Chapter 1
Teamwork Behavior:
A Review to Interconnect Industry 4.0 Entities

Paraskevi Tsoutsa
University of Applied Sciences of Thessaly, Greece

Panos Fitsilis
University of Applied Sciences of Thessaly, Greece

Omiros Ragos
University of Patras, Greece, Greece

ABSTRACT

Teamwork has become an important research field and its contribution to organizational performance has attracted attention of researchers from several disciplines. The development and application of newly emerged technologies such as Industry 4.0, Internet of Things, and cyber physical systems create additional concerns for teamwork which claim to be integrated into existing models. The objective of this chapter is to advance research on teamwork, by facilitating researchers with a review which identifies the key factors that affect teamwork behavior both in human and in agent-based teamwork models, while indicating if and how they are inter-related. A review of related studies was conducted, and, as a result, a range of factors that affect teamwork behavior to both human and agent-based models was identified and analyzed. From the analysis, stand out factors that gain attention while newly-appeared factors are determined from recent studies about models shift towards dynamic and realistic environments. These discoveries point to new aspects of teamwork behavior.

1. INTRODUCTION

Team working has been thoroughly studied by psychologists and human resource experts over the last decades. During these years, many researchers studied why humans succeed or fail in joint activities and a variety of models have been developed that follow social - psychological approaches for human team formation while focusing on concepts that involve different strategies and approaches. In early studies,

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authors proposed models focused on specific characteristics that team members should have such as personality, functional expertise, competencies, goal orientations, teamwork orientations, etc. (Delarue et al., 2008; Mathieu et al., 2008). As the team research matured, research moved firmly from dealing with single characteristics that teams and members have to a variety of behaviors that team members expose (Rousseau et al., 2006; Salas et al., 2008). Ultimately, in recent studies member's tasks and behaviors are grouped into distinct roles within the system that are aligned with the expertise of team members (Kozlowski et al., 2015). Increasingly, researchers propose that teammates, jointly with the operational tasks that they perform in a team, they also have to play some other role such that of coordinator, contributor, idea generator, etc. Indeed, as it is witnessed by empirical studies, these approaches are effective for certain contexts, tasks and domains (Berlin et al., 2012).

Apart from human team working, another area where similar problems have been studied and team work theories are applied is the area of software agents. As with humans, a group of software agents must accomplish given tasks by organizing themselves according to their individual characteristics and their role within the overall system. Furthermore, complex teams that comprise of humans and agents were studied, since in the real-world scenarios, agents play a variety of roles in their interactions with humans; they support humans in tasks that they jointly perform or independently work to carry out tasks for which they are responsible (Van Wissen et al., 2012). Examples of applications to human–agent teams include autonomous agent pilots that work together with people to complete a joint mission, mission execution assistants for astronauts (Tambe, 1997), personal assistants interacting with users, e.g. Siri for iPhone and Cortana for Windows Phone (Kato et al., 2014) and hybrid teams consisting of humans, robots and virtual characters situated in a flexible industrial production environment (Schwartz, 2016). Considering that humans and agents have different capacity and capabilities in order to combine their strengths, it is crucial to have good coordination (Bradshaw et al., 2012) and other behaviors that humans do. Indeed, the studies on agent teamwork have been motivated by concepts and theories that were developed on human teamwork. In doing so, common characteristics with human team working are used, e.g. planning, coordination, collaboration.

While past studies on team formation focused on interaction only between human or agents, in recent years studies research heterogeneous teams of humans, agents and agents in robotic settings, where agents or robots acting autonomously alongside humans as peers. In such heterogeneous teams, most studies are based on the assumption that the non-human team members need to act in the same manner that human ones do. Examples of such teams are teams of robots in rescue operations (Beck et al., 2016) and teams of humans, robots, and virtual agents cooperating in production settings (Schwartz et al., 2016).

Today's industry environment is so complex that work is done in teams composed of members that are either humans, agents or robots where each one is specialized in specific tasks. For example, humans together with various e-commerce cooperative agents created by different companies having different standards need to collaborate and the successful result for the endeavor depends on the team rather than the individual effort of the member. When referring to team with such content, in this work the term agent-based teams is used. In the context of Industry 4.0 (Data, 2011), embedded systems will be linked with organizational processes to transform industries and this will enable the real time connection between humans, machines and smart objects. In other words, Industry 4.0 (i4.0) envisions a future where, in industries, humans and Cyber Physical Systems (CPS) are effortlessly connected while exhibiting teaming behavioral attitudes. In order for these entities to effectively be connected and working as a team, models referring to team working in literature are investigated.