SFB 637 Autonomous Logistics

Becker, M.; Timm-Giel, A.; Görg, C.: Self-Organization Concepts for the Information- and Communication Layer. In: Hülsmann, M.; Windt, K. (eds.): Understanding Autonomous Cooperation in Logistics - The Impact on Management, Information and Communication and Material Flow. Springer, 2007

Self-Organization Concepts for the Information- and Communication Layer of Autonomous Logistic Processes

Markus Becker, Andreas Timm-Giel, Carmelita Görg

Communication Networks, Otto-Hahn-Allee - NW1, University Bremen, 28359 Bremen, Germany

As described in Chapter XX on Historical Autonomy in ICT, self-organisation is a well-known concept in information- and communication technology. In this chapter we will show how self-organisation can be employed in the Information- and Communication Layer of Autonomous Logistic Processes.

Autonomic Communication, Autonomic Computing and Self-Star

Especially the concepts Autonomic Communication, Autonomic Computing and Self-Star, already mentioned in Chapter XX, are of interest to be applied in Autonomous Cooperating Logistic Processes.

The components involved in the processes, in particular the vehicles, need very reliable communication systems due to their mobile nature. The communication equipment fixed to the vehicle has to be highly reliable to avoid frequent reset/repair times. The time the transport vehicle spends in the garage for resetting, reconfiguring or repairing the communication system is necessarily downtime and hence extremely costly. Resistance of the shipping companies against unreliable IT systems has become obvious with the introduction of the TollCollect system (Bundesverband Güterkraftverkehr Logistik und Entsorgung e.V. 2005).

The next paragraphs will introduce example applications of Autonomic Computing and Self-Star such as Self-organized Selection of Communication Networks, Service Discovery, Gateway Discovery and Ad hoc Routing that are needed for always best connected communication services of sensor and mobile nodes.

Self-organized Selection of Communication Networks and Services

To show the application of the concepts, a self-organized selection of communication networks has been implemented, called Autonomous Communication Gateway. The autonomous communication gateway is documented in (Becker et al. 2006a) and has been demonstrated as part of an autonomous logistic support system (Becker et al. 2006b; Morales et al. 2006). The device has the ability to communicate using three different communication networks, namely *Wireless Local Area Network* (WLAN), *Universal Mobile Telecommunication System* (UMTS) and *General Packet Radio Service* (GPRS).

The independence of the different systems can be established by means of MobileIP and *Virtual Private Network* (VPN).

For the autonomous logistic processes case the permanent addressability is established by the use of a *Virtual Private Networks* (VPN), as shown in Figure 1. The VPN provides static Internet Protocol addresses for use in the applications, although the IP addresses change, when changing the communication network. This approach includes encryption of the transmitted data, which is crucial to business data. The mechanism of VPN can be used in this case, because only connectivity to one node is needed. In the general case when more than one node needs to be connected, a MobileIP solution should be preferred.

The standardized MobileIP as described in (Montenegro et al. 2003) provides Internet Protocol (IP) layer mobility. The components enabling the mobility are the Home Agents (HA) and Foreign Agents (FA). The mobile nodes needs to register with one of the agents. When in a foreign network, it registers with a foreign agent, which will inform the home agent of the current Care of Address (CoA). Several implementations of MobileIP exist and are tested in more general scenarios. Furthermore Mobile IP combined with mobile ad hoc networks can be used for gateway discovery, as described in a later section.

SFB 637 Autonomous Logistics

Becker, M.; Timm-Giel, A.; Görg, C.: Self-Organization Concepts for the Information- and Communication Layer. In: Hülsmann, M.; Windt, K. (eds.): Understanding Autonomous Cooperation in Logistics - The Impact on Management, Information and Communication and Material Flow. Springer, 2007

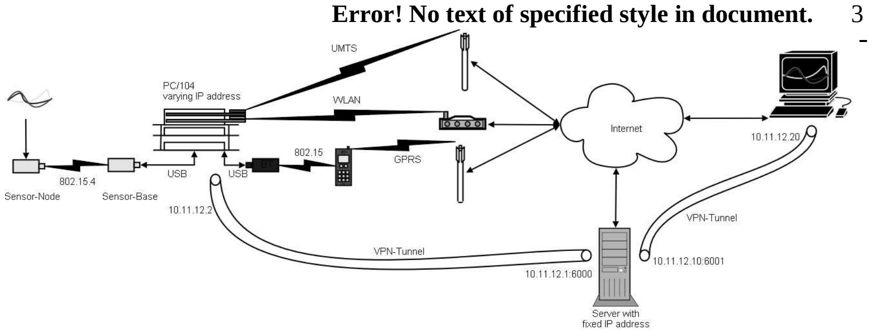

Figure 1: Autonomic Network Selection as Support for Autonomic Logistic Processes

Communication Selection

The communication selection process includes the service availability and additional selection criteria, e.g. cost and required data rate of the application. Currently the application that is in use is the surveillance of sensor data using the system as described in Chapter XX (Jedermann+Behrens).

Communication Timing

A self-organizing instance needs to evaluate the advantage of transmitting the data against the costs of the transmission. This instance might decide to postpone the transmission of the data until a cheaper system is available or the importance of the data has increased. Additionally, in future it is planned to give feedback to the autonomous logistics application on the available networks, their bandwidth, the costs, changes in availability and security. The application can then decide, depending on this information, to delay its transmission, aggregate its data or to signal the gateway to use a different system.

This approach yields an economic use of the scarce and expensive wireless bandwidth.

Service Discovery and Gateway Discovery

Another area in which self-organization plays a major role is Service Discovery. Service discovery is the process of detecting which services are available and where they are available.

There are many different methods and implementations of Service Discovery. Standardized Protocols such as ZeroConf (Cheshire 2006), SLP (Gutmann et al. 1999), SDP (Handley et al. 2006), Sun Microsystem's Jini (Jini 2006) or Microsoft's Universal Plug and Play (UPnP Forum 2006) as well as research protocols such as GSD (Chakraborty et al. 2002) and Konark (Helal et al. 2003) are available, to name only a few.

For autonomous logistic processes there are at least two service discovery types: Sensor Discovery and Gateway Discovery.

Sensor discovery is the discovery of sensor nodes with specific sensors as discussed in Chapter XX (Jedermann+Behrens). The mentioned protocols cannot be used in Wireless Sensor Networks because of their dependence on IP networks, instead specialized WSN solutions are needed that take into account the low memory space, low data rates, limited energy sources, for example (Raluca Marin-Perianu et al. 2006)

Gateway discovery in Internet Protocol based wireless networks such as the one depicted in Fig. 2 means discovering the node that provides a connection to the infrastructure network, e.g. the Internet. Usually only one node provides this service to all the other nodes. There are several solutions to autonomic gateway discovery. In this project two approaches are going to be considered. The first approach is called Proxy Gateway. The second approach is an integration of the already mentioned *Mobile Internet Protocol* (MobileIP) and *Ad-hoc Networks* (MANETs).

The gateway discovery in the Proxy Gateway approach uses a modified gateway (in the vehicle) that replies to route requests to an unknown network node with its own address and forwards the data. This approach provides connectivity of the logistic ad-hoc network (e.g. in the vehicle) to the Internet. Addressability of the logistic ad-hoc network from the Internet is not included.

The second approach to gateway discovery integrates MobileIP (Montenegro et al. 2003) and MANETs (Macker and Chakeres 2006). The Foreign Agent of MobileIP, which handles the registration of Mobile Nodes, advertises its gateway functionality into the MANET. The nodes receiving the advertisement can use the address specified in the advertisement for identifying the gateway to the Internet. Implementations of MobileIP and AODV for embedded devices such as Access Points have been developed by the authors (Becker et al. 2006c).

Ad hoc Routing

The working principles of ad hoc routing have already been discussed in Chapter XX on Historical Autonomy in ICT. Here we present the usage of ad hoc routing in logistical environments.

Figure 2 depicts the usage of ad hoc networks in logistics. The nodes and packages have communication units attached to them. Those communication units set up a mobile ad hoc network. The networks might be divided into sub-networks depending on the spatial distance between them. When for example a packet is loaded into a vehicle, existing radio links will be discontinued and new links will be established.

A commonly investigated usage scenario of ad hoc networks in the *Collaborative Research Centre* (CRC) is the intelligent transport good, which decides itself with which transport vehicle to start negotiations for transport services. Factors considered are for example: expected time of arrival at the destination, risk not to arrive in time, suitability of transport vehicle for the transport, costs, and sensors available in the transport vehicle to monitor the transport conditions.

When the packet is loaded onto the transport vehicle the agent representing the transport good can be copied from the RFID tag into the board computer of the transport vehicle. The agents of more intelligent goods can communicate themselves with the vehicle's agent (see Figure 3). It is also possible that the transport good is just identified by the transport vehicle, which then downloads the transport requirements from the Intra- or Internet. Among other things the transport good is advising the vehicle's agent on how to configure the sensors to monitor the right transport conditions.

Other scenarios foresee that a sufficient number of sensors are in the transport vehicle and also on the transport goods themselves. Each transport vehicle configures a sensor network out of the available sensors suitable for monitoring the required transport conditions.

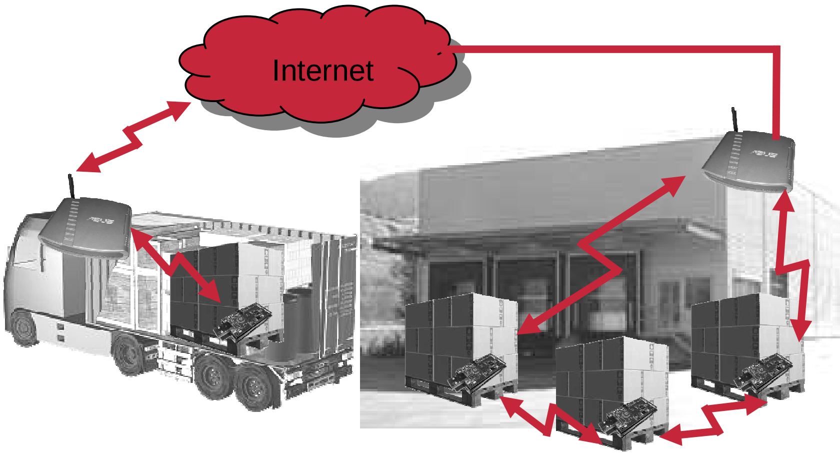

Figure 2: Ad hoc routing in logistic applications

Conclusion

This chapter has shown examples of the application of self-organisation approaches in the information and communication layer of autonomous logistic processes: the self-organized selection of communication networks, gateway discovery and ad hoc routing. The self-organisation methods applied here aim at improving the communications of logistic objects.

Becker, M.; Timm-Giel, A.; Görg, C.: Self-Organization Concepts for the Information- and Communication Layer. In: Hülsmann, M.; Windt, K. (eds.): Understanding Autonomous Cooperation in Logistics - The Impact on Management, Information and Communication and Material Flow. Springer, 2007

References

Becker M, Wenning BL, Timm-Giel A, Görg C (2006a) Usage of Mobile Radio Services in Future Logistic Applications. In Proceedings of Mobilfunktagung 2006, pp. 137 - 141. Osnabrück, Germany.

Becker M, Jedermann R, Behrens C, Sklorz A, Westphal D, Timm-Giel A, Görg C, Lang W, Laur R (2006b) Sensoren und RFIDs für selbststeuernde logistische Objekte und deren mobile Vernetzung. Bremen, Germany. Berichtskolloquium des SFB 637.

Becker M et al. (2006c) Port of MobileIP (uob-nomad) and AODV (aodv-uu) to an embedded platform: https://dev.openwrt.org/browser/packages/net

Bundesverband Güterkraftverkehr Logistik und Entsorgung e.V. (2005) LKW-Maut in Deutschland - Wahrung von Schadenersatzansprüchen im Zusammenhang mit dem Aufspielen der neuen OBU2-Software. http://www.bgl-ev.de/web/service/nutzungsausfall-tollcollect.htm

Chakraborty D, Joshi A, Yesha Y, Finin T (2002) GSD: a novel group-based service discovery protocol for MANETS, Proc. MWCN 2002

Cheshire St (2006) DNS Service Discovery (DNS-SD) http://www.dns-sd.org/

Guttman E, Perkins C, Veizades J, Day M (1999) IETF RFC 2608: Service Location Protocol, Version 2

Handley M, Jacobson V, Perkins C (2006) IETF RFC 4566: SDP: Session Description Protocol

Helal S, Desai N, Verma V (2003) Konark - a service discovery and delivery protocol for ad-hoc networks, Choonhwa Lee, Proc. IEEE WCNC 2003

Jini (2006) http://www.jini.org/wiki/Main_Page

Macker J, Chakeres I (2006) http://www.ietf.org/html.charters/manet-charter.html

Marin-Perianu RS, Scholten J, Havinga PJM, Hartel PH (2006) Energy-Efficient Cluster-Based Service Discovery in Wireless Sensor Networks. Technical Report TR-CTIT-06-43 Centre for Telematics and Information Technology, University of Twente, Enschede. ISSN 1381-3625

Montenegro G, Roberts P, Patil B (2003) http://www.ietf.org/html.charters/OLD/mobileip-charter.html

Morales E, Ganji F, Jedermann R, Gehrke JD, Lorenz M, Wenning BL, Becker M, Behrens C, Congil J, Ober-Blöbaum C (2006) SFB-Demonstrator "Intelligenter Container". Bremen, Germany. Newsletter des SFB 637 1/2006.

UPnP™ Forum (2006) http://www.upnp.org/