A Monitoring Framework of Collaborative Supply Chain for Agility
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Abstract: The project C2NET "Cloud Collaborative Manufacturing Networks" is a H2020 project started in January 2015. It aims at developing a cloud platform, which allows the development of services for the management of collaborative planning processes between partners of a supply chain.

This paper introduces a monitoring framework organized through 4 main services in the platform: modeling, detection, adaptation and assessment services. The framework provides main features: data collection in the supply chain field and automatic model generation of supply chain plans and situations; model comparison for detecting deviations and propagation of the deviations; agile adaptation for different deviations; a dashboard for visualize and assess the supply chain situation.

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1. INTRODUCTION

Due to restricted resources, European SMEs (Small and Medium Enterprises) hardly have access to advanced management systems and collaborative tools. The project C2NET (C2Net | D6.6 - White Paper of C2NET platform / openness and portability - Deliverables 2016) aims at creating a cloud platform, for managing the life cycle of collaborative supply chain plans and the associated data. The platform covers 3 main features: real-time Data Collection Framework (DCF) that collects data from partners sites (IoT and legacy systems) and store data into the cloud; configurable OPTimization service (OPT) that propose optimization algorithms for designing a plan; and Monitoring Plan Execution (MPE).

This paper aims at introducing the MPE framework. MPE is in charge of supporting the supply chain agility of a network of enterprises. As suggested in (Charles et al. 2010), supply chain agility implies to solve several issues: a visibility issue in order to use the huge amount of data and build a coherent model of the status of the supply chain; a detection issue in order to detect the happening of disturbances; a decision issue in order to select quickly an adapted solution; a deployment issue for coordinating the response in practice.

2. Literature Review

The term of monitoring applied on supply chain has rarely been employed. It therefore resulted in a recommendation called SCMo (Merle 2003, Borgström and Hertz 2006) developed by Odette where monitoring is “the effort of the actors in a supply chain to manage and control visibility of information regarding flows of products and services in different levels and directions”. SCMo is dedicated to pull automotive industries and supports “the permanent checking that current inventory is synchronized with the respective demand”.

Supply chain visibility on the contrary is recognized as an important contributor to agility (Charles et al. 2010), risk (Martin Christopher and Hau Lee 2004, Nooraie and Parast 2015, Messina et al. 2016) or responsiveness (Gunasekaran et al. 2008) management in order to avoid mistaken decision making, the bullwhip effect, excessive inventories, jeopardizing the profit margin (Li et al. 2015). In these contexts, supply chain visibility (Nooraie and Parast 2015) is the capability of sharing on-time and accurate data on customer demand, amount and location of inventory, cost of transportation, and other logistics dimensions throughout an entire supply chain. It must help enterprises to identify and act upon the risks and opportunities of their supply chains (Messina et al. 2016) considering they are confident in the fair usage of the gathered data. The research on supply chain visibility has focused on the usage of the shared data. But, in C2NET, due to the huge amount of data that can be collected this visibility objective faces some Big Data issues:

- Quality issue: the key is to get accuracy, timeliness, completeness, consistency properties of the data at the aggregation level of their usage (Hazen et al. 2014).

- Modelling issue: the key is to transform data so that they are interpreted according to user models. This can be made thru the mapping of meta-models (Wang et al. 2016).

- Detection issue: the key is to identify events from big flow of data according to some patterns. This can be achieved by complex event processing (Luckham 2008, Cugola and Margara 2012).
2. MONITORING PLAN EXECUTION FRAMEWORK

In the MPE framework, there are mainly 5 components interacting (Fig. 1). In the Pilot system, there are legacy systems, for example ERP or SAP systems, in which we have the data associated to supply chain plans and situations. Also there can be IoT (Internet of Things) devices, which is providing data in the field, for example, the real-time stock levels, transportation information or machine status. These data should be the input of the component Monitoring service. Potentially there will not be access direct to the legacy systems. Dealing with this kind of authorization problems, it is possible that the supply chain actor extracts data from their legacy systems and uploads manually a .csv file as the input of the Modeling service.

Fig. 1. The monitoring plan execution framework.

The modeling service receives the input data from the pilot system and through the data converter it transforms different format of the data into a standardized event format (WSN, wireless sensor networks). The CEP (Complex Event Processing) engine is subscribed to these events and makes the interpretation from the data into instances according to a reference meta-model. Though these mechanisms the R-model (reference-model), which contains the planned information is generated. It will be sent to the detection service.

The detection service receives this R-model and stores it in a graph database. And the detection component is subscribed to this database. Once there are new R-models, the detection component obtains it and duplicates it. The duplication of the R-model is used as S-model (situation-model). Besides the subscription to the graph database, the detection component is also subscribed to the CEP engine. Once there are new associated data arrives, detection component will update the S-model according to the new data. And a comparison between the R-model and the S-model is made after the S-model has been updated. If there is a deviation in between, an alert will be generated and sent both to the supply chain actors for notification and to the adaptation service.

The adaptation service receives the alert of a deviation has been detected, and it will analyse the alert to see whether it is significant. The adaptation service will try to provide a simple solution, for example, to delay one order for one week. This solution will be sent to the supply chain actor for validation. Once it is validated, the solution will be executed. If the deviation is significant that no simple solutions could be found, the adaptation service will invoke an orchestration of a negotiation process, which enables the actors can solve the deviation collaboratively.

The assessment service is subscribed to the graph database. It will obtain the S-models and make it visualized in a dashboard in order to provide the actor a visible situation. Also besides the situation models, there will be also charts showing the management of the KPIs those are pre-defined.

3. MODELING SERVICE

The RMM is based on a Generic Collaboration Meta-Ontology (CMO), with the idea of developing layers around a core meta-model.

Fig. 2. The layered structure of the CMO.

The core is centered on a meta-model related to the general concepts of collaboration in social systems. This “kernel” is common to all collaborative situations whatever the application domain is. The domain layer is associated to supply chain collaborative planning. It allows defining all the concepts associated to supply chain collaboration, inheriting these concepts from the previous layers and being populated from various complementary standards and already existing ontologies. This layer should also fix the semantic issues associated to the data.

The core is organized in 4 complementary packages:

- Context package including components and characteristics of the considered environment, and also opportunities or threats specific to these environment characteristics. The supply chain layer contains the concepts considering the environment elements of a supply chain: Market, Location, Goods, Natural/Social Context and also the risks in the environment.

- Objective package contains the common facts and objectives, which has to be managed by the collaborative network. In the supply chain layer for the objective is the Lvl Processes those for satisfying customer needs. These
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