definitions of our global processes.

Figure 2 shows an overall view of this research work. In this picture, we illustrate the top cooperative intelligence that we gently consider with our frameworks. Basically, we conceptualize the top intelligence of our solutions and extract our models (green boxes in Figures 2 and 3) to finally design the type of frameworks that support the overall functioning of these models. In other words, we define our frameworks once we have designed our supporting models, with sufficient detail, at an appropriate level of abstraction.

Figure 3 exemplifies this design method. In this case, we look at the organizations and their cooperative links in the most generic abstractions, whereas we focus on the architecture, services, and AI systems at the computational level of abstraction. Further, we decide on fitting technology abstractions at the operative level so that the full range of architectures, services, and AI techniques become accurately available in all the interconnected organizations.

In these solutions, we understand cooperation as a global architecture where *human mental processes* can relate to each other with or without systems. It is a global network where all the employees can share some kind of knowledge (thinking) and interact (collaborate) in a positive, effective way through appropriate, moral/ethical behaviors. Usually, individuals think and execute their own behaviors, for their own benefit, and for their organizations. And managers should be responsible for developing both individual and organizational behaviors according to their human capacities.

In our models, all the individuals and organizations behave and think according to a single intelligence, a single mind, and a single heart. Then cooperation becomes natural, without much thinking, reasoning, or computation support.

We understand *human capacities* as the major belonging of our intelligence. Indeed, we can all work as part of a cooperative mind. Cooperative knowledge and behaviors relate to each other in a simple, natural way. And the same results can be achieved in our organizations. Thus, we would like global organizations to think and behave in a natural way based on human capacities. And our computational models must support these.

Nowadays, there are thousands of organizations that require some *motivational support* to encourage people in these objectives. There is, indeed, a strong tendency to approach some of the principles of behavior-based AI around motivational agents. But we must be careful that we do not replicate "human emotions."

In our approach, we consider *organizational capacities* as competences that can be developed from within individual capacities and related motivations. These competences can be seen, for example, as suitable combinations of management, business (or governance), and/or computational abilities. In practice, we analyze these capacities and support them with our GS&POC models. For example, we analyze *global management* as a set of human capacities that help to develop individual and cooperative models for our superior (nonreplicable) intelligence.

We believe that most human capacities (global or individual) are adaptive, in nature, to any unknown, changing condition. And so, we would like to achieve with our systems, especially, in the case of complex, large-scale organizations.

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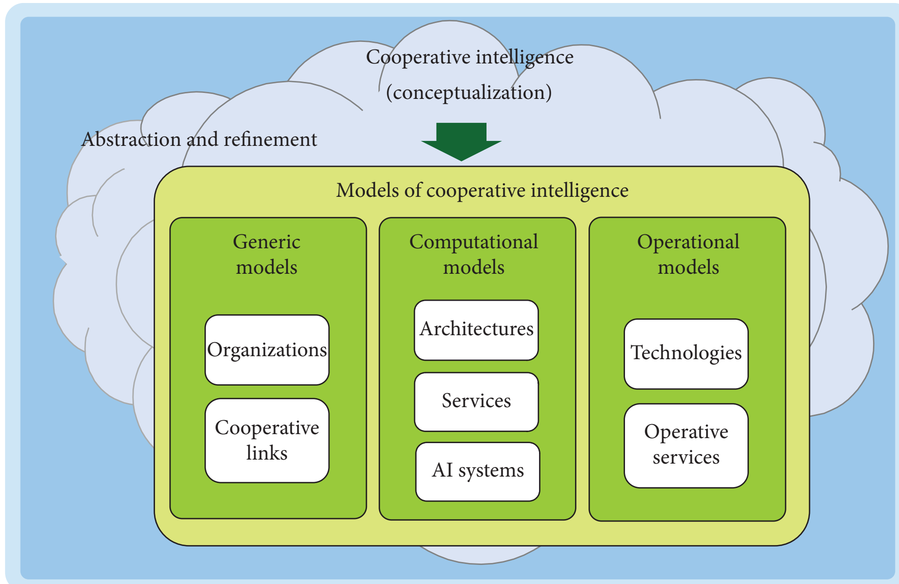

Figure 2: Design aspects for modeling and supporting cooperative intelligence.

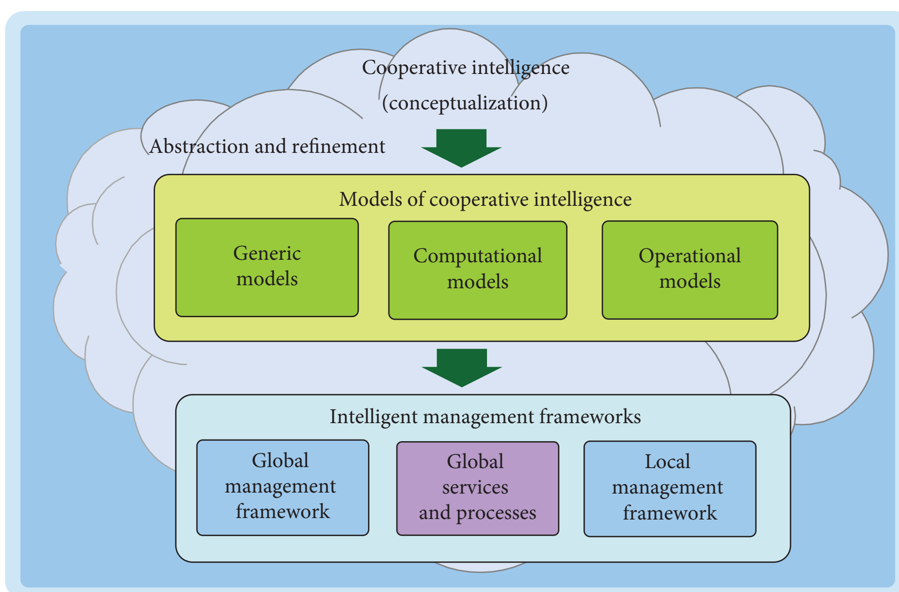

Figure 3: Intelligence, models, and frameworks.

In general, the adaptation process of a human capacity occurs from the working of some inner connections (and related mechanisms) to the outside world. And the replication of an adaptation process for our systems depends, mainly, on the computational level of abstraction. In this abstraction, we apply behavior-oriented insights from AI to design system behaviors and lower-level actions.

In our generic abstractions, all participants (humans) can cooperate and become truly adaptive to external changing conditions. And we design artificial systems for helping people improve their behaviors and thinking, for helping people cooperate with each other. Thus, we require our computational models to have appropriate inner (lower level) workings, just as humans need too, to develop themselves as core elements of their organizations. Further, we believe that the AI of these internal mechanisms depends mostly on new work of humans, and not only on IT solutions.

Some organizations develop their own technology to improve business or public governance, and to secure their operative environments and data. In our abstractions, humans select (and/or develop) technologies to facilitate human work. Thus, we require human behavior and thinking to take control over current technologies. And this is, from our point of view, one of the most important aspects of the "process in the organization," especially in IT departments, where the IT management is becoming very complex to foresee, due to current heterogeneous platforms

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(and changing situations) in their operative environments. However, current AI systems are solving some complex situations analyzing enormous amounts of data.

6. A Top-Down Approach

Here we present a five-level, top-down approach to design IMFs using *service-oriented*, *architecture-oriented*, and *process-oriented* refinement techniques. This approach serves to design the kind of structures and mechanisms that are required to support our global views of intelligence.

Figure 4 illustrates the five abstractions of our approach. These abstractions and the refinement techniques (used to move from one abstraction to another) are described in the following sections.

6.1. Generic Cooperation Abstraction. The first abstraction is a qualitative network of global organizations, a generic cooperative model among generic organizations and top-level cooperation. In this network, the nodes represent the organizations, and the edges show their cooperative and manageable links. It is a dynamic model for global organizations.

Figure 5 represents a global model with four generic organizational entities involved in global cooperation. These are Industrial Organizations (O1), Government Institutions (O2), Sociocultural Entities (O3), and Companies (O4).

Each of these organizational entities encapsulates some industry, government, sociocultural, or enterprise functions and objectives with *cooperative values*. It is a globally oriented institution that integrates moral/ethical behaviors and knowledge and computational models to support these. And in our approach, all the organizations respond to the same laws and ethical principles. The type of principles characterizing our global intelligence approach [2].

Furthermore, each organizational entity represents a cooperative unit that we describe in terms of *global modeling* like, for example:

- Global Knowledge and Behavior Participants.
- Global Knowledge and Behavior Managers.
- Global Knowledge and System Behaviors.

The cooperative links (edges) can be either directed or bi-directed arrows (see Figure 5). A bi-directed edge means that the organizations that it connects can cooperate (through knowledge acquisition and/or system behavior interactions) in both directions. A directed edge represents a single directed action and/or system behavior pattern.

In our computational models, every organization that they support represents either a private or a public institution with moral/ethical behaviors and thinking, as it corresponds to global intelligence. With generative AI approximations, however, the computational model would only support knowledge-based conversations with trained models.

The computational model of an organizational entity requires some kind of functional mechanism to support both knowledge acquisition and cooperative system behavior executions. It is an intelligent architecture that controls the registration and intelligent delivery of knowledge and the execution of moral, principled system actions to support top-level behaviors.

Each top-level organization can be divided into any suitable set of suborganizations and internal interactions. And this helps us to design more detailed collaborations inside and outside the organizations.

We define and use several types of interactions (e.g., collaborative tasks) to mean multiple, flexible low-level cooperation. All these interactions add new qualitative and quantitative information to our models. The overall map of interactions of a cooperative model describes the top cooperative model. The shape and complexity of this network depends on the decisions made during the design process.

A suborganization incorporates low-level knowledge and behavior elements like, for example:

- Global Knowledge Providers and Consumers.
- Global Behavior Contributors and Managers.
- Global Resources and System Behavior Patterns.
- Individual Functions (e.g., "reasoning").
- Organizational Functions (e.g., "collaborating").
- Intelligent Actions (e.g., "system behavior control" or "knowledge acquisition").

The individual and organizational functions as well as the intelligent actions underline the introduction of computational intelligence in the approach. This is further detailed in the following abstractions.

6.2. Service-Oriented Abstraction. In our top-down approach, we propose a *service-oriented refinement technique* to create global, intelligent services at the second level of abstraction. The resulting intelligent services integrate knowledge and system behavior structures. They represent basic elements of knowledge and system behavior interactions.

The service-oriented refinement technique facilitates the evolution of our generic cooperative models into global platforms of intelligent services. Basically, this technique consists of analyzing global objectives and functions and describing these in the form of "services." These service descriptions facilitate also the next process-oriented refinement, like in ITIL v4. Nevertheless, we can be flexible in the way that we approach the design of our GS&POC models.

For example, we can identify the architecture and related activities (basic processes) first and extract the global services at last. The only problem that we have found with this second approach is that it is difficult modeling the organizations without having any idea about the type of services that they can share through their cooperation. Further, we try to support high level intelligence and so we think that these sharable structures like services should be identified first, in terms of, for example, static forms of intelligence (e.g., system behavior

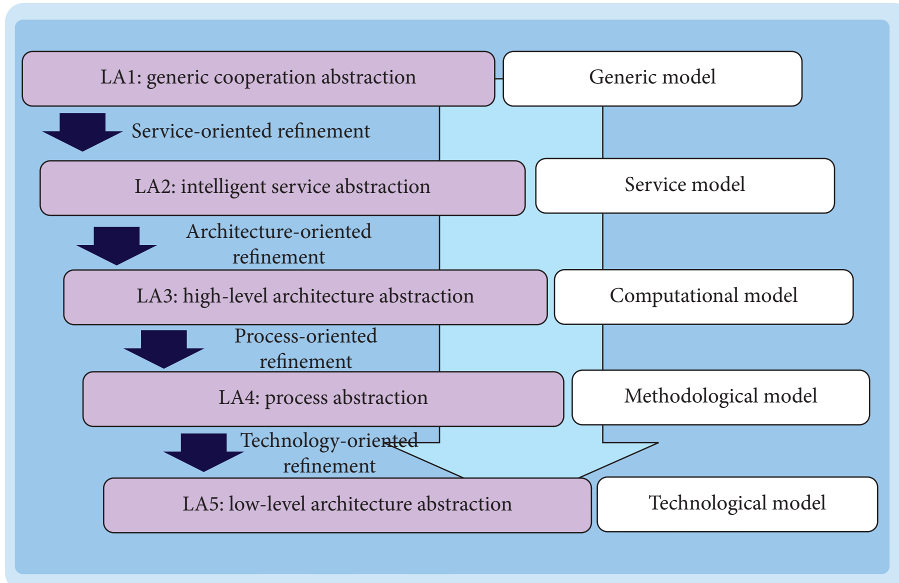

Figure 4: A top-down approach to design IMFs.

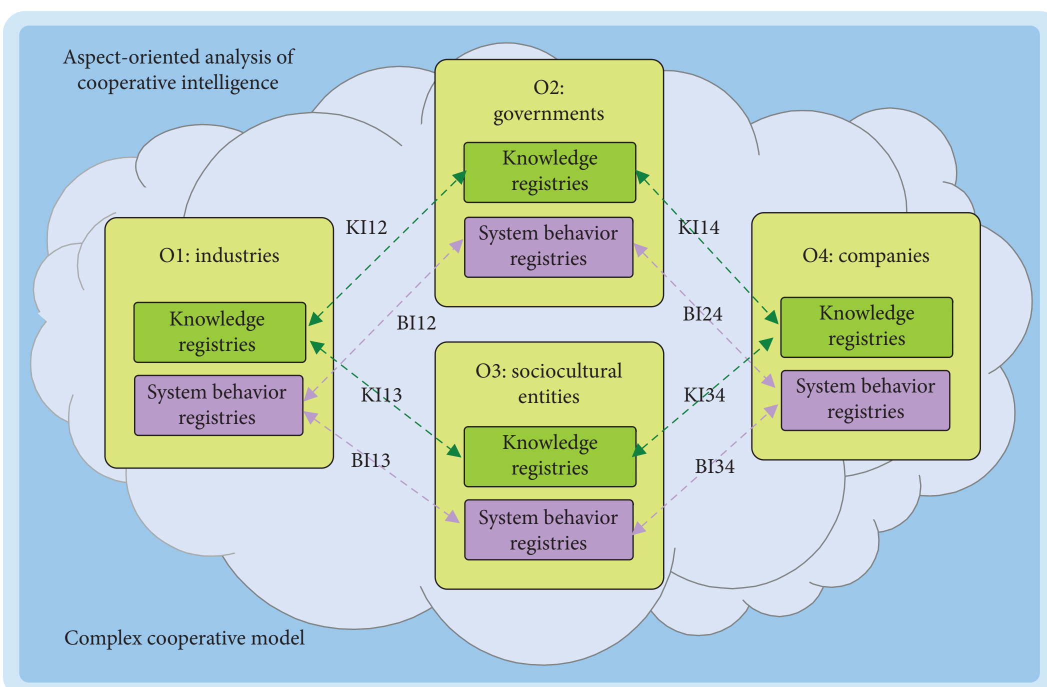

Figure 5: Generic model of knowledge and system behaviors.

patterns). Then we can design all the dynamic mechanisms and functions that help to control and process such system structures.

Using our approach, we define global services as basic combinations of single intelligent services, according to our higher-level abstractions. An *intelligent service* integrates knowledge and system behaviors. The final service model depends on the high-level network of interactions and the refinement process to support these. It represents a set of dynamic structures to help thinking and acting in global, cooperative networks.

In [37], we describe four major types of services: *knowledge-based services*, *behavior-based services*, *hybrid services*, and *generative AI services*, to mean that all these services can be mapped to special purpose AI applications based on classical or more recent AI techniques. For example, a knowledge-based service can be mapped to an AI application implementing decision making processes or recommendations based on traditional rules (e.g., *fuzzy control rules*) over the *knowledge* of the system (data and metadata registries describing knowledge). Similarly, a behavior-based service can be mapped to an AI application

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implementing decision making processes or recommendations based on *trained models* (using neural networks and learning algorithms) over the system behaviors and low-level actions of the system.

Furthermore, we refine our superior models in the form of services following a top-down technique largely inspired by the ITIL v4 framework. Following these standards, the *global service strategies* are identified first for making a unique environment of interactions. They provide direction (toward strategic objectives) and a vision for developing our global services. They are an integral input for *global service design* where most of our processes are involved during process-oriented refinement (see Section 6.4), including service catalog management, service availability management, and capacity management.

Global service development makes the services available for all their users, meeting the strategy and its objectives through processes like change management and deployment management. Finally, *global service operations* maintain the services to ensure that they operate as they were designed to. Some of the processes involved in these operations are incident management and problem management. But we believe that all these processes can be better approximated and methodologically defined once the architecture of the organization has been established.

6.3. Architecture-Oriented Refinement. The third abstraction represents an architectural approach to system design. In this level, we design, adapt, and/or integrate service-oriented architecture with more detailed knowledge-based and system behavior–based structures and engines. Nevertheless, we can also be flexible in the way that we add the architectural elements into our models and abstractions. Indeed, it is possible to identify and define new global services while we develop new computational models (with or without AI systems) to support human knowledge and system behavior networks.

In our previous work [48], we designed some registration and intelligent delivery engines (IDEs) for learning-oriented models. Here, we introduce new architecture designs to develop more thoughtful engines and system behavior modules in our abstractions.

Our intelligent architecture statically and dynamically generates global services using hybrid registries, service registration and management engines (RMEs), and service delivery engines to help higher level abstractions. All these functional elements serve to create, integrate, and control system behavior executions (like low-level system actions), knowledge acquisition, and/or decision-making processes using AI techniques.

A hybrid registry includes knowledge structures and system behavior patterns, as initially identified in service definitions (in the second abstraction). Intelligent engines compute higher level interactions (among mapped applications) according to this.

The RMEs create, store, and administer intelligent services. The delivery engines process and intelligently deliver these services. These engines implement intelligent processing mechanisms to support top-level cooperative tasks. Its underlying control mechanism highlights relevant "AI" being processed by the engine. Further, behavior-oriented AI techniques can be used to train new structures so that architecture can be observed to learn new system behaviors (and lower-level actions).

We use these registries and engines as flexible design elements for our computational models. Indeed, we can integrate these functional elements at any abstraction of an intelligent cooperation. For example, Figure 6 shows a top computational model based on intelligent services registries, RMEs, and IDEs. In this computational model, some industrial and government organizations can register and deliver intelligent services using those engines. The employees of the industrial organization can internally register and manage some services while publishing other services into the government organizations. Similarly, the employees of the government organization can register and deliver globally oriented services into the interconnected (cooperatively linked) industrial organization.

When we integrate registration, management, and delivery engines into a computational model, we make the underlying mechanisms and systems processing the services of the modeled cooperation. In essence, what this cooperative network means is that we can support a generic cooperative model with a functional architecture where all the participants can access and execute global services. Every time an employee makes a request through a delivery engine, the mechanisms and controllers of this functional module collect the corresponding service templates and execute knowledge processing and system behavior interactions accordingly. Thus, the resulting architecture is "almost operative." However, it requires some method to describe how to register, manage, and deliver these services. And this is what we define in the following process-oriented refinement technique.

Using current AI techniques, architecture-oriented refinement would take advantage of AI applications based on data-driven computational models trained with large and changing *datasets* (using neural networks and learning algorithms). This would reduce the computational efforts in developing the applications mapped from the services at the cost of energy in applying the learning methods.

6.4. Process-Oriented Refinement. The fourth abstraction is based on *process orientation*. Here we introduce methodological aspects of design to continue supporting our top-level, intelligent cooperation. We identify and integrate lower architectural elements of development with some general procedures to complete a general, abstract definition of IMFs based on some ITIL v4 processes.

An ITIL process is a "structured set of activities designed to accomplish a specific objective" [39]. And every process needs management to control its overall performance toward efficiency and objective achievement. These control mechanisms and the process enablers (resources and capabilities) form the *process model*. The most important resources of the process model are people, capital, infrastructure, application, and information. Process managers ensure that the processes are executed correctly.

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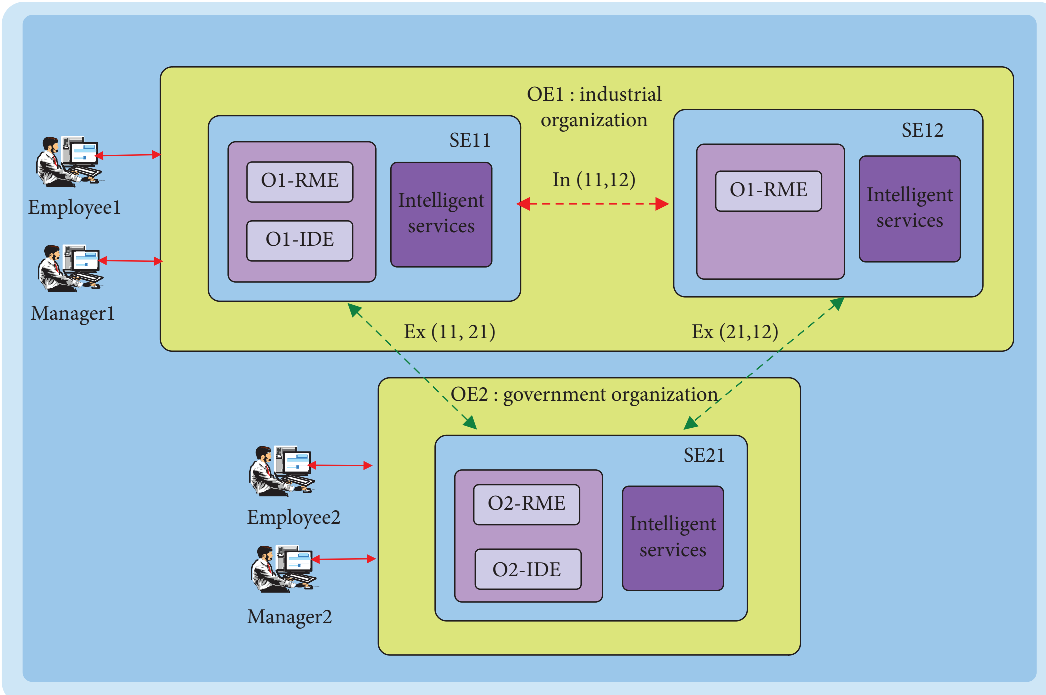

FIGURE 6: Architectural module integration.

In our approach, we define a *global process* as a set of *roles*, *responsibilities*, and *activities* that encapsulate the main features of our higher-level abstractions. One global process can include one to many of these process elements. The roles and responsibilities define who is responsible for doing what, in terms of creating and/or managing the global (and local) services and functional engines of our architecture. The activities formally describe the methods for these processes.

Other relevant concepts related to our global process's definitions are *authority*, *capacity*, and *accountability* [49]. These are directly connected to the following role definitions for our IMF proposal:

- *IMF Manager*: Overall responsible for the IMF solution. He/she has the capacity and the authority to supervise all the processes involved in the solution.
- *Service Owner*: Person responsible for one specific service. He/she has the capacity and the authority to supervise all activities around service design, management, and delivery. This owner reports to the IMF Manager.
- *Process Manager*: Supervises and has authority in all activities of a specific process and is responsible for maintaining an appropriate level of competence and capacities in all people involved in the process. This manager reports to the IMF Manager.
- *Architecture Manager*: Supervises all process activities involving the design, configuration, implementation, exploitation, and maintenance of the software architecture, overseeing major capacities involved. This manager reports to the IMF Manager.
- *Cooperation Manager*: Supervises all process activities around the design, integration, and administration of cooperative system behaviors being incorporated into the software architecture. This manager reports to the Architecture Manager and controls major capacities involved with system behaviors.
- *Process Staff*: They are responsible for performing all the activities of the assigned process and report to the Process Manager. They have no authority to impose their solutions.

The resulting processes around these services establish most of the methods (activities) that are required to convert our computational models (with or without architectural elements and/or AI systems) into operative models of intelligent services. These models behave as highly distributed systems. They incorporate hybrid intelligent mechanisms and processes to execute the services. The final users of these operative abstractions contribute to their global networks, either creating new cooperative knowledge or executing intelligent system actions according to the global and/or local processes. Thus, a final user can be either a human, an automated service, or another basic process.

Using our global processes and high-level architecture, the employees of an organization could search, find, and/or create new services based on, for example, individual and/or organizational system behaviors. The managers can supervise and authorize these new services, according to our process-oriented abstractions.

ITIL processes can be used in combination with AI techniques. For example, Zarrazvand and Shojafar [41] used fuzzy cognitive maps to model "the problem of needing ITIL

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processes." In [40], chatbots are used to simulate how humans behave as conversational partners offering the IT services. In our top-down approach, we can also introduce AI techniques and, more particularly, learning methods to drive data among lower-level elements of our architectures. Further, we can incorporate online chatbots to support intelligent language models and conversations for user-oriented services.

6.5. Technology Abstraction. Finally, we propose a technical abstraction (the fifth level) based on more detailed architectural orientation and processes. In this last abstraction, we introduce some technological aspects of development to continue supporting our cooperation. More particularly, we create, adapt, and evolve special purpose technologies to complete our GS&POC models. And we design final IMFs using efficient technologies like, for example, AI data-driven methods. But we can be flexible and efficient in the way that we adjust our technologies and related standards.

The employees of an organizational entity can specialize in any of the available abstractions. For example, a software engineer could specialize in architecture-oriented abstraction for intelligent SOA constructions. Model builders (and other related roles) can construct system abstractions from higher level designs, looking at local components (e.g., in one organization) or global elements (e.g., knowledge sharing interactions). Further, web technologies and web intelligence techniques can be incorporated at this level of abstraction to develop the knowledge registries and their interfaces. Further, we can refine our architectural components at the level of data so that new AI data-driven methods can also be incorporated to automate part of the higher-level models.

7. IMFs

An IMF is a vertical association of GS&POC elements (e.g., "global services") that can be obtained through our abstractions and refinement techniques. An IMF is a direct, open, and flexible combination of services, architectures, and processes. It is an organized set of structures and mechanisms to support and manage intelligent cooperation. In practice, we define two types of IMFs: local IMF (LIMF) and global IMF (GIMF).

A LIMF describes the management solution of an organizational entity. GIMFs represent vertical structures for associated organizations. It is an intelligent process-oriented framework that helps to develop computational models to support top global, cooperative intelligence. One GIMF can include one to many LIMFs.

In our approach, managers need to develop themselves, as much as they need to develop the human capacities of their employees and business (or governance). Thus, our management solutions start at the "inner capacities of intelligence" and move into processes-oriented abstractions. Once a manager is ready to behave naturally, ethically, and morally, and to think securely, people can understand how to cooperate, according to his/her instructions. Further, once a manager has *internally evolved to behave safely*, all the employees will be able to follow him/her and to cooperate. If the manager does not know how to respond to external and/or internal changes, the employees cannot develop appropriate capacities. And our computational models must support these adaptive processes and individual/organizational capacities.

The major feature of our top-level cooperative model is "morality." It is a global solution for promoting and supporting moral and ethical behaviors and thinking. It is a large-scale, integrated system that can be globally transferred to "management" in terms of moral and ethical principles.

Other important aspects of our management solutions are "trust and respect." Human cooperation relies on these. People cannot really cooperate when they do not trust each other. It is extremely difficult for a manager to trust an organization if the organization does not follow this principle.

We all learn how to get to know people and organizations. The question is: what is the best approach to encourage people to cooperate with others? Our knowledge management supports the most natural, more open human behavior through appropriate service definitions.

The employees and managers cannot know all the details of their heterogeneous operative models, especially in global, large-scale organizations. We need to trust how the organization globally works, without knowing all its internal mechanisms; we need to support open models of intelligence to be able to trust how the global mechanisms function, and more particularly, how to achieve our goals. In this sense, the high-level design of our computational models (architectures) provides sufficient knowledge about the organization for these goals.

The changing conditions of our working environments can negatively influence our tasks. However, we can solve this negative effect. We trust the human capacity to resolve any negative situation and to focus on "positive thinking" until the environment reaches an equilibrium. This stabilization makes sense "within and outside" the individual; it can occur in complex cooperative environments as generally required in global cooperation.

We all learn in our minds how to behave safely. And cooperative behavior cannot be difficult to foresee. Any cooperative behavior is approachable by mentally healthy people. Having a positive thinking about "our colleagues" truly improves cooperation. And our computational models must support this.

"Training and development give people greater control and ownership over their jobs, making them capable of taking care of customers and creating better management–employee relationships" [4]. And managers must be "prepared to effectively cope with national diversity and global strategic complexity" [19].

8. Evaluation Case Study

In September 2015, many world leaders adopted the 2030 Agenda for *Sustainable Development* under UN initiative.

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This includes 17 SDGs and 169 targets, mainly to tackle current climate change, to end poverty across the entire world, and to promote quality education to all. Since then, many governments have been translating the global SDGs into national targets, procedures, and legislations. They have established long-term national visions according to their capacities. Indeed, many organizations around the world are currently involved in these national strategies, recognizing the critical relevance of sustainability for all. However, very few have engaged in *sustainability management*. These organizations need effective, responsible management, playing an active role in moving toward the achievement of the SDGs, i.e., making these goals a reality at the local (national) and global levels.

In general, the management of SDGs requires large technological system transformations [50]. However, this is not the major problem. The major issue is how to achieve and manage global sustainable solutions with real and effective *global service delivery* to all countries [51] and how to deliver and manage new global services through global cooperation [52]. And following [53], these subsequent goals involve four major processes: prioritizing SDGs, contextualizing SDGs, *collaborating with other organizations*, and innovating through business process remodeling.

Education also plays a prominent role in SDGs; it is a critical tool for making sustainable development and management. SDG4, based on education, is at the heart of the current national strategies. This global goal ensures "inclusive and equitable" education and promotes "lifelong learning opportunities for all"; it ensures global education plans; it attempts providing "good education for all" [5]; it can transform knowledge and obtain moral/ethical behaviors from all citizens. And all this requires a "reorientation" of the educational systems and their technologies so governments can incorporate and measure sustainability in their educational plans and legislations.

In our case study, we design an IMF to accelerate current progress toward these SDG4 achievements. We assume that global cooperation with SDG4 can help in the management of more commitment for education, especially for developing countries. Indeed, global cooperation with our IMFs can help governments and education-related institutions to grow more global, more intelligent capacity in education.

Translating the global SDG4 into an *educational context of a nation* requires a long-term vision (model) supported by clear national targets, cooperative strategies, and related educational processes for the year 2030. A successful SDG4 implementation requires close coordination (management) of national target efforts as well as concrete organizational responsibilities, ensuring long-term, global solutions for our future generations. Furthermore, various groups within society (e.g., business and citizens) must cooperate with the educational entities in defining and implementing this global, sustainable vision for national targets. For example, governments involved in the 2030 agenda can collaborate to give primary school to all children in developing countries. And the private sector groups can provide more investment to improve technological access to education and learning in these countries.

Thus, the top-level generic model for our IMF draws a superior *cooperative intelligence* among these education-related entities and groups (see Figure 7). This cooperative network incorporates generic governments, civil society entities, research entities, educational institutions, and private sectors. And three core elements of this generic model are the SDG4-centered *action plan,* the *monitoring and reporting procedures*, and *cooperative strategies* placed at the government entity. Additionally, there are more cooperative strategies and SDG4 *indicators* identified within the other entities of the cooperative model.

With the action plan, the government can execute, for example, relevant tasks with educational institutions or private sectors. For example, the government can reorient educational systems by inserting sustainability in national legislation. The monitoring and reporting procedures are needed to track progress until 2030, evaluating national target achievement and measuring adequate SDG4 indicators in each entity involved. This SDG4-related, high-level management also includes cooperative strategies within the other entities to encourage "faster achievement" of the SDG4 and "SDG principle-based management" [5]. For example, these cooperative strategies between entities must promote the following:

- Improving education quality and curriculum: Governments can collaborate with universities and research institutions to regularly update curricula based on industry needs. For example, Finland has implemented a competency-based approach where curricula are revised every few years to match global trends in technology and sustainability. Additionally, in Germany, dual education programs integrate practical vocational training with academic learning, ensuring graduates are job ready.
- Adjusting the progress of science and technology: Countries like Singapore have integrated AI-driven learning analytics to personalize student education. AI-driven platforms can analyze students' progress and adapt learning content, accordingly, helping slow learners while challenging advanced students. Another example is South Korea's investment in virtual reality classrooms, which allow students to conduct virtual science experiments without requiring physical lab equipment.
- Improving research and innovation: The European Union's Horizon Europe program funds collaborative research projects across member states, ensuring knowledge exchange and innovation in sustainability and education methodologies. Likewise, the United States' National Science Foundation (NSF) grants support interdisciplinary research projects combining AI and sustainability education.
- Creating global partnerships: UNESCO's Global Education Coalition is a prime example, where public and private sectors join forces to develop digital education platforms for underprivileged students worldwide. Another example is the African Virtual University, which partners with institutions across Africa to provide higher education through online learning.

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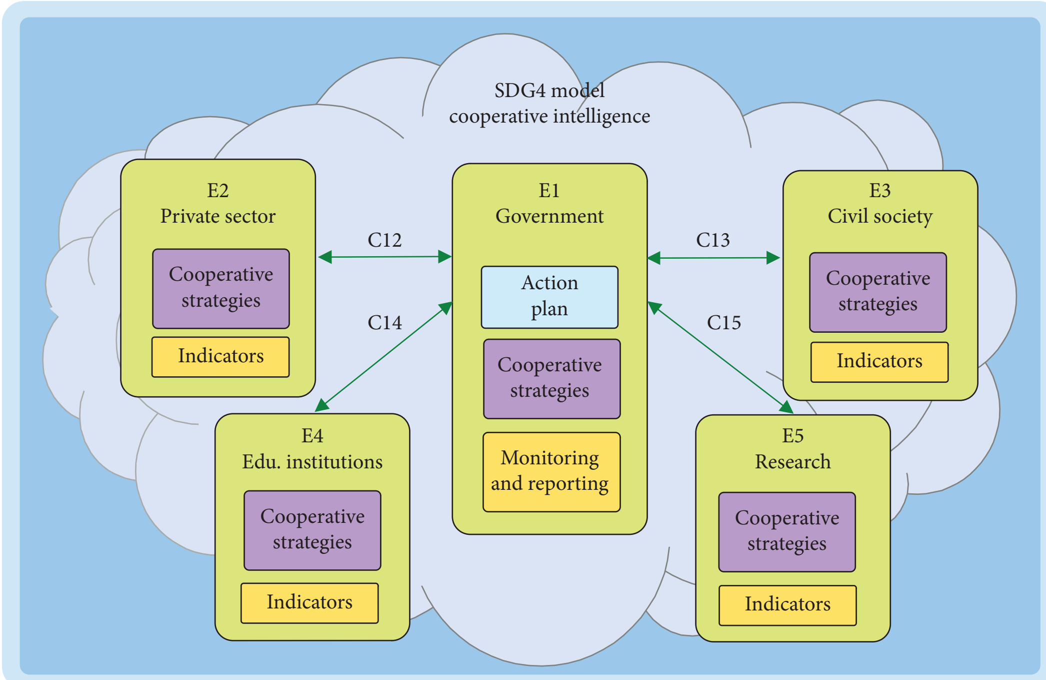

Figure 7: Generic model: cooperative intelligence for SDG4.

- Improving educational environments: The "One Laptop per Child" initiative provides digital devices to students in developing countries, enabling remote and interactive learning opportunities in rural areas. In addition, the Indian government has implemented the E-Pathshala program, which offers free digital textbooks and resources to students and teachers.
- Improving research funding: Governments and private entities, such as the Bill & Melinda Gates Foundation, provide grants to research projects aimed at developing innovative educational tools and methodologies. The Chinese government's Thousand Talents Program also funds returning scholars to establish research institutions focused on educational technology.
- Augmenting student mobility and joint research: Erasmus+ in Europe allows students and researchers to study in different countries, promoting cross-cultural exchange and academic collaboration. Similarly, the Fulbright Program in the United States funds international student and faculty exchanges to foster academic cooperation worldwide.

Indeed, relevant efforts to achieve and manage sustainable education must be done at every entity through the execution of these cooperative strategies. Further, as first-level management, the government is responsible for establishing the corresponding, lower-level cooperative procedures and compiling and supervising progress reports from all the related entities.

We use our top-down approach to design an IMF for this sustainable model. In the first abstraction of our IMF (see Figure 8), all the elements of the top generic model are mapped into *cooperative system behaviors*, *knowledge*, and *legislations*. Each entity is responsible for executing moral, principled system behaviors to complete cooperative procedures according to the legislations. And each entity contains appropriate knowledge registries to execute these cooperative system behaviors. For example, in educational institutions, some of these principled system behaviors that would be delivered according to human actions must be:

- Informing the government about new educational plans: Universities should submit annual reports on the effectiveness of their sustainability courses. For example, Harvard University continuously refines its environmental studies programs based on policy changes and global sustainability needs. In contrast, Denmark's Green Schools initiative involves local communities in shaping sustainability-focused curricula.
- Informing the government about current indicators in sustainability: Schools can participate in sustainability audits, measuring factors such as energy consumption and waste management, then reporting these findings to national education authorities. For instance, Japan's Eco-Schools Program requires schools to meet specific sustainability benchmarks before receiving certification.
- Sharing and updating global legislation on sustainable education: Institutions like the United Nations University collaborate with policymakers to ensure educational content aligns with international sustainability regulations. The Global Compact on Learning has developed standardized sustainability education guidelines adopted in multiple countries.

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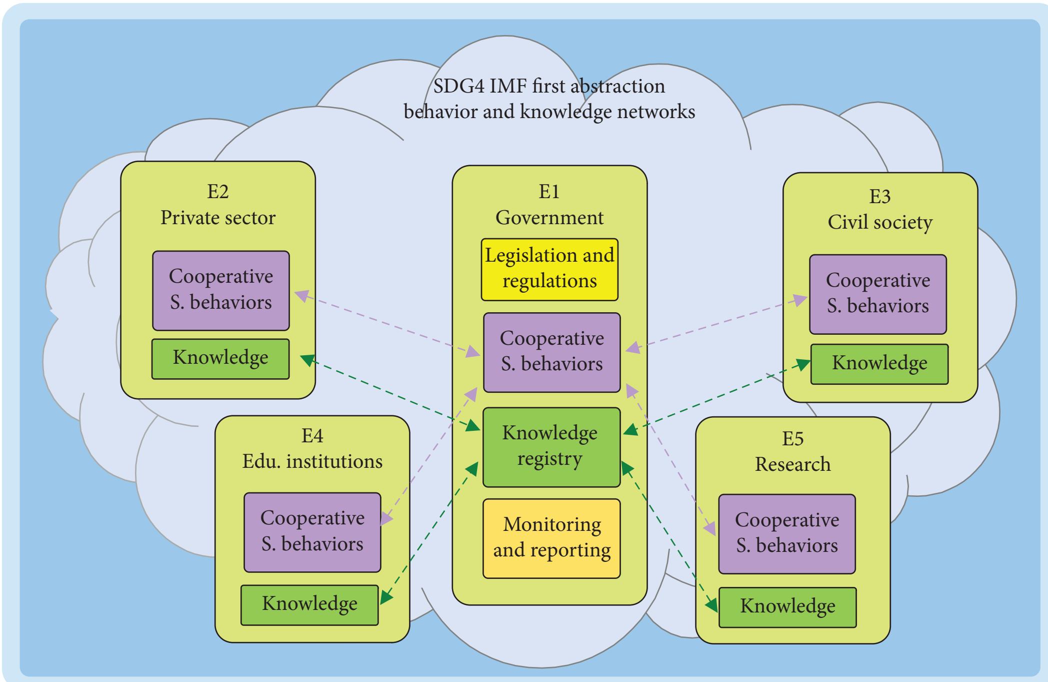

Figure 8: SDG4 IMF: first abstraction with knowledge registries and system behavior cooperation.

- Sharing professionals' curriculum and making appropriate actions: Universities should establish international faculty exchange programs to allow experts in sustainability to teach across different institutions, enriching the global academic environment. Teach for All network connects teachers worldwide, enabling cross-border teaching.
- Requesting help and support for improving educational environments: Schools in developing countries can request support from international organizations like UNICEF to provide infrastructural improvements such as solar-powered classrooms. In Rwanda, the African Development Bank has funded the construction of sustainable schools powered by renewable energy.

And the knowledge registries of this same institution must incorporate at least:

- Precise information about sustainable curriculum: A central database where universities document best practices for integrating sustainability into different subjects. For example, Australia's National Centre for Sustainability provides an online repository of lesson plans and case studies.
- Precise information about sustainable studies: Research publications and case studies on the impact of sustainability education on students' career paths and societal contributions. The United Kingdom's Higher Education Sustainability Initiative compiles research data from multiple institutions to track sustainability education outcomes.
- Educational legislation on sustainability: A repository that tracks changes in educational policies related to sustainability, ensuring compliance with international agreements. The European Commission's Eurydice network provides a centralized database for monitoring sustainability-related education laws.
- Curriculums of educational professionals: A record of faculty members specializing in sustainability education, making it easier to allocate teaching resources efficiently. The International Society of Sustainability Professionals maintains a global directory of certified sustainability educators.

Through the service-oriented refinement of our top-down approach, we design an *intelligent services portfolio* (catalog) into a GS&POC model that is key for the achievement of SDG4 at this national level. This ensures the well-being of future generations. Some of these intelligent services involving knowledge and cooperative system behaviors within the educational institution could be:

- Updating sustainable curriculum: Universities can implement AI-driven course recommendations that adjust curricula based on the latest research in sustainability and industry demands.
- Updating sustainable studies: Institutions can develop online repositories where educators share best practices and successful case studies in sustainability education.
- Navigating professional curriculums: AI-powered career guidance systems can analyze students' interests and skills to suggest personalized learning paths toward sustainability-focused careers.
- Updating educational legislation: Governments can use blockchain technology to maintain transparent and up-to-date records of sustainability-related education policies.

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- Reporting progress in SDG4: Digital dashboards that aggregate real-time data on SDG4 metrics, enabling policymakers to track progress and make informed decisions.
- Developing sustainability certification programs: Universities can collaborate with global accreditation bodies to offer sustainability-focused certifications, ensuring students and professionals gain recognized credentials in sustainable practices.

The interactions between the top cooperative entities (their system behaviors) and the precise exchange of information (knowledge) required to carry out these services can be performed by the service-oriented architecture characterizing our IMF.

In Figure 9, we represent this architecture connecting the government and the educational organizations. This figure shows how the employees in both organizations can register and/or use new intelligent services. Additionally, the managers in both organizations can administer these intelligent systems according to lower-level processes, as we describe later.

This global information system (Figure 9) is crucial for measuring progress toward SDG4 implementation according to all the educational indicators. It enables simultaneous data collection and further processing toward efficient and adequate sustainability reporting. Further, with this computational model, we automate "some" of the processes related to the management of current educational entities in sustainable development. Basically, all these processes, obtained through the process-oriented refinement of our approach, introduce some specific methods to register, manage, and deliver the intelligent services of the architecture.

Some of these processes for *services design management* are:

- Service portfolio management (creating and administering new services using the service RME).
- Service availability management (when and how to make the services available through the service delivery engine).
- Resource capacity management (administering the capacity of all the resources of the services).

Some of the processes for *services development and operations* include:

- Service architecture management (to integrate and manage the services within the architecture).
- Service deployment management (to deploy the services within the architecture).
- Change management (to administer all the changes involved with new services and/or evolved services).
- Incident management (to administer all possible incidents in the operative model of architecture).
- Problem management (to administer all the resources to solve any possible problem in the operative architecture).

For each of these processes, we must define the *activities*, *roles*, and *responsibilities* to guarantee that all of them are performed correctly. The activities represent the core methodological definitions of our IMF. Further, there is a top-level management supervising the global performance of all the processes toward SDG4 achievement.

The quality of our intelligent services can be evaluated through the analysis of our cooperative processes toward SDG4, including the coordination of activities for decision making and information exchange. Finally, managers using this IMF must guarantee that top moral/ethical behaviors are completed so the organization performs at a higher level of intelligence.

9. Case Study Assessment

The intelligent management model based on GS&POC can play a fundamental role in improving the administration of educational resources and in optimizing cooperation between academic institutions at a global level. In the context of the SDGs, specifically SDG4 on quality education, this approach would allow for the coordination of efforts between governments, universities, and private entities to promote more sustainable and inclusive educational strategies.

An example of the implementation of an IMF in education could be its use in a network of universities seeking to optimize the distribution of educational resources at an international level. Using our architecture based on AI, these institutions could share methodologies, materials, and learning tools in real time, reducing operational costs and improving educational quality in developing countries. In addition, intelligent cooperation systems would allow for the identification of gaps in education, facilitating the efficient allocation of funds and teaching staff in regions where they are most needed. The expected impact of the IMF in this context would be measured through various key performance indicators, such as access to digital education, student retention rate, and improvement in teacher training.

Likewise, its application could facilitate the implementation of personalized learning platforms that adapt to the individual needs of students, promoting more inclusive and effective educational models. Altogether, the IMF would offer a scalable and adaptable solution that would help accelerate the fulfillment of the educational objectives set out in the 2030 Agenda.

As we have suggested in Section 8, the current management of SDGs requires to deliver new intelligent services through global cooperation. And, with our framework, we have demonstrated that it is possible to design global cooperation (in an educational environment) and to incorporate intelligent (AI-driven) services to perform such cooperation. In our most recent publications, where we continue evaluating the feasibility and flexibility of IMFs, our cooperative system behavior interactions (incorporated from top level cooperative model) activate and run possible combinations of AI-driven services. This is especially

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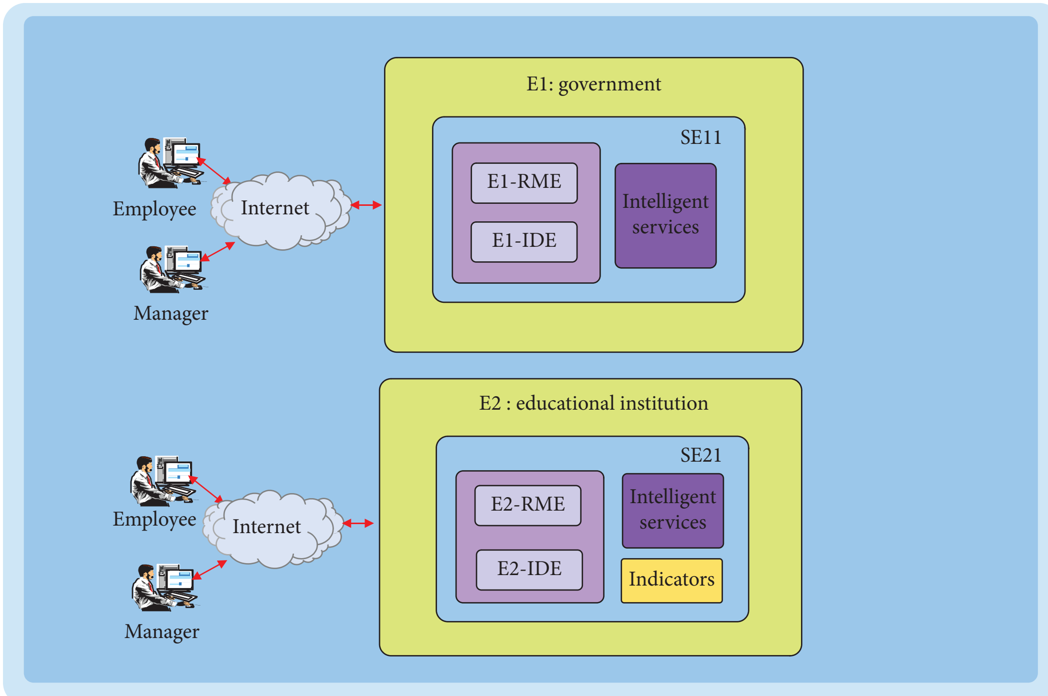

Figure 9: SDG4 IMF: third abstraction with intelligent services and engines.

relevant for developing countries which can incorporate such cooperative system behaviors to be able to activate AI-driven services being delivered by developed countries. More generally, this capability demonstrates how the intelligence of the approach is also strongly connected to the sustainability of our case studies.

10. Conclusion

This paper has presented an innovative approach to developing smart management frameworks that facilitate global cooperation in sustainability-oriented organizations. Using models such as GS&POC, it has been demonstrated how smart services, organizational architecture, and processes can be integrated into a flexible framework to improve decision making and efficiency in educational settings and beyond. The top-down design methodology has been key in this process, allowing a structured evolution from conceptual models to operational implementations. Further, the work has shown:

- Relevant insights to manage global, generic organizations.
- New principles and rules for intelligent management with related AI solutions.
- New organizational principles for process-oriented cooperation which are not supported in current standards like ITIL v4.
- GS&POC abstractions based on suitable computational intelligence for our IMFs.

The development of our smart management frameworks is especially relevant in the context of the SDGs, where global cooperation is essential to achieving common goals. Through this study, the potential of these frameworks to optimize resource management and improve operational efficiency of organizations in different sectors has been identified. Beyond education, IMF could be applied in areas such as public service management, healthcare, and digital governance, offering innovative solutions for sustainable development.

In terms of future applications, this work lays the groundwork for the design of smart cooperation systems in multiple domains. The flexibility of the model allows it to be adapted to different scales, from individual organizations to international collaboration networks. In this sense, the IMF not only represents a step forward in organizational management but also opens new possibilities for the digital transformation of public and private entities.

11. Future Work

The next step in this research will be the validation of the proposed framework in real environments by implementing pilots in educational and governmental organizations. To do so, we will seek to collaborate with institutions interested in adopting IMFs based on GS&POC, implementing concrete demonstrations and evaluating their impact through specific performance and user satisfaction metrics.

Prior to these implementation pilots, we are planning to run other publications yet providing formal definitions and technical implementation details for our IMF proposal. This shall include concrete data structures and data flaws between abstractions, integration algorithms, system diagrams, pseudocode, and other formal notations for our abstractions and refinement techniques. This work will provide further

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technical interpretations and will enhance future reproducibility of our IMF approach.

Parallelly, we will investigate concrete implementation details for the AI techniques integration within our IMF. In this paper, we have outlined how our intelligent services incorporate both knowledge and behavior structures and mechanisms. Future investigations will explore how these intelligent services can be mapped to AI applications based on concrete trained models using neural networks and learning algorithms. Additionally, we will investigate how to implement the cooperative system behaviors of the framework using appropriate knowledge-oriented and behavior-oriented AI techniques. For example, it might be interesting to investigate how our framework can be connected to well-known models like the Skill/Rule/Knowledge-based model of Rasmussen [54], more recently extended for cooperation in [55].

Another key aspect of our future work will be the integration of advanced AI technologies in the IMF. This will include the application of machine learning techniques for process optimization, as well as the development of intelligent agents capable of facilitating cooperation between different entities. The incorporation of web intelligence and data-driven AI technologies will improve the responsiveness and adaptability of these frameworks in complex and changing scenarios. In addition, the possibility of extending the model to additional sectors such as healthcare and public administration, where smart cooperation can generate a significant impact, will be explored. It will be analyzed how IMFs can contribute to improving data management in critical infrastructures, optimizing resource allocation in hospitals and strengthening the resilience of governments in the face of global crises. These advances will contribute to consolidating the role of the IMF as a key tool for sustainable development and global cooperation in the digital age.

Data Availability Statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Conflicts of Interest

The authors declare no conflicts of interest.

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