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Abstract. Our research question focusses on the complex networks of organizations of business partners that by exchanging data and sharing control collaborate for typical business or social objectives. We revisit such networks of organizations studied under the collaborative networks research area in a multidisciplinary attempt to construct a common balanced sociotechnical framework based on the interactions between social and engineering sciences. Our proposal discusses the collaborative network under the 4.0 following industry time frame classification, considering momentous evolution steps towards the digital. This paper presents and discusses research towards balanced sociotechnical concepts and definitions founded on previous studies with a recognized influence from social science and engineering systems. The paper further points out a strategy to validate the research in a Robotic Process Automation (RPA) case and, in the context of the HORUS project with BP Portugal.

Keywords: Sociotechnical Systems, Collaborative Networks 4.0., Sociotechnical framework.

1 Introduction

Industry 4.0 represents an evolving paradigm of manufacturing systems as growing adoption of automation artifacts towards digitization, as discussed in [24]. In essence, the corresponding advancements are motivated by the aim of producing maximum output with minimum resources. The fast-growing adoption by industry of digital technologies such as cyber-physical systems (CPS), Internet of things (IoT), and cloud computing [24], have been a significant research and development driver.

Although over the last few decades, the technological evolution progressed at a pace of growth not uniformly followed by all research areas since the creation of common understandings between different scientific disciplines takes time. The endogeneization of technology advances has been, for a long time, a concern of social science researchers [21]. The Tavistock Institute in London pioneered the concept of sociotechnical systems by the end of the 1960s, to understand the symbiosis between workers and the manufacturing processes and technology.

The more recent decades have also seen the emergence of collaboration in industry and services, raising research questions such as how to best support the interactions between humans and intelligent autonomous systems. Further to the traditional partnership among people and organizations, the concept is now also relating to the growing integration of independent, smart computing elements where the necessarily evolving role of workers needs to be studied. When researching the non-technical challenges of Industry 4.0 [10], it is imperative to discuss the social consequences and context implications from a generalized adoption of digitalization.

Trends to increase control by intelligent autonomous systems, in most cases associated with marketing pressure, need to be carefully studied. A typical result is that the work usually performed by people replaced by computing systems, which raises the question of rethinking an alternative role for human workers. One example of such a fast move is the adoption of software robots to substitute personal interaction with office-like informatics systems by mimicking web interface interactions. Such autonomous computing systems, sometimes identified as Robotic Process Automation (RPA) components [13], constitute a new family of technology artifacts. A simple example of applying the RPA strategy is to imagine a mobile application that, from an authenticated voice order, e.g., "*Please transfer fifty euros from my expenses account to X's allowance account*," automatically transfers the amount from one account to another. Such an intelligent computational agent, activated by voice orders, translates the request into the equivalent interactions with the respective mobile banking app. This trend is getting momentum since the approach does not require complicated and costly changes to the organization's informatics systems. A programmer can simply develop the robotic computational element to install in a mobile or a web browser, e.g., the money transfer between bank accounts. No changes are necessary to the home banking interface, the RPA element just impersonates user interactions, from authentication to filling the proper form fields in the same way the user does to interact with the home banking App.

While simple and with potential value for businesses and people in a diversity of application domains, the RPA technology raises several questions both at the organization level and from the perspective of a collaborative network's organization. Collaborative Networks (CN) [3] and, in particular, what is proposed in [8] as emerging Collaborative Networks 4.0, consider a wide adoption of advanced digital collaboration forms. Taking our simple RPA example, the question is how the adoption of robotic process automation in organizations influences attitudes from an ethical point of view and how we can prevent social disruptions. We mean by social disruptions situations leading to drastic changes in workforces, e.g., the drastic reduction of the workforce without a strategy to establish paths able to integrate workers in alternative functions through training plans or other social or management strategies.

Adopting a balanced approach to the research of the sociotechnical dimensions in CN4.0 is needed to contribute to an equilibrium between social and information sciences, and technical realizations and engineering perspectives. The aim of achieving such balance is a not novel idea, as evidenced by earlier research on balanced automation, namely the introduction of the anthropocentric manufacturing concept centered on people [7]. Despite such more initial contributions, a shared understanding and a clear identity for the sociotechnical system remains an open research question, which we address in this work.

The remaining of this paper organizes as follows: Section 2 presents and discusses related research from the social sciences, management, informatics, and engineering fields, establishing the ground for a balance developing twined perspective among social sciences and technical achievements, leading to a sociotechnical understanding of the next generation of collaborative networks or CN 4.0. In Section 3, based on related research, we present and discuss a sociotechnical framework to structure and propose guidelines and rules contributing to a balanced, collaborative network under the CN 4.0 vision. Section 4 introduces two ongoing projects grounding the strategy for the validation of the proposed sociotechnical framework. Finally, in Section 5, we present conclusions and directions for further research towards a balanced CN 4.0 sociotechnical framework.

2 Sociotechnical Research Approach

The sociotechnical research dates back to the 1950s emerged as a paradigm shift in the way of thinking and managing organizations. The sociotechnical thought roots from the social sciences, and sociotechnical thinking [24], coined in Great Britain from the coal mines case. This research showed that early in 1949, workers had found a way to regain group cohesion and self-regulation, increasing their power, and participate in decisions regarding the organization of their work, albeit with more advanced mechanization. Against the mainstream of Taylorism and bureaucratic principles, the sociotechnical theory claimed an "organizational choice" conducted by the Tavistock Institute of Human Relations in London led by Eric Trist.

Since the edition *of Organizational Choice* in the 1960s [26], a group of social scientists relied on the thesis that organization of work could shape almost independently from technological constraints - there would always be room for an "organizational choice" [5]. Nowadays, the increasing trend for the immateriality of technology makes it possible to consider more design alternatives for production systems that better correspond to the potential of the human user, namely to individual and collective autonomy and cooperation, which in turn increases the organization's effectiveness and efficiency. An essential insight into the approach of sociotechnical systems involves social and technical elements, being the two systems intertwined in a complex network of mutual causality. In other words, the social and technological aspects of organizational systems feed on each other, as new technologies open up new possibilities for work and, in turn, new ways of working open the way for technological change [27]. In reacting to technocentric thought, researchers rooted in the sociotechnical systems (STS) perspective argue that better results are achieved if people, machines, and context meet together [30].

The open system concept is of paramount importance for sociotechnical systems since the worker is, according to [19], a complex, dynamic, stochastic, nonlinear, nonsteady, and self-organizing system. The concept of an open system grounds on the definition proposed by Bertalanffy [30] for living organisms and their interaction with the environment defined by the steady-state theory, according to which an open system is characterized by a steady-state achieved by some stimulus after a disturbance. A sociotechnical system embodies workers as open, living systems interacting in contexts, influencing, and conditioning the technical systems. The sociotechnical discourse is strongly influenced by the open system concept, as formulated by Bertalanffy [30]. As such, the sociotechnical theory has developed the notion of the "interaction of social and technical elements," an essential dimension for studying the performance of systems. The interactions between workers and technology artifacts encompass linear cause and effect relationships when planned, and generally estimated as nonlinear relationships, complex and even unpredictable if unexpected [31]. The resulting interleaved socio and technical elements have different forms of behaving when compared with the technological artifacts, establishing that people are not equipment. Furthermore, with the increasing systems' complexity and interdependencies, technology can demonstrate nonlinear behavior as well. The linear and nonlinear types of interaction arise when a sociotechnical system enters into operation. The mutual adjustment is identified in [28] as the "joint optimization" of two subsystems. Based on these contributions we can summarize sociotechnical systems as showing the following main characteristics as discussed in [4]: i) systems must have interdependent parts; ii) systems have separate but interdependent technical and social subsystems; iii) systems' goals are reached by more than one way (there are always design choices made during the process of development); iv) systems' performance relies on the joint optimization of the technical and social subsystems. Two foundational principles embed early sociotechnical studies, namely: (i) a systems approach, and (ii) emphasis on the interaction between the social and the technological parts.

From our perspective, we need some equilibrium between the sociotechnical and the more technical discourse, i.e., what we call a balanced approach. One paradigmatic example is the innovation in user data entering as materialized by the Robotic Process Automation (RPA) concept. In a simple definition, "*RPA is an umbrella term for tools that operate on the user interface of other computer systems in the way a human would do*" [29]. This view focuses on the innovation aspect but does not address any social concern. However, the mentioned article touches, in fact, social issues when the authors state that "*work that can only be done by humans*." Thus, despite not directly related to social studies, that research shows some social concerns. In [13], while not following a sociotechnical discourse, the social skills and other human competencies like creative thinking or intellectual judgment are used to delimit the intervention domain for the discussed computing software-based robots, the RPA.

Another example of related research develops a framework for intelligent monitoring of a multi-agent system seen as a sociotechnical system [11]. In this case, the advanced concepts to approach a social discourse is a sociotechnical system, including the interplay between humans, organizations, and technical systems. The organizational aspect is not, however, explored or even related to the proposed monitoring system; it diagnoses merely, reconciles, and compensates the technical system. In what seems a complementary approach, a theoretical model for the integration of Industry 4.0 with sociotechnical centers puts the discourse at the organizational level [24]. Despite the formulation of a digitalization strategy to optimize the organization, the sociotechnical language differs. The idea of tandem, establishing a worker-technology tight symbiosis, the proposed six principles — people, infrastructure, technology, processes, culture, and goals— grouped into three perspectives - vertical integration, horizontal integration, and end-to-end integration - are contributions for the sociotechnical (re)construction.

The concept of virtual organizations' breeding environment (VBE), offering a preparedness condition for the creation of dynamic virtual organizations, associates the notion of prestige as a social recognition to measure value related to collaborative networks [1]. The social nature is also associated with the creation of knowledge and knowledge exchange as a core process in knowledge creation and, therefore, a fundamental contribution to trust management. The social perspective is explored further in the classification of VBEs by associating social prestige and considering formal or social orientation in finding social values [2]. This research founds the need to develop a framework where persons and technology somehow framed in organizations and networks cooperate under complex interaction mechanisms.

3 A Sociotechnical Framework for Collaborative Networks 4.0

Future Collaborative Networks is, in our research, understood as featuring entities that interact mostly based on digital mechanisms and structured collaboration concepts. Regarding the digital artifacts, we are thinking of intelligent computational elements (smart technology artifacts), which have the potential of replacing workers and becoming a kind of "digital worker," e.g., the RPA case [29], [15]. Structured collaboration concepts defined as business and social processes join persons or workers. Workers interact employing digital mechanisms, e.g., create a group, invite partners or friends, cowrite a report, establish privacy rules, subscribe to events, from many other daily life activities. Another example requiring research on social aspects when moving towards digitalization is the case of using robots in healthcare to attend patients, in which it is crucial to consider the impact on them[6]. However, from the existing literature, it is difficult to get a common rationale to establish a minimal consensus or a common framework sustaining the discourse and facilitating specialized mappings to each of the participating knowledge domains.

Two approaches can be used as a starting basis in designing such a common understanding:

The modeling of sociotechnical systems, as presented in [22], can be founded on socio-semantic frameworks establishing a hierarchical approach based on three classes of models: i) micro-level, ii) meso-level, and iii) macro-level dynamics. The idea is to build a model based on the study of terms or *n-grams* to identify semantic patterns and, in this way, establish clusterings of related concepts. This research argues about the proximity of understanding social networks of a sociotechnical system where the approach hereby adopted can help to understand semantic interactions in social systems. The proposed agent-nodes and concepts establish complex graphs where contents are exchanged and mediated by technical solutions. Nevertheless, the approach lacks the main concern associated with the symbiosis between technology artifacts and workers.

The second case is derived from the Information Systems perspective and was carried out in a scholarly context, leading to the proposal of the Neo-STS neo-sociotechnical framework. The Neo-STS framework aims at information systems scholars to understand work trends and technology enablers [32]. This research defines a working system as a symbiosis of mutually-shaping social and technology systems. It also proposes a set of axioms to help to structure sociotechnical work organization through the concepts of containment and nested-ness: i) *premise 1* **-** sociotechnical systems encapsulate work systems, ii) *premise 2* **-** work systems are a composite of social or technical elements, iii) *premise 3* **-** composing elements make work systems to derive purpose, meaning, and structure from the multiplicity of contexts, and iv) *premise 4* **-** work systems are the support of work performance, and goals and values alignment.

The discussed sociotechnical, and related research cases focus on partial perspectives. To our knowledge, no generic reference model exists framing the core concepts under a unified model and considering both the social and engineering sciences and technology bodies of knowledge. The need for a unified model motivates the proposal of what we designate by Sociotechnical System Collaborative Network (STS-CN). This STS-CN framework is a Sociotechnical System (STS) made of STS nodes. An STS node is a sociotechnical system, as depicted in **Fig. 1**., which can be a composite of other sociotechnical systems (subsystems) or units. A unit is a terminal concept since it can not further decompose into sub-elements. We adopt the concept of system as discussed and defined in the context of INCOSE[1] under an attempt to unify an important concept for both the engineering body of knowledge and other disciplines such as the social sciences [23], [12]. Any system, both real and abstract, is defined as "*A complex whole, whose properties are due to its constituent parts, as well as to relationships among the parts*," which we graphically map into the abstraction presented in **Fig. 1**, where the whole is the sociotechnical system delimited by some particular context or application domain. The parts that we refer to as elements are called Units if not decomposable into other elements.

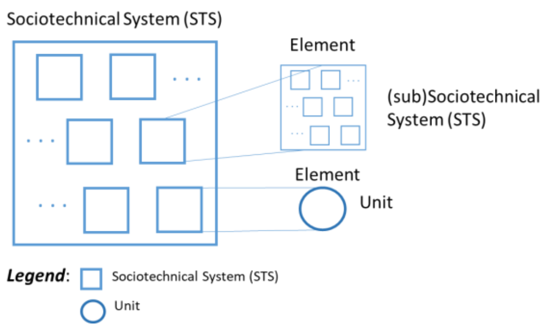

Fig. 1. The abstract representation of a Sociotechnical System

[1] The International Council on Systems Engineering - https://www.incose.org/

The Unit concept represents a single entity such as a worker or a technology artifact in the context of a sociotechnical system. By adopting standard "system concepts" to our proposed balanced approach, we delve into concepts which, in most cases, come from the social sciences to establish a unified discourse for the proposed complex sociotechnical CN 4.0 system. We further incorporate the simple Conceptual Modeling language also used in [20] to model sociotechnical critical air traffic management systems with a focus on workers' (air traffic operators) interactions with system user interfaces. We define a sociotechnical system as a concept inheriting the INCOSE systems definition, as depicted in **Fig. 2**, formalized using the CmapTools [9]. We adopt a slightly different vocabulary, e.g., instead of a part to identify a leaf or terminal non-decomposable element commonly used in mechanical engineering, we choose the term ***Unit,*** meaning a terminal concept. A Unit does not decompose into other (sub)units. The Unit is a terminal concept referring to a tangible or conceptual thing.

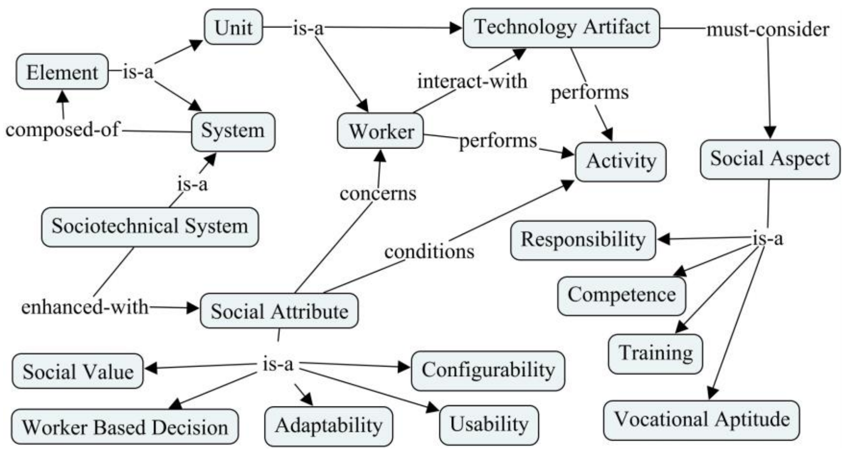

Fig. 2. Relating concepts of a Sociotechnical System in a Concept Map

A Unit can be a Worker or a Technology Artifact, seen as a single entity. By Technology Artifact, we mean an informatics system (Isystem) [18], [17], offering some form of interaction with workers, e.g., a web browser of a mobile application. Both Workers and Information System carry out activities which we do not detail further since they can involve a complex sequence of atomic operations guided by some execution logic established by a program. If a Unit is a Worker, the actions follow a manual procedure, and if the Unit is an Isystem, the instructions follow some computer programming language and computing mechanisms. The sociotechnical dimension of the Technology Artifact is represented by the "***must-consider"*** that associates it with its "***Social Aspect."*** The Social Aspect decomposes further into a set of sub-aspects, associated with it through the ***is-a*** relationship in Fig. 2, including ***Responsibility***, ***Competence***, ***Training***, or ***Vocational Aptitude***, as essential features to be considered in the design of the respective Isystem. The proposed features are not complete and need to be further detailed. They incorporate Isystem development tools, e.g., a validation mechanism based on some questionnaires for users to feedback valuable suggestions to improve the technological artifact.

In the proposed balanced sociotechnical framework for CN 4.0, the ***Sociotechnical System*** concept justifies the specialization concerning the ***system*** since it is "***enhanced-with"*** specifying its "**Social Attribute**." In other words, a Sociotechnical System needs to show its ***Social Value***, ***Worker Based Decision***, ***Adaptability***, ***Usability***, and ***Configurability***. The proposed features summarize what seems a consensus in the sociotechnical systems research community. Still, our purpose is not to formulate the set of concepts as final but rather to contribute to an accurate and consensual definition. Moreover, our concern is related to the balanced perspective since the consensus needs to go beyond the social sciences and also embrace related research areas from engineering sciences.

One interesting question is how to establish a metric for the Social Value of a sociotechnical system. The EU 7th FP research project entitled Theoretical, Empirical and Policy Foundations for Building Social Innovation in Europe (TEPSIE) defines social value as "*the kind of value that innovation is expected to deliver: a value that is less concerned with profit and more with issues such as quality of life, solidarity, and well-being*" [25]. On the other hand, another research developed at Standford considers that "*Social value is not an objective fact. Instead, it emerges from the interaction of supply and demand and, therefore, may change across time, people, places, and situations*" [16]. Another proposal to rethink value is focused on monetary value contribution and proposes a theoretical framework for the definition of value in social contexts [14].

In our sociotechnical framework, it means that workers or people in a collaborative network shall experience the necessary mechanisms that make them develop their work. A worker negotiating some product development with one or more partners, for instance, in the context of a collaborative network, shall have the means to discuss the terms of the contract, and suggest and accept changes. Furthermore, after achieved an agreement, to close the negotiation, the worker shall have the means to digitally sign it and, this way, commit the negotiation process. If a series of technology artifacts were to offer such expectations, they should perform reliably, be complete for the mission and let all participants be confident in their performance. One main open question is how to embed social values into the design, development, and validation of such technology systems. The clarification of concepts hereby presented expects to help better understanding how the development of technology systems can incorporate sociotechnical attributes from their conception. Since different background knowledge participates in the events of sociotechnical systems, having a common framework seems to be of paramount importance.

The other attributes follow the same rationale since they aim to underlie our framework, and with the validation strategy discussed later in Section 4, they expect to provide further understanding. **Social Values**, such as fairness, customer benefits, and work organization models, among others, are embedded by technologists in shaping technological choices of systems design. The ***Worker Based Decision*** feature means that the user of the technology artifact can make the changes, namely withdraw previous decisions, which she/he considers necessary for the execution of the underlying activity. The worker based decision also implies that a technology artifact reliably logs all the decisions and modifications to produce pieces of evidence protecting the user in case of some auditing process. The ***Adaptability*** feature means that the technology artifact adapts interface mechanisms according to user needs. An example is a keen awareness of different languages and time zones of workers collaborating on different continents in the context of a collaborative network. When collaboration involves workers with language restrictions, the participating technology artifacts shall introduce some translation services. By ***Usability,*** we mean the design of user interfaces that maximize user accessibility, safety, and simple access mechanisms to needed interface elements. Again, the usability feature relates to competencies or specialized bodies of knowledge, such as e.g., the Interaction Design Foundation[2], a research source for this specific domain. The last concept, ***Configurability***, is defined in [11], in the context of a sociotechnical system as *"... self-reconfigurable, i.e., capable of switching autonomously from one configuration to a better one ...*". The mentioned research proposes to incorporate a *Reconcile* mechanism to find a better configuration capable of better fulfilling user objectives and a *Compensation* mechanism to make the changes effective. We consider Configurability reflected in the capabilities of a technology artifact to change behaviors under the user's control to improve execution quality and performance.

Finally, we discuss the projection of the proposed sociotechnical thoughts to the collaborative network context. In particular, we envisage an integrated digital network of sociotechnical systems, as depicted in **Fig. 3**. One central aspect is the unified sociotechnical thinking across Collaborative Networks (CN).

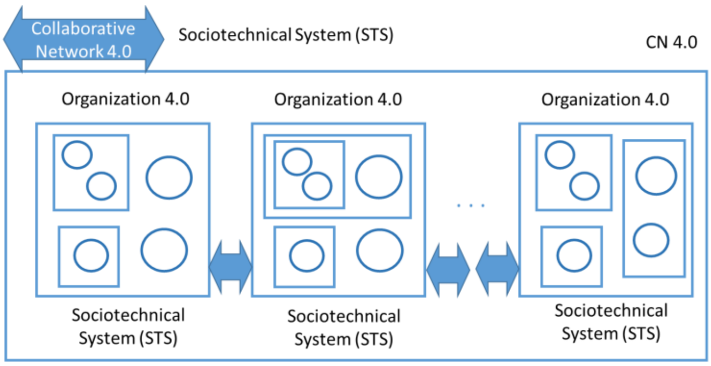

Fig. 3. Collaborative Networks 4.0 as a Sociotechnical System

Following the definition of a sociotechnical system depicted in **Fig. 1**, a collaborative network connects instances of those systems that interact to do business and play as a social actor. Our objective is, in a first approach, to clarify and if possible formalize the intrinsic behavior of a sociotechnical system in a network context as a strategy to help to develop a better, more efficient, and "learning" technical system for users at this level considering the system of systems CN. A straightforward example can be an administration employee going to a healthcare service to check the refund of his expenses without the need to scan an invoice and check in the email messages

[2] Interaction Design Foundation - https://www.interaction-design.org/literature

reporting steps of its processing. If a CN 4.0 environment exists involving the (smart) systems of the administration, the healthcare, the laboratory of medical tests, and other involved stakeholders, the user, in the example a public servant, is expected to access a unique employee management interface and access to relevant information on collaborative business processes executed in the background. The simple example offers users the best automation services to make them transparent concerning the number of document exchanges that the organizations are required to carry out. The scenario is possible but still difficult to implement since different organizations with different socio-organizational cultures need to put their technology artifacts in cooperation. However, our research concern in this work is not the technical feasibility but rather to get insights on how to conceive sociotechnical systems, framed by the discussed framework.

One interesting aspect that derives from different roles of a public servant and of a user of a healthcare system is considering the following case: i) a servant as a user of the healthcare system, and ii) the servant as an employee of the Public Administration. In both servant and user roles, the expectation is that services integrate, e.g., reimbursement of healthcare expenses shall automatically resolve. We think that a systemic approach to Collaborative Networks 4.0 makes the research challenging since it has to incorporate many views to make services integration more useful and comprehensive.

4 Exploratory Strategy for Validation Case Studies

We discuss two ongoing projects aiming to play as validation case studies for the proposed framework: i) the implementation of robotic process automation (RPA) system from the perspective of a consulting company implementing RPA solutions and, ii) in the HORUS project to rethink the automation of support and maintenance services in a forecourt fueling network. The HORUS project we discuss as a second case aims to develop a technical system to control post-payments in a forecourt fueling station. The post-payment models may lead to situations where drivers leave the forecourt without payment, the motivation for an open standard to automatically manage fueling authorizations accepted at the Point of Sale (POS) technical system.

The RPA case bases on the experience of the private consulting company BTEN in developing processes automation projects for both public and private organizations. From an initial interview with BTEN CEO and partners responsible for RPA projects and based on an anonymous and abstract analysis of deployment projects, the following analytical framework was agreed:

- Motivations for an RPA, to be generalized for any process/technology innovation project;
  - ***Socio-Organisational***, e.g., task content; characteristics of operations; organization of work, skills requirements;
  - ***Socio-Economical*** e.g., productivity; wages; labor costs.
  - ***SocioTechnical***, e.g., quality of tasks, processes coordination; integration of servives; person/technology interactions.
- Achievements considering sociotechnical changes:

- ***Worker inclusion***, e.g., workers adapting to RPA configuration and operation needs, including training and moving to new functions;
- ***User satisfaction***, e.g., new and integrated, services for citizens or customers.

The proposed framework founds on past and ongoing project cases where the proposed analytical dimensions bases on preliminary observations. As an example, a six months project involving six experts among architects and developers in a public organization was motivated by the need to solve pending delayed processes. One considered aspect we classify as a ***SocioTechnical*** issue driving the adoption of RPA was the ***quality of tasks,*** identifying repetitive operations that could be automated. Another aspect considered by the project was ***worker inclusion,*** realized through training activities and development of new skills. The ***user satisfaction*** (relating to citizens in the case) has also been a primary driver for the project, addressed by solving delayed processes. **Fig. 4**. depicts the proposed Balanced Sociotechnical Analytical (BSAF) framework shaped as a concept map.

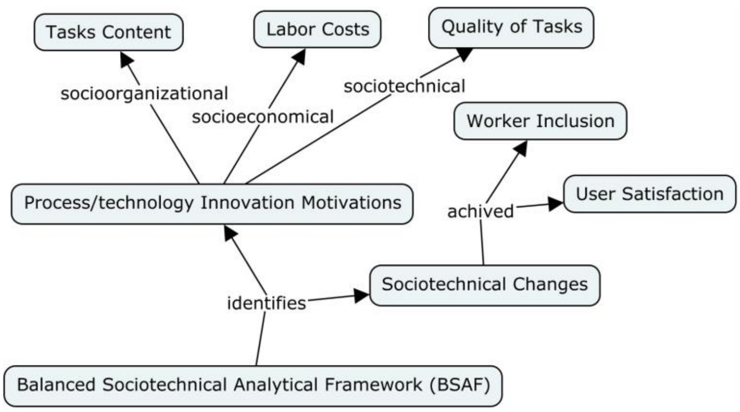

Fig. 4. Concept map of the Balanced Sociotechnical Analytical (BSAF) framework

The intention is to extend the application of this framework to new cases of BTEN and also to apply a similar approach directly to customers that agree to participate in the study. The purpose is to consolidate the analytical framework aiming to help both consulting companies to address new customers and also customers themselves, as an approach to better comprehend the founded mechanisms for a win-win implementation of RPA.

The HORUS case has a distinctive nature since the approach is not RPA but rather the automation of the maintenance of technical systems in a fueling forecourt of a fuel distribution network. In this case, workers from the fuel company have to coordinate problem solving actions with workers from suppliers responsible for groups of technical systems. In this case, the challenge is intrinsically collaborative since three independent suppliers are required to coordinate the support and maintenance of the technological systems under their responsibility. Beyond the technical elements establishing how technological systems organize and interact, the relevance for our research is how workers from the collaborating partners and users/customers *perceive* the changes. A critical change of the collaborative maintenance process and technology framework is the possibility of workers from the fuel company and competing suppliers with interdependent technical systems to follow any failure of any computational or cyberphysical system event and its resolution. It means that workers with coordination or operation roles from different organizations develop contributions under an enhanced, mutually "observed" collaborative digital environment. Therefore, our purpose here is not to discuss the technological approach but rather to understand the needed changes as a sociotechnical system. Following the technical and organizational innovation, our main objective is to apply the framework to diagnose the automation achievements under the proposed balanced sociotechnical framework for collaborative networks 4.0.

5 Conclusions and Further Research

In this paper, we propose and discuss a balanced sociotechnical framework for collaborative networks 4.0. The proposed analytical framework is presented and discussed in the context of two exploratory cases, one considering a research partnership with BTEN consulting and the second one, the HORUS research project with BP Portugal, to rethink the processes and the technology system used in a fueling distribution network.

One primary purpose is to understand the motivation for adopting collaborative automation processes from a socio-organizational, socioeconomic, sociotechnical analytical framework. As a complementary analytic dimension, we purpose to include both worker inclusion and user satisfaction. We assume the proposed analytical dimensions as a first attempt, which, based on further data, will probably evidence the need for additional accurate criteria.

In particular, the collaborative network 4.0 context raises additional research questions. Workers are supposed to join more extensive organizational settings making decisions on pressing a button in a desktop, laptop, or mobile interface with an impact on networked business partners. Such challenging collaborative scenarios where workers are accountable under risky decision processes need to be further studied. A balanced sociotechnical CN 4.0 means each networked business partner adopts a whole digital integrated working setup getting workers and clients/customers, respectively, to adapt and to perceive learning experiences.

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