Applying the ATAM to an Architecture for Decentralized Control of a Transportation System

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Abstract. For two years, we have been involved in a challenging project to develop a new architecture for an industrial transportation system. The motivating quality attributes to develop this innovative architecture were flexibility and openness. Taking these quality attributes into account, we proposed a decentralized architecture using multiagent systems (MASs). A MAS consists of multiple autonomous entities that coordinate with each other to achieve decentralized control. The typical advantages attributed to such decentralized architecture are flexibility and openness, the motivating quality attributes to apply MAS in this case.

The Architecture Tradeoff Analysis Method (ATAM) was used to provide insights wether our architecture meets the expected flexibility and openness, and to identify tradeoffs with other quality attributes. Applying the ATAM proved to be a valuable experience. One of the main outcome of applying the ATAM was the identification of a tradeoff between flexibility and communication load that results from the use of a decentralized architecture.

This paper describes our experiences in applying the ATAM to a MAS architecture, containing both the main outcomes of the evaluation and a critical reflection on the ATAM itself.

1 Introduction

For two years, Distrinet [1] has been involved in a challenging R&D project (EMC^2 [2]) to develop a decentralized architecture for an industrial transportation system. Our industrial partner, Egemin N.V. [3], is a Belgian manufacturer of Automatic Guided Vehicles (AGVs) and control software for automating logistics services in warehouses and manufactories using AGVs. Traditionally, one computer system (central server) is in charge of numerous complex and time-consuming tasks such as routing, collision avoidance, or deadlock avoidance; the AGVs themselves have little autonomy. This traditional architecture has successfully been deployed in numerous practical installations, but the evolution of the market has put forward new requirements for AGV Transportation systems [4]. Especially in highly dynamic systems, where the situation changes frequently, problems are experienced. A new and innovative architecture is needed that offers additional qualities, like flexibility and openness, to cope with the highly dynamic environments.

Taking these quality attributes into account we proposed a decentralized architecture using multiagent systems (MASs). Typical advantages attributed to a MAS architecture are flexibility and openness, being the motivating quality attributes to apply MAS for the

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AGV transportation system. A second motivation, from the research perspective, was the opportunity to evaluate MASs and our reference architecture [5] in a real industrial application and asses if it really fulfilled the attributed quality attributes. The Architecture Tradeoff Analysis Method (ATAM) [6,7] was used to provide insights wether our architecture meets the expected flexibility and openness and to identify tradeoffs with other qualities. This paper describes our experiences in applying the ATAM to the MAS-based architecture, containing both the main outcomes in terms of tradeoffs and what we have learned and a critical reflection on the ATAM itself.

Overview. The remainder of this paper is structured as follows. Section 2 describes the requirements, the motivation and a short overview of the MAS architecture. Section 3 describes the outcomes of the ATAM workshop. Section 4 reflects on the ATAM workshop. Section 5 describes related work and we conclude in section 6.

2 Decentralized Architecture for Automatic Guided Vehicles

An AGV transportation system uses unmanned vehicles that are custom made to be able to transport various kinds of loads, from basic or raw materials to completed products. Typical applications are repackaging and distributing incoming goods to various branches, or distributing manufactured products to storage locations. An AGV uses a battery as its energy source. AGVs can move through a warehouse guided by a laser navigation system, or following a physical path on the factory floor that is marked by magnets or cables that are fixed in the floor. Egemin N.V., our industrial partner for the EMC^2 project, develops and delivers such AGV transportation systems tailored to the needs of the specific production-plant or warehouse. Thus AGV transportation systems is a product-line system that is used in several concrete products with different functional and (possible contradicting) quality requirements.This section describes the main functionalities, the important quality attributes, the motivation to apply a MAS architecture and a short overview of the MAS architecture for the AGV Transportation system.

2.1 Main Functionalities

The main functionality the system should perform is handling transports, i.e. moving loads from one place to another. Transports are generated by client systems. Client systems are typically warehouse management systems, but can also be particular machines, employees or service operators. In order to execute transports, the main functionalities the system has to perform are:

- Transport assignment: transports are generated by client systems and have to be assigned to AGVs that can execute them.
- Routing: AGVs must route efficiently through the layout of the warehouse when executing their transports.
- Gathering traffic information: although the layout of the system is static, the best route for the AGVs in general is dynamic, and depends on the current conditions in the system. Gathering traffic information allows the system to adapt the routing of the AGVs to these dynamic conditions.