Distributed protocols for asynchronous cooperative mobile robots

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Theme. Distributed protocols for asynchronous cooperative mobile robots.

1. Aim of our research:

We consider a distributed system composed of cooperative autonomous mobile robots executing tasks provided by a user application. The robots are communicating by exchanging messages through a wireless ad-hoc network. In this context we focus on the essential problem, which is the collision avoidance between mobile robots. This necessitates the presence of a deterministic distributed protocols, which guarantee that no collision can occur between robots while moving towards their goals.

2. Approach:

Distributed computing extends its scope to address problems relevant to mobile environments (mobile computing). This creates new challenges to traditional distributed computing, by considering problems related to the physical position of the nodes [Def01]. We consider a distributed system composed of autonomous mobile robots communicating by exchanging messages through a wireless ad hoc network. We address the problem of collision avoidance such that no collision between robots can occur while robots are moving towards their destinations. It is essential to establish a middleware that handles a group of mobile robots as one entity, for that we need group membership [YDK05], and failure detectors techniques [HDY04]. The collision freedom system provides a solid and a reliable lower level layer that deals with a group of robots. Other properties like reaching the final goal (termination) and the dead lock freedom property are handled in the upper layers.

3. Progress of this year:

We have an asynchronous distributed system, so there are no timing assumptions on the communications delays. Consequently it is impossible to keep track of positions of other robots, because of the mobility and the asynchrony of the communications. We use a reservation system, such that a robot reserves a path and releases it after reaching the end of this path. All robots agree on the reservation each time a path is reserved. The reservations are consistent, in order to achieve the consistency we adapt some protocols used in

traditional distributed systems. Adapting the traditional protocols creates many challenges due to the mobility issues of robots, the asynchrony of communications, and the ad-hoc wireless communications characteristics. These communications are characterized by limited communication range and link breakage between nodes. [YCD06]

We build protocols which guarantee collision freedom (safety property) in mobile ad hoc environments as well as in wireless LANs. We developed proofs of correctness of our protocols, and performed an implementation to parts of the system.

4. Future directions:

The future directions of our work are the following:

- Providing a complete implementation of the system on real robots and test it by running an application.
- Refactoring.
- Handling the fault-tolerance issues that tolerate the crash of a certain number of robots.
- Providing a simulation of the system.

5. Publications:

R. Yared, J. Cartigny, X. Défago, and M. Wiesmann. Locality-preserving distributed path reservation protocol for asynchronous cooperative mobile robots. *Technical Report JAIST, IS-RR-2006-003*, Feb. 2006.

R. Yared, X. Défago, and T. Katayama. Distributed collision freedom protocol for a group of autonomous mobile robots In the *JSF workshop* (*Journées Scientifiques Francophones*) *JSF 2005*. Tokyo, November 2005.

System Implementation: implementation of robotic control system with graphical user interface and parts of collision freedom protocols.

6. References:

[YCD06] R. Yared, J. Cartigny, X. Défago, and M. Wiesmann. Locality-preserving distributed path reservation protocol for asynchronous cooperative mobile robots. *Technical Report JAIST, IS-RR-2006-003*, Feb. 2006.

[YDK05] R. Yared, X. Défago, and T. Katayama.
Fault-tolerant group membership protocols using physical robot messengers. In *Proc. 19th IEEE Intl. Conf. on Advanced Information Networking and Applications (AINA'05)*, Vol. 1, pp. 921-926, Taipei, Taiwan, March 2005.

[HDY04] N. Hayashibara, X. Défago, R. Yared, and T. Katayama.
The ϕ accrual failure detector. In *Proc. 23rd IEEE Intl. Symp. on Reliable Distributed Systems (SRDS'04)*, pp. 66-78, Florianópolis, Brazil, October 2004. IEEE CS Press.

[Def01] X. Défago.
Distributed computing on the move: From mobile computing to cooperative robotics and nanorobotics. In *Proc. ACM Int'l Workshop on Principles of Mobile Computing (POMC'01)*, pages 49–55, Newport, RI, USA, August 2001.