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Evolution From Human Virtual Teams to Artificial Virtual Teams Supported by Artificial Intelligence. Results of Literature Analysis and Empirical Research

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Abstract

Purpose: The paper addresses the research problem of the new organizational reality which will include hybrid virtual teams, where both humans and artificial agents will be members and management tasks or leadership roles will be assumed by artificial intelligence. The objectives of the paper are to initially answer 4 research questions: (1) what are the characteristics of virtual teams in the era of intelligent technology, (2) what is the role of technology in changing the human-machine relationship, (3) to what extent can artificial intelligence replace humans in a virtual team, (4) how can team members be replaced by artificial intelligence in a virtual team.

Design/methodology/approach: The research method is a literature review and our own empirical research concerning the new organizational reality with hybrid virtual teams consisting of humans as well as artificial agents. The research data was the results of a long-term observation of a virtual team which was conducted in June 2021 in a group of students who worked 36 hours using online management tools in TransistorsHead.com and MS Teams.

Findings: The research has shown that virtual teams require different ways of communication and that consequences of working in such a team change the types of tasks, time spent working together as a group and social aspects of cooperation between team members. This experiment has shown that

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the decision-making process based on artificial entities can fulfill the requirements of virtual teams and that such entities can be considered as teammates or teams (Team As A Software – TAAS). It is also possible also to imitate a human-like manager (Manager As A Software – MAAS) or its higher evolutionary copy, namely a "sophisticated superhuman machine".

Research limitations/implications: The research results presented here are an example of research conducted from 2012 on, by means of online managerial tools, concerning the work of virtual teams and the opportunity to replace a human manager with a robot one. The answers to the research questions can only be applied to the studied group of students and cannot be generalized for all teams. Future research will be conducted with a wider group of respondents.

Originality/value: The originality of the presented research results lies in the fact that the data collected during the research represents the real activities undertaken by the manager and his/her team members during the 36-hour work on the task concerned rather than being mere declarations of these activities by the respondents.

Keywords: virtual teams, artificial management and leadership, artificial teammates, evolution of virtual teams, autonomous teams.

JEL: M12

Ewolucja zespołów wirtualnych od złożonych z ludzi do wspieranych przez sztuczną inteligencję. Wyniki analizy literatury i badań empirycznych

Streszczenie

Cel: w artykule podjęto problem badawczy dotyczący nowej rzeczywistości organizacyjnej, w jakiej znajdą się hybrydowe zespoły wirtualne, w których członkami będą zarówno ludzie, jak i sztuczne obiekty, a zadania zarządcze lub role przywódcze przejmie sztuczna inteligencja. Celem artykułu jest wstępna odpowiedź na cztery pytania badawcze: (1) jakie są cechy zespołów wirtualnych w dobie inteligentnych technologii; (2) jaka jest rola technologii w zmianie relacji człowiek – maszyna; (3) w jakim stopniu sztuczna inteligencja może zastąpić człowieka w zespole wirtualnym; (4) w jaki sposób członkowie zespołu mogą być zastępowani przez sztuczną inteligencję w zespole wirtualnym.

Metodologia: metodą badawczą był przegląd literatury oraz badania empiryczne dotyczące nowej rzeczywistości organizacyjnej z hybrydowymi zespołami wirtualnymi. Dane badawcze zostały zgromadzone w wyniku długookresowej obserwacji zespołu wirtualnego, która została przeprowadzona w czerwcu 2021 roku wśród grupy studentów pracujących 36 godzin z wykorzystaniem narzędzi zarządzania online w TransistorsHead.com i MS Teams.

Wyniki: badania wykazały, że zespoły wirtualne wymagają różnych sposobów komunikacji, a konsekwencje pracy w takim zespole zmieniają rodzaje zadań, czas spędzony na wspólnej pracy jako grupa oraz społeczne aspekty współpracy pomiędzy członkami zespołu. Eksperyment wykazał, że proces decyzyjny oparty na sztucznych bytach może spełnić wymagania zespołów wirtualnych, które mogą być traktowane jako członek zespołu (Team As A Software – TAAS). Możliwe jest również naśladowanie menedżera podobnego do człowieka (Manager As A Software – MAAS) lub jego wyższej ewolucyjnej kopii „wyrafinowanej nadludzkiej maszyny".

Ograniczenia/implikacje badawcze: przedstawione wyniki badań są przykładem badań prowadzonych od 2012 roku z wykorzystaniem menedżerskich narzędzi online nad pracą zespołów wirtualnych i możliwością zastąpienia menedżera-człowieka menedżerem-robotem. Odpowiedzi na pytania badawcze można odnosić tylko do badanej grupy studentów i nie można uogólniać dla wszystkich zespołów. W przyszłości prowadzone będą badania w szerszej grupie respondentów.

Oryginalność/wartość: oryginalność przedstawionych wyników badań polega na tym, że dane zgromadzone w czasie badań przedstawiają realne czynności podejmowane przez menedżera i członków jego zespołu podczas 36 godzinnej pracy nad zadaniem, a nie są tylko deklaracjami tych czynności przez respondentów.

Słowa kluczowe: zespoły wirtualne, zarządzanie i przywództwo oparte na AI, roboty jako członkowie zespołu, ewolucja zespołów wirtualnych, zespoły autonomiczne.

1. Introduction

The modern world more and more relies on smart technologies, where work is being performed automatically and the role of an employee changes (Herschlag, 2020). Therefore, many tasks are performed in a digital environment and an automated way of doing business is becoming ever common (McAfee & Brynjolfsson, 2016). Recent experiences with the pandemic of COVID-19 have triggered a change of rules of work and cooperation in teams (Waizenegger et al., 2020). Many people have become a part of virtual teams working with less face-to-face contact. Many of their tasks started to be automated and their content mainly turned to digital data (Waizenegger et al., 2020).

This paper addresses important issues of perceiving possible configurations of virtual teams, measuring how their members operate and how their work can be automated. The research problem concerns the new organizational reality with hybrid virtual teams whose members will be humans as well as artificial agents and where management tasks, or a leader's role, will be taken over by artificial intelligence (McAfee & Brynjolfsson, 2016).

Therefore, the main research question is how artificial agents can co-exist with human beings in virtual teams. When it comes to details, there are the following specific research questions:

- RQ1: What are the features of virtual teams in the age of smart technologies?
- RQ2: What is the role of technology in changing the human-machine relationship?
- RQ3: To what extent can artificial intelligence replace a human in a virtual team?
- RQ4: How can human team managers be replaced by artificial intelligence in a virtual team?

The purpose of this paper is to present initial answers to these specific research questions found by two research methods. On the one hand, we conducted a wide literature review concerning how artificial management and virtual teams have developed over the last 30 years (Smith & Green, 2018). On the other hand, we also conducted our own experiments in the field of mapping the work of virtual teams and their members' behavior with the use of online management tools (TransistorsHead.com) based on the system of organizational terms (Flak, 2020).

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On this foundation, we showed configurations of virtual teams and suggested coexistence of various forms of virtual cooperation between humans and artificial agents. This paper contributes to the knowledge on human work which is going to be developed by artificial intelligence. This will stimulate future scientific research and promote search for new forms of effective cooperation between humans and artificial agents.

2. Emerging Artificial Virtual Teams in the Organizational Reality

In this section, we will present an initial answer to research question RQ1, which concerned the features of virtual teams in the age of smart technologies.

Under the traditional approach, a team consists of two or more individuals (Kozlowski & Ilgen, 2006). Team members are independent and they share responsibility for specific results in an organization (Herschlag, 2020). They also share roles, goals and results (Braun et al., 2012). According to Levi (2016), a team's success means completing its task, developing social relations and giving benefits to team members. Therefore, not every group can be considered as a team (Pyszka, 2015).

When a group becomes a team, it must go through at least four phases, i.e.: familiarization, first conflicts, joint agreement of strategies and means, joint work (Carr et al., 1998). These phases are in line with the theory of group growth. Tuckman (2005) listed such phases: forming, storming, norming and performing. In these phases, a team incorporates behavioral elements which shape its maturity, capabilities as well as relationships based on trust and interdependence (Tuckman, 2005).

Referring to the aforementioned features, a virtual team should not differ from a traditional face-to-face team. However, literature emphasizes differences, especially additional consequences of such a model of cooperation. Virtual teams have been defined many times in the last 25 years. Townsend et al. (1998) defined a virtual team as "a group of geographically and/or organizationally dispersed co-workers that are assembled using a combination of telecommunications and information technologies to accomplish an organizational task". Townsend et al. (1998) suggested that this kind of team may be temporary and adaptive to organizational and environmental changes. Serrat (2017) added that a virtual team is a group of people who routinely work interdependently for a joint objective across time, distance, organization and culture. It means that virtual teams, as geographically and/or organizationally dispersed members, work toward a shared goal by using various kinds of technologies (Ale, Ahmed, & Taha, 2009). The distinctive features of virtual teams include computer-based communications, temporal and geographical dispersion and task distribution (Hertel et al., 2005).

Analyzing the virtual nature of such teams, we can consider the first important feature of a virtual team, which is a way of communication. Fiol and O'Connor (2005) found that virtualness is perceived as an extent of face-to-face contact among team members (frequency of contact) and that technological support and dispersion represent tendencies rather than definitional attributes of virtual teams. This was because virtual teams may make no use of technology while face-to-face teams may make great use of technology (Griffith & Neale, 2001). Fiol and O'Connor (2005) also suggested that physical dispersion as a physical distance among members (Hinds & Bailey, 2003) was not clear. According to Kraut et al. (2002), they found that the effects of proximity among team members fall off rapidly with even very small distances. The consequence of this fact would be that the team members who reside near each other, but who never meet, may experience dynamics very similarly to those who interact across great distances, especially that virtualness depends on a way of communication (Griffith & Meader, 2004).

Despite the fact that digital tools used to communicate in teams seem to be an invention of recent years, it is worth mentioning that such solutions were proposed to enhance communication in dispersed teams many years ago. According to Daft and Lengel (1986), technology-induced media richness was seen as a bandwidth issue, ranging from no technology support to very rich support such as synchronous high-quality videoconferencing. Twenty years later, Fiol and O'Connor (2005) underlined a social context of information which was available during group communication. Poor communication due to the inability to fully participate in both verbal and non-verbal communication and a lack of informal communication can result in difficulties in establishing trust (Olson & Olson, 2006).

Another important feature of virtual teams is a continuum of virtualness (Griffith & Neale, 2001). There is an assumption that teams which never meet face to face are different in a nonlinear way comparing to those which sometimes meet, even if only occasionally (Griffith et al., 2003). Fiol and O'Connor (2005) state that virtualness does not lie on a single continuum, from nonvirtual to purely virtual. Assuming the virtualness of teams, Fiol and O'Connor (2005) suggested that both face-to-face and pure virtual teams differ in nonlinear ways from hybrid teams that meet occasionally.

The third feature which distinguishes traditional teams and virtual teams is a division of tasks among team members. Gradual advances in collaborative systems and online management tools go hand in hand with the emergence of new work arrangements (Hughes et al., 2001), in particular what is referred to as virtual work (Watson-Manheim et al., 2002). Consequently, virtual teams, supported by collaborative technologies (Jang et al., 2000), started, these days, to become an increasingly popular form of organizing

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work at the group level. According to Riemer and Vehring (2012), such advances gradually led to the point where organizations appeared virtual as they lost their traditional, physical and spatial structure, such as working in buildings or offices. Globalization and the COVID-19 pandemic have boosted the implementation of virtual team work where employees working from home use virtual tools to collaborate with their teammates (Franken et al., 2021).

On the foundation of these three main features of virtual teams, namely a way of communication, a continuum of virtualness and work division, there are consequences which form characteristics of virtual teams in the age of smart technologies.

Martins et al. (2004) stated that the main moderators of virtual team characteristics include a wide range of contingency factors such as task types (creative tasks and qualitative tasks are better than tasks requiring coordination), time spent working in a group (satisfaction with the team's processes and outcomes increased with time, time is crucial to quickly integrate a virtual team), and the team's social context (open communication and coordination improve performance).

As far as the task types are concerned, it is pointed out that the integration of diverse tasks with perspectives and directions towards a common goal is different from that in a common team (Herschlag, 2020). When acting together, team members must cope with different values, views, and passions, collaboratively answering questions that they would not always think to reflect about alone. Additionally, digitization of work and social interaction, combined with AI, allows for designing automated real-time feedback systems capable of just-in-time, just-in-place support during complex problem solving at work (de Laat et al., 2020).

Time spent working in a group in a virtual team is based on technology-mediated interactions (Dixon & Panteli, 2010). Chudoba and Watson-Manheim (2008) found a substitute of face-to-face interactions, namely the establishment of virtual continuities that emerged within teams as face-to-face and technology-mediated interactions worked in conjunction with one another. Task distribution in virtual teams could not be as effective as in face-to-face teams because of less interactivity in building a shared interpretive context among group members and diminished social presence (Peifer et al., 2021).

According to Breuer et al. (2016), the team's most crucial social context is trust. Other recent research proved how much it influences virtual team performance (De Jong et al., 2016). Trust requires that certain conditions should be met, such as a shared culture, social context, values, physical proximity, and information exchange (Serrat, 2017). Virtual teams have a problem to establish deterrence-based and calculus-based trust, but it is possible to establish knowledge-based and identification-based trust (Serrat,

2017). Trust determines whether team members ask each other for help, share feedback, and discuss issues and conflicts. Therefore, it seems that building mutual trust and personal knowledge about collaborators is more important to good collaboration than resolving technical issues during interactions by means of computer-mediated communication technologies (Treinen & Miller-Frost, 2006).

The social presence theory developed by Short et al. (1976) form the foundations of interpersonal communication and symbolic interactionism, which can be defined as "the degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships". Gunawardena and Zittle (1997) clarify this as the degree to which a person is perceived as "real" in mediated communication. They investigated whether social presence affected the degree of satisfaction of learners who were communicating via CMC and found that social presence was a strong predictor of satisfaction. However, this approach was presented many years ago; this could be important in the emergence of the flow effect and an increase in mutual trust between virtual team members (Peifer et al., 2021).

According to Kear et al. (2014), social presence relates to the need for users of technology-based cooperation to perceive each other as real people, to be seen both socially and emotionally as a real person and to see each other as real. Chun-Ming and Meng-Hsiang (2016) noted that computer-based communication is less intense in social presence than face-to-face communication but different computer-based communications between communicators and receivers can affect the levels of social presence. Recently, social presence has been used to examine the efficacy of telecommunications media, considering digital interfaces in human-computer interactions (Kim, 2015).

Based on the literature analysis presented above, an initial answer to research question RQ1 about the features of virtual teams in the age of smart technologies can be formulated. Firstly, the main features of such virtual teams are a different way of communication, a continuum of virtualness and a specific work division. Secondly, the consequences of working in such a team changes types of tasks, time spent working together as a group and social aspects of cooperation between team members.

3. Role of Technology in Changing the Human-Machine Relationship

In this section, we will present an initial answer to research question RQ2, which concerned the role of technology in changing the human-machine relationship.

The role of technology in organizations evolves, including the use of robots and intelligent algorithms in creating and managing teams (Kelleher

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et al., 2015). Larson and DeChurch (2020) indicated that we are currently entering a new stage of robotics and automation in which intelligent agents are taking over executive functions, i.e. team selection, providing feedback on the processes carried out by teams, intervening in controversial situations in the team decision-making processes.

To answer the research question pointed out above, it is necessary to mention the term "human-computer interaction" which was introduced in 1983 in "The Psychology of Human-Computer Interaction" (Card et al., 1983). Until the beginning of the 1980s, the number of scientific papers sent only to the ACM (Association for Computing Machinery) HCI conference multiplied 10 times and is still increasing (Kim, 2015).

From the very beginning, HCI focused on the perceived ease of use and perceived usefulness. They were investigated in terms of their role within the framework of the Technology Acceptance Model (Davis, 1989). The perceived ease of use is defined as the extent to which an individual believes that using a computer system will be effortless. The perceived usefulness is the extent to which users notice that using a computer system in their job will increase their job performance (Davis, 1989). Within mainstream HCI, it was proved that the perceived ease of use and the perceived usefulness can be validated (Ahuja & Webster, 2001). The other two main research themes within HCI are the provision of software support for the specification and generation of software artefacts and the modeling of human-computer tasks and activities (MacKenzie, 2013). It is necessary to underline that in any human-computer interaction, humans take actions using their sensors, brain, and manipulators (hands, legs, mouths, etc.) to do things. When these three elements work together to achieve a goal, human performance rises (Alonso-Martín et. al, 2015).

However, the relationship between human and technology is changing. It is worth saying about a growing role of intelligent agents (Larson & DeChurch, 2020), not only as a "tools for humans" (Ma et al., 2018). Referring to DeConstanz at al. (2018), a technology is assigned to various devices, software, protocols and other devices to assist in increasing the results of teams.

This also applies to robots, which should be seen as a technology that does nothing more than increase a team's efficiency. However, when they are part of a team, they have a clear role to play and a unique contribution. They become real agents (McAfee & Brynjolfsson, 2016). It corresponds to the view of robots as increasingly becoming capable of assisting humans as partners or peers, working together to carry out joint work (Ma et al. 2018).

This approach implies that a computer representation of knowledge based on human-computer interaction is needed to construct knowledge-based systems (Flak, 2020). In Figure 1, there are main elements which can shape a human-machine relationship.

Figure 1
Structure of a aspects shaping a human-machine relationship

Source: Alonso-Valerdi, L.M, & Mercado-García, V.R., 2017, pp. 33–54.

In this case, it is important to distinguish human embodied robots from non-embodied robots which can play a role of a team member and are based on AI (Larson & DeChurch, 2020), i.e. they perform tasks that require not only automation but human intelligence, because they are rather based on behavioral tasks. Therefore, Larson and DeChurch (2020) propose the terms "agents" and "human-agent teams". They also distinguish between human-robot teams and human-AI teams. According to Ma et al. (2018), human-robot teamwork creates a new host of interdependencies and questions that need to be addressed to achieve a proper level of effectiveness. Changes in technology stimulate changes in HRM at the individual, team and organizational level, which is important in value creation for the organization (Pyszka, 2018). Ma et al. (2018) mentioned the key role of communication, coordination, and collaboration for virtual teams. They pointed out that creating effective human-robot teams is challenging because robotic

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capabilities are continually advancing by leading to better physical abilities, cognition, and awareness. Recent developments in artificial intelligence have the potential to further revolutionize the integration of human and artificial cooperation during team work (Seeber et al., 2020). The challenge is how to design a machine to complete a task, which is not enough to ensure good teamwork and task execution. This kind of team has to understand the context of its relationship and the interdependencies between virtual team members (human and artificial) at work (Ma et al., 2018).

To summarize the initial answer to research question RQ2, it is worth mentioning four ways of changing the human-machine relationship by means of technology in the future. Firstly, there can be intelligent agents and powerful tools; secondly, simulated teammates and tele-operated devices; thirdly, autonomous systems and supervisory control; fourthly, humanoid robots and mechanical-like appliances (Shneiderman, 2020). The main assumption of these solutions was that machines should be intelligent, autonomous and human-like. They should support people's abilities, raise their self-efficacy, respect their responsibility and enable their creativity (Shneiderman, 2020).

4. Replacing Humans in Virtual Teams With Artificial Intelligence

In this section, we will answer research question RQ3, which was about the possibility of replacing humans with artificial intelligence in virtual teams. On the one hand, this process is very dynamic and not well recognized in the literature (McAfee & Brynjolfsson, 2016). On the other hand, there are several examples of practical use of artificial intelligence, or more generally technology, in virtual teams.

The characteristics of virtual teams presented so far indicate a role of artificial intelligence and technology in terms of cooperation between team members. First of all, the role of a recruiter is played by artificial intelligence, selecting team members according to specific characteristics and competences, e.g. on the basis of games on recruitment platforms, allocating them according to built-in algorithms (Freire & deCastro, 2021). There is also an online searchable tool with which project teams can search for teammates who want to join their team. The ideal teammates are chosen by their characteristics and competencies (Gomez-Zara et al., 2019). Algorithms based on artificial intelligence can also form teams from balanced personality types in order to choose teammates who are less conflicted and have greater satisfaction when working in homogenous teams (Lykourentzou et. al, 2016).

Derrick and Elson (2018) indicate strong determinants of communication with an artificial agent during the management process and they see a possibility of leadership automation. They focus on transactional leadership

and propose that this form of leadership needs to be automated. In this process, an intelligent agent system can be trained to provide leadership to human team members based on a computer-to-human interaction (Derrick & Elson, 2018).

According to this idea, Larson and DeChurch (2020) pointed out leadership challenges ensuing from technological advances. Organizations in the digital age need to consider two directions for leadership development: (a) including technologies in relations between humans and (b) exploring ways in which emerging AI tools can develop leaders' competencies.

The first direction is focused on four perspectives, but only two of them are concentrated on a virtual team, i.e. using technology as a virtual team creation medium and as a teammate view (Larson & DeChurch 2020). The virtual team creation medium perspective considers the role of relationship-building activities during a team-building process as an additional area of leadership. In the teammate view perspective, leaders need to understand that there is a strong imperative of building effective relationships between human teammates, human teammates and artificial teammates and, last but not least, between artificial teammates.

The second direction concerns exploring how AI tools, such as cognitive assistants, can augment leader relational competencies in 360-degree feedback, coaching, mentoring or action learning (Day, 2000). Larson and DeChurch (2020) point out that there are popular voice assistants (e.g. Amazon's Alexa, Google Home or IBM Watson) to work one-on-one with team members to target individualized learning, development and self-regulation.

Humans and machines are collaborating in new ways and organizations are increasingly leveraging human-automation teams (Derrick & Elson 2018). Conversational agents, physical robots, virtual customer-service agents, and many other pseudo-intelligent agents use text clues, vocal cues or other environmental sensors to retrieve information from the user and respond appropriately to help individuals complete everyday tasks (Derrick & Elson 2018). Alternatively, cognitive assistants can work as teammates to help the team learn and develop together. They may "see things" that team leaders might miss, e.g. the structure of leadership, manifesting in subtle speech patterns otherwise undetectable to humans (Larson & DeChurch 2020).

During their experimental research, Derrick and Elson (2018) examined the relationship between simplified automated leadership (goal setting, performance monitoring, performance consequences), social presence (Text-based Automated Agents, Embodied Automated Agents – Avatar, LVA Hologram), task performance (number completed, data entry accuracy) and follower satisfaction (process and outcome satisfaction). They assumed the following relations: automated leadership can increase efficiency but social presence has a positive moderating effect on performance outcomes, automated leadership can decrease outcome satisfaction, automated

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leadership can increase positive perception of the automated leader when the level of the social presence is rising (Derrick & Elson, 2018).

At this point, it is necessary to go back to the social presence theory presented in Section 2, which is a significant moderator of virtual teamwork outcomes. There are two reasons for this. Firstly, social presence can be achieved through simulating interaction with another real person (Hess, et al., 2009) and, secondly, it is created by machine accuracy, responsivity, predictability and dependability (Merritt & Ilgen, 2008). It is also interesting how intelligent solutions based on artificial intelligence can influence the work of managers by reducing the amount of time spent on administrative work and making decisions (Kolbjørnsrud et al., 2016; Parry et al., 2016; van der Vecht et al., 2018).

According to Lawless (2021), all issues previously identified as teams, organizations and social systems have to be revisited in preparation for the dramatic change coming from quick arrival of autonomous human-machine teams (A-HMTs) in the military, science, transportation systems, medical systems and society. Relying on the interdependence theory, he found that in order to achieve efficiency of A-HMTs, artificial intelligence should not be applied ad hoc. He claimed that well-fitted virtual teams must maximize their performance through good machine-human communication (Lawless, 2021). However, there are two conditions to be met. Firstly, humans or artificial agents must be selected in a neutral trial-and-error process in which the best teams can be replicated. Secondly, a well-fitted team cannot be obtained in static tests but it is only available from the dynamic situations which stress a team's structure when it performs autonomously.

Despite the fact that implementing autonomous human-machine teams (A-HMTs) is not easy, to summarize the answer to research question RQ3, it is worth saying that the prospective benefits of AI to the decision-making process are beyond discussion. They can be practicably implemented in a social settings by AI-based systems (Parry et al., 2016). AI-based team membership could theoretically be deployed at a local level in their scope of operation (Chen, 2019). However, there are also philosophical dilemmas about ethical aspects of artificial leadership and artificial teammates and about whether they can really feel as a part of a virtual team (Smith & Green, 2018).

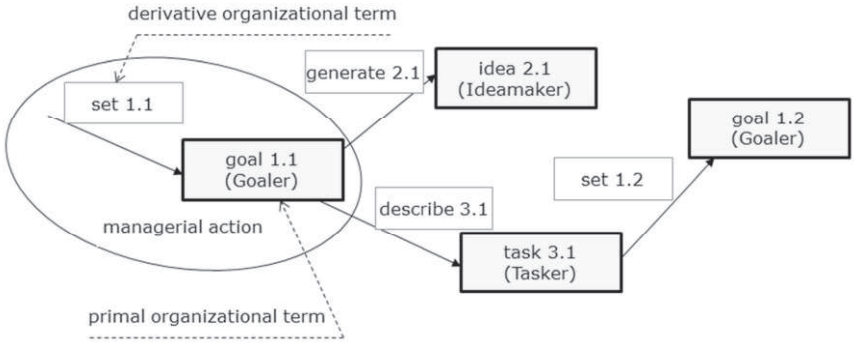
5. First Step to Artificial Agents Instead of Human Team Managers

In this Section, we present an example of the way in which human managers could be replaced by artificial agents. The answer to research question RQ4 is based on the empirical research which we have conducted for several years with the use of online management tools TransistorsHead.com (Flak, 2017) and their theoretical foundations called the system of organizational terms (Flak, 2018).

The traditional analysis of teamwork is based on observations, questionnaires related to members' opinions, the development phase of the team or the leadership style. Current technologies of artificial intelligence, machine learning and algorithms indicate going beyond the analysis of the opinions of respondents and moving towards research using the mechanisms of analyzing the characteristics of people and mapping their actual behavior (Yang, Flak, & Grzegorzek, 2018).

Therefore, in order to achieve a precise and coherent view of teamwork which could be efficiently used in team management automation, it comes as challenge how to represent a succession of different types of managerial actions one after another carried out by a team manager. The pioneering answer to this challenge is the system of organizational terms, which is a complex of ontological and epistemological aspects designed for research on managerial action patterns (Flak, 2013; Flak, 2018; Flak 2020). As shown in Figure 2, this methodological concept is combined with a process (Brajer-Marczak, 2016) as a derivative organizational term and a resource (Barney, 1991) – as a primal organizational term – into the term of "managerial action" (Flak, Yang, & Grzegorzek, 2017).

Figure 2
Fundamental structure of managerial actions



Source: Own elaboration.

A certain managerial action can be measured by online management tools such as tools implemented in the TransistorsHead.com (Flak, 2017). In Figure 3, there is a dashboard with 10 online management tools covering 10 managerial actions.

When virtual team members use online management tools of TransistorsHead.com, their managerial actions are recorded in a sequence of time (Flak, Yang, & Grzegorzek, 2017), which allows us to understand the real activities of human managers and human team members (Flak & Pyszka, 2013; Flak, 2020; Flak, 2021).

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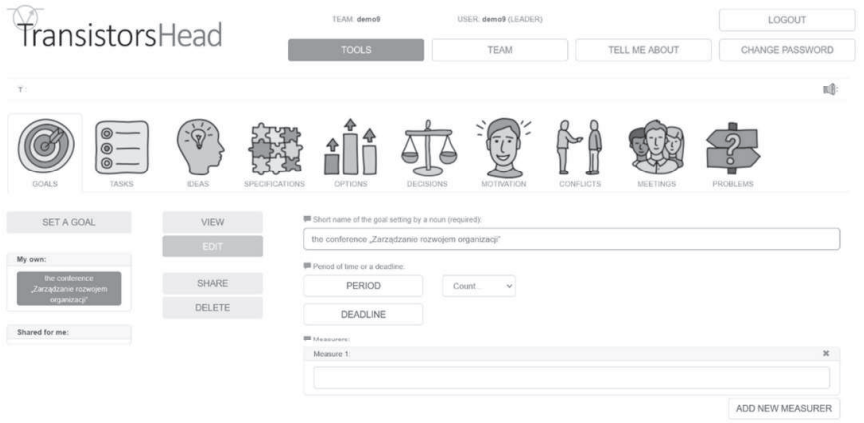
Figure 3
Dashboard of online management tools as research tools



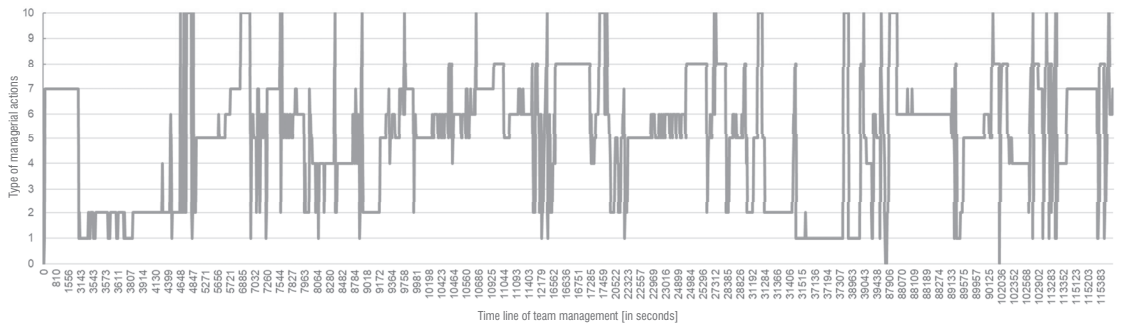
Source: Own elaboration.

The first step in replacing human team managers by artificial agents is the concept of recording behavior of human members and reproducing this behavior in a similar project again by algorithms (Flak, 2020). Such an approach can be exemplified by the results of a long-term observation of a virtual team which was conducted in June 2021 among a group of students at the University of Silesia in Katowice. Students of the master level of studies, trained in managerial techniques during two academic courses, were given a task to design and plan a talent show produced by the Krzysztof Kieslowski Film School which was planned to be broadcasted on YouTube. During 36 hours, the participants in the research were using online management tools in TransistorsHead.com and MS Teams.

In Figure 4, there is a real histogram of managerial actions taken by a human manager of the virtual team. In Figure 5, there is a program of managerial actions for an artificial manager which was created on the foundation of real managerial actions. There was a need to clear repetitions and actions which were too short or not finished (they were taken as trials or unintended attempts by the human manager). This program of managerial actions for an artificial manager was used in the next research conducted in December 2021; however, its results will be described in the next publications on this topic.

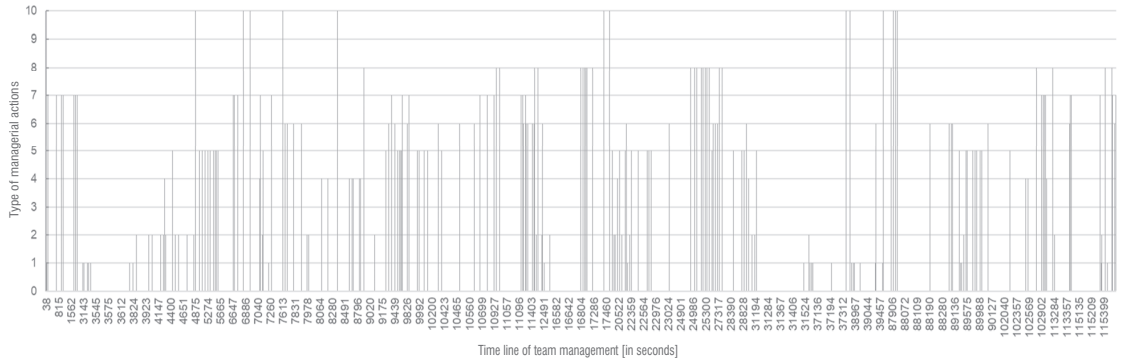
The types of managerial actions are as follows (functions in TransistorsHead.com shown in Figure 3): 1 – set goals (GOALS), 2 – describe tasks (TASKS), 3 – generate ideas (IDEAS), 4 – specify ideas (SPECIFICATIONS), 5 – create options (OPTIONS), 6 – choose options (DECISIONS), 7 – check motivation (MOTIVATION), 8 – solve conflicts (CONFLICTS), 9 – prepare meetings (MEETINGS), 10 – explain problems (PROBLEMS).

Figure 4
Real managerial actions taken a human manager in a virtual team



Source: Own elaboration.

Figure 5
Program of managerial actions designed for an artificial manager in a virtual team.



Source: Own elaboration.

https://doi.org/10.7172/1644-9584.96.3

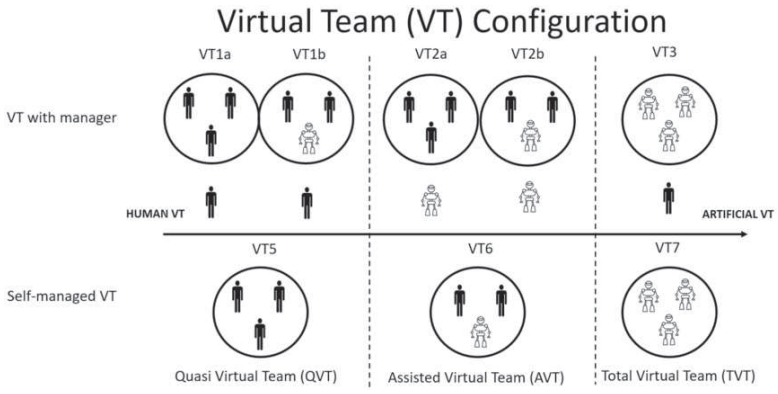
This method of creating knowledge of managerial actions in virtual teams is useful not only for the role of a team leader. In the same way, all human team members can be tracked and recorded in order to repeat their most frequent actions in similar projects in the future. This approach was also tested in the past experiments (Yang, Flak, & Grzegorzek, 2018). Giving an initial answer to research question RQ4, it is possible to say that imitation is still one of the ways of creating a human-like manager or, at the same time, its higher evolutionary copy (in the original "sophisticated superhuman machine" – the author's note) (Schaal, 1999).

6. Conclusions

In the paper, we presented a literature review and our own empirical research concerning the new organizational reality with hybrid virtual teams consisting of humans as well as artificial agents. In this organizational reality, management tasks, or even the leader's role, would be taken over by artificial intelligence. We gave initial answers to four specific research questions covering this research problem. These answers obviously need to be developed, examined by empiric data and practice in the future.

However, we strongly believe in the prediction that in approximately 125 years, all human jobs will be automated by "high-level machine intelligence" (HLMI), which means the state when unaided machines can accomplish every task better and more cheaply than human workers (Katja et al., 2018). Therefore, we tried to predict this inevitable future in the field of virtual teamwork. The possible processes of virtual team development are presented in Figure 6.

Figure 6
Evolution from human virtual teams to artificial virtual teams supported by artificial intelligence



Source: Own elaboration.

We suppose two directions of the evolution from human virtual teams to artificial virtual teams supported by artificial intelligence. The first, vertical direction of evolution is a change from virtual teams with a manager to self-managed virtual teams. The second, horizontal direction of evolution could be a change from totally human virtual teams to totally artificial virtual teams. As shown in Figure 6, there are several combinations of such evolution.

We claim that the most important classification of virtual teams contains:

- Quasi V-T – human beings collaborating with each other, using virtual environment and working through the internet,
- Assisted V-T – mixed teams with partial participation of artificial teammates and even self-managed or managed by the computer (a virtual leader called Manager As A Software MAAS) or artificial teammates managed by a human manager,
- Total V-T – a totally virtual team with artificial members (i.e. ANN – customer service office, SOPHIE – accounting and invoices, RICHARD – technical support, etc.), chat-bots, voice-bots and virtual assistants with human features and with the possibility to read signals (non-verbal and verbal) from clients to better solve their problems – Team As A Software (TAAS).

Going back to the prediction of Katja et al. (2018) about job automation, it is really surprising that the managerial profession is not listed in these jobs. Nevertheless, the preliminary research on the use of the system of organizational terms as a methodological concept of management sciences and other results of research literature review provide the basis for formulating a vision of the development of virtual teams in the age of smart technologies. It can be predicted that team management will be gradually automated. In the future, there could be competition between the manager-man and the manager-robot leading their own teams (Kelleher, Namee, & D'Arcy, 2015; Flak, 2020). It would be the realization of Peter Drucker's words. He wrote that computer systems ("computers") would not only serve to collect information, but the algorithms written in them would be able to replace managers over time (Drucker, 1967).

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