Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 64 (2015) 290 – 297

Procedia
Computer Science

Conference on ENTERprise Information Systems / International Conference on Project MANagement / Conference on Health and Social Care Information Systems and Technologies, CENTERIS / ProjMAN / HCist 2015 October 7-9, 2015

Service-Based Socio-Cyberphysical Network Modeling for Guided Self-Organization

Alexander Smirnov[a,b], Nikolay Shilov[a,b]*

[a]SPIIRAS, 39, 14 Line, 199178, St.Petersburg, Russia
[b]ITMO University, 49, Kronverkskiy pr., 197101, St. Petersburg, Russia

Abstract

Socio-cyberphysical networks tightly integrate humans, real-world objects and IT infrastructure. In some cases of cyberphysical networks, their configuration can be done in a centralized way (e.g., automated production line configuration). However, for socio-cyberphysical networks the centralized control is not possible due to the independence and autonomy of the network members (e.g., employees of an enterprise). The paper proposes an approach to model such network via a set of interacting socio-inspired services. Such services are capable to model behavior of the network participants taking into account their preferences, strategies and social norms. The interoperability of the services is achieved due to the usage of common standards (such as WSDL and SOAP) at the technological level, and common ontology at the semantic level. The developed conceptual model of socio-inspired service is presented together with behavior patterns and methods for their processing.

Peer-review under responsibility of SciKA - Association for Promotion and Dissemination of Scientific Knowledge

Keywords: socio-cyberphysical system; socio-inspired service; service-based modeling; behavior modeling; behavior pattern

1. Introduction

Cyberphysical networks tightly integrate heterogeneous resources of the physical world and IT world[1,2]. This term is tightly related to such terms as Web 4.0[3,4] and Internet of Things[5,6,7]. Currently, there is a significant amount

* Corresponding author. Tel.: +7-812-328-8071; fax: +7-812-328-0685.
E-mail address: nick@iias.spb.su

1877-0509
Peer-review under responsibility of SciKA - Association for Promotion and Dissemination of Scientific Knowledge
doi:10.1016/j.procs.2015.08.492

of research efforts in the area of cyberphysical networks and their applications, e.g., in transportation[8], production[9], and many other. Having analysed the state-of-the-art of different CPS approaches and supporting technologies, among the other conclusions, Horvath and Gerritsen conclude that "the next-generation of CPSs will not emerge by aggregating many un-coordinated ideas and technologies in an incremental fashion. Instead, they will require a more organized and coordinated attack on the synergy problem, driven by an overarching view of what the future outcome should be"[10].

Configuration of cyberphysical networks is a complex task, which is currently researched intensively[11,12,13]. In many cases such systems can be controlled in a centralized way; and given efficient configuration algorithms, nearly optimal configurations can be achieved. The situation changes when dealing with socio-cyberphysical networks. Such networks go significantly beyond the ideas of the current progress in cyber-physical systems, socio-technical systems and cyber-social systems to support computing for human experience[14]. They tightly integrate physical, cyber, and social worlds based on interactions between these worlds in real time. Such systems rely on communication, computation and control infrastructures commonly consisting of several levels for the three worlds with various resources[15] as sensors, actuators, computational resources, services, humans, etc. Socio-cyberphysical networks belong to the class of variable systems with dynamic structures. Their resources are too numerous, mobile with a changeable composition. Planned resource interactions in such systems are just impossible. Obviously, one cannot control all members of such a network, but only some of its components (e.g., machines, computers, intelligent devices, etc.) to influence the whole network operation. Guided self-organization of socio-cyberphysical networks could be an efficient way to organize its behavior. However, taking into account not only combination of information from sensors and information systems but also application of behavior analysis techniques for predicting future actions of human network members could significantly improve the efficiency of such an organization.

One of the ways to do it is to model the operation of such a network. The paper proposes an approach to model a socio-cyberphysical network via a set of interacting socio-inspired services. Such services are capable to model behavior of the network participants taking into account their preferences, strategies and social norms of the network members. The interoperability of the services is achieved due to the usage of common standards (such as WSDL and SOAP) at the technological level, and common ontology at the semantic level. Different types of services and their behavior models are described as well as different negotiation strategies.

The paper is structured as follows. The description of the developed modelling approach to guided self-organization is discussed in the next section. Section 3 presents the conceptual model of socio-inspired service lying in the core of the proposed approach. Behavior analysis techniques are discussed in section 4. Main results are summarized in the conclusion.

2. Guided Network Self-Organization: Approach

The analysis of literature related to organizational behavior & team management has showed that the most efficient teams are self-organizing teams working in the organizational context (Fig. 1). For example, social self-organization has been researched in a number of efforts[16,17]. However, in this case there is a significant risk for the group to choose a wrong strategy preventing from achieving desired goals. For this purpose, self-organizing groups / systems need to have a certain guiding control from an upper level. However, In order for distributed systems to operate efficiently, they have to be provided with self-organization mechanisms and negotiation protocols.

The process of self-organization of a network assumes creating and maintaining a logical network structure on top of a dynamically changing physical network topology. This logical network structure is used as a scalable infrastructure by various functional entities like address management, routing, service registry, media delivery, etc. The autonomous and dynamic structuring of components, context information and resources is the essential work of self-organization[19]. The network is self-organized in the sense that it autonomously monitors available context in the network, provides the required context and any other necessary network service support to the requested services, and self-adapts when context changes. Self-organizing systems are characterized by their capacity to spontaneously (without external control) produce a new organization in case of environmental changes. These systems are particularly robust, because they adapt to these changes, and are able to ensure their own survivability[20].