INTEGRATION OF VARIOUS IT SYSTEMS AND SENSOR INFORMATION FOR THE HANDLING OF RFID-ENABLED CATERING GOODS IN THE AVIATION DOMAIN

Falk Scheiding, Kresimir Vidackovic
Fraunhofer IAO, Nobelstr. 12, 70569 Stuttgart, Germany

Felix Tönnies, Reinhard Becker
autoID systems GmbH, Heilbronner Straße 26, 74336 Brackenheim, Germany

Keywords: System integration, RFID, Middleware, Dashboard, XML, Electronic data interchange, Aviation, Airline trolleys.

Abstract: The paper describes the main results of a research project as a use case for cross-company system integration in the airline catering domain. Especially the connections of IT systems of different process participants and sensor information along the catering supply chain as well as the replacement of paper-based lists are among the achievements. Today, airline caterers suffer the lack of information and the laborious data transfer to their corresponding IT systems. On the other side, airlines have no overview about the quality of the catering process. Besides, they also have a lack of information concerning important facts like the stock of trolleys or high-value catering goods. The paper shows a solution for the integration and better analysis options by using RFID tags on the catering trolleys, middleware software and XML files for the information flow and a monitoring dashboard to visualize up-to-date statistics for the management of resources.

1 INTRODUCTION

In the aviation domain, the integration of participating members and their IT systems is a huge challenge. The logistic processes which especially cover the handling of catering goods for the usage on board are affected by media disruptions, delays and opacity. Furthermore there is a variety of participants with different IT systems and processes involved. In order to avoid the typical problems which arise from such a distributed system and to make a suggestion for an integrated and transparent information and systems chain in the aviation domain, the German Federal Ministry of Economics and Technology (BMWi) funded a research project between 2007 and 2010. The project has a wide range of objectives, such as the development of new business models and the integration of RFID (Radio Frequency IDentification) technology in the aviation domain. Fraunhofer IAO and autoID systems GmbH, two members of the project consortium, have been responsible for the task of system integration which was one of the most important challenges of the project.

The foundations for achieving a seamless integration between various IT systems is to establish an overall data interchange format based on XML (eXtensible Markup Language) for all the mainly paper-based lists (e.g. assembly list, loading list etc.) as well as transfer messages and to integrate it into the IT environment. Furthermore, for getting more transparency along the catering logistics process, the catering trolleys and important high-value goods have to be equipped with RFID transponders.

An integration middleware is used to transport the relevant messages and sensor data. An event-driven and therefore real-time monitoring dashboard is responsible to track and visualise the RFID events along the whole logistics process and to generate warnings in case of bottlenecks.

In section 2, we depict the importance of integration in the aviation domain and airlines. In section 3, we describe our proposed solution in

Scheiding F., Vidackovic K., Tönnies F. and Becker R..
INTEGRATION OF VARIOUS IT SYSTEMS AND SENSOR INFORMATION FOR THE HANDLING OF RFID-ENABLED CATERING GOODS IN THE AVIATION DOMAIN.
DOI: 10.5220/0003332100910097
In *Proceedings of the 7th International Conference on Web Information Systems and Technologies* (WEBIST-2011), pages 91-97
ISBN: 978-989-8425-51-5

detail by showing how relevant events can be tracked and organised through an RFID-based system using a middleware for distribution and XML structures for the standardised data interchange. In section 4, we discuss the verification of our solution by describing a built-up system demonstrator and conclude with an overview of the main results of the project.

2 MOTIVATION

The aviation domain is suitable for the introduction of an integrated and automatic system. There are a large number of objects to handle and millions of passengers have to be served (cf. Schnathmann, 2009, p. 177). That is the reason why airline catering deals with a huge amount of information. Due to the fact that airlines learned to handle information with the help of IT systems very early (e.g. for reservations and ticketing processes), the basic environment and knowledge already exists. Nevertheless, most of the applications were developed to solve specific problems and were provided by different software companies or user groups. This is the reason why most of the systems were not and still are not integrated. Nowadays, the urgency of system integration is identified (cf. Jones, 2004, p. 227).

Another important requirement of such a system with a turnover of goods is their transparency and inventory management. In practice, in supply chains like in the airline catering domain, many errors may happen. Items or boxes that are supposed to be in one trolley are loaded into another one, items get lost or trolleys are sent to the wrong clearance position. RFID is likely the right technology with the most impact concerning such problems. RFID tags can be applied and provide the opportunity to track and trace every kind of e.g. lost shipment (cf. Garfinkel, Holtzman, 2006, p. 27-29). The whole trolley management with its specified transport and storage processes should be organised in a way that it is as efficient and economic as possible. Therefore, it is necessary to know the status of each individual trolley. It is possible to draw conclusions from the analysis of the whole process chain if e.g. trolleys should be added to or withdrawn from the process (cf. Dolenek, 2009, p. 135). Furthermore, it is crucial that there is a distinct and well elaborated data structure used for the integration of such a system, so that every instance (e.g. trolley) is identifiable and unique in the whole process (cf. Dolenek, 2009, p. 139).

3 SOLUTION DESCRIPTION

The main idea with integrating the process cycle and the IT environment is to enable the tracking of the relevant events during the catering process, insert them into the IT system, analyse them and distribute them to the other responsible participants. The tracking of main events e.g. the loading of trolleys into the aircraft and the comparison with the freight list on board will be implemented by using RFID transponders on trolleys as well as RFID gates and readers at several positions between the caterer facilities and the airport and at the aircraft doors. The main transfer messages will be available as electronic documents and will also be inserted into the flow of information e.g. the freight list which is stored on board. These are XML documents which are transferred via an integration middleware between the different IT systems of the participating partners. Sending documents electronically reduces the error rate and provides the opportunity to calculate important key performance indicators for analysing the efficiency of the whole system. A monitoring dashboard which displays these indicators gives the operators the possibility to interfere the process directly or as a long-term strategic change (e.g. for a better planning of trolleys and their cycle through the network).
In the following, we describe the main elements of the developed integrated systems solution:

- The process participants and the integrated IT systems architecture
- The middleware as the system integrator which forwards all the relevant messages and RFID sensor data to the participants
- The XML files and their structure which are used for the communication by the systems
- The event-driven monitoring dashboard which shows the location and statistics of the events and messages

3.1 Process Participants and IT Architecture

The process of airline catering includes several participants.

Airport: The airport is responsible for the complete flight schedule. The airport software creates the schedule which has to be considered by airlines and caterers for the catering logistics process.

Passenger: In an integrated, pull-based logistics chain, the passenger is the one who starts the process flow of catering goods. Today it is possible or even common to book flights online at home from the private computer, so the additional ordering of individual catering goods (e.g. special meals or duty free concessions) and services for the flight or the destination is imaginable as a new offer for the passengers. As we wanted to simulate such an online booking scenario, we developed the prototype of a pre-flight shop realised with up-to-date programming frameworks (like ICEfaces) which can be seen in figure 1.

Figure 1: The user interface of the pre-flight shop.

Airline: Subsequently in the information flow, the airline is the next participant which is introduced. The booking and ordering information from the passengers will be collected by the airline and an assembly list for the goods will be created.

Caterer: The caterer receives the assembly list which shows what he has to load into the trolleys. He now has to plan his flow of goods in a way that he can load the trolleys as planned in the assembly list. Different software systems support this by planning the assembly lanes. At the end a freight list with the loaded goods is generated which will directly be communicated to the aircraft crew.

Aircraft: The aircraft and the entire crew receive the freight list and store it in the onboard server. They now have to take care that the incoming trolleys match with the freight list.

All these participants are working with their own IT systems. In order to integrate them, we developed an XML data interchange format and a middleware application which distributes the messages through every participant. Figure 2 shows the arrangement of the different participants and the information flow.

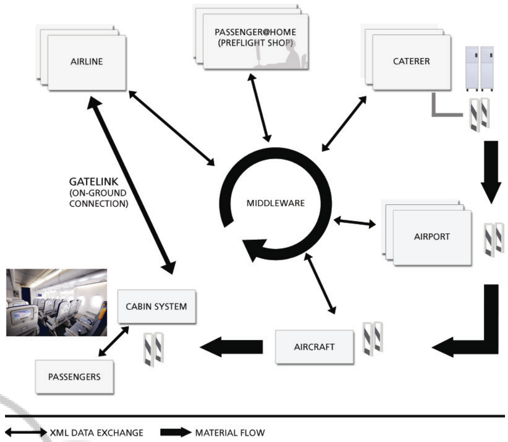

Figure 2: Participants of the information flow.

3.2 Integration Middleware for the Distribution of Messages and RFID Sensor Data

In order to get the full benefit of an RFID-based system, it is necessary to incorporate RFID data into the decision making processes. The IT systems of the participants are the central elements for these processes. Middleware connects the RFID hardware with the IT systems. RFID hardware is useless without the Middleware as integrating software (cf. Hunt, Puglia, M., Puglia, A., 2007, p. 33).

The middleware is responsible for the communication between all the participants involved in the process. Concerning the research project, it was completely developed by the project team of autoIDsystems and was used in several other projects and use cases before. The main idea of using the middleware is to route data between the RFID network and the IT systems and therefore it is responsible for the quality and usability of the information which is produced by RFID systems as Hunt et al. (2007) described the main functions.

The middleware is the central data hub for the communication of all participants. The flow of data is organised by a messaging bus which works like a post-office box. The messages are hold in queues until they are collected. The queues can handle many different data formats but the receptor has to know the data structure. Due to this fact the data structures of e.g. the electronic lists are predefined as XML-files which will be introduced in section 3.3. In that way, it is possible to provide all the information to many partners without changing their IT systems and media for processing the data. Even new and not planned participants can be integrated easily if access is granted.

Several components from various domains have to be integrated via the middleware. This is accomplished by connecting them to the messaging bus which is used as the central communication interface. The processing of the incoming events and documents will be done by the database and application server. The other integrated systems can be seen in figure 3. The integration architecture of the project includes the following elements:

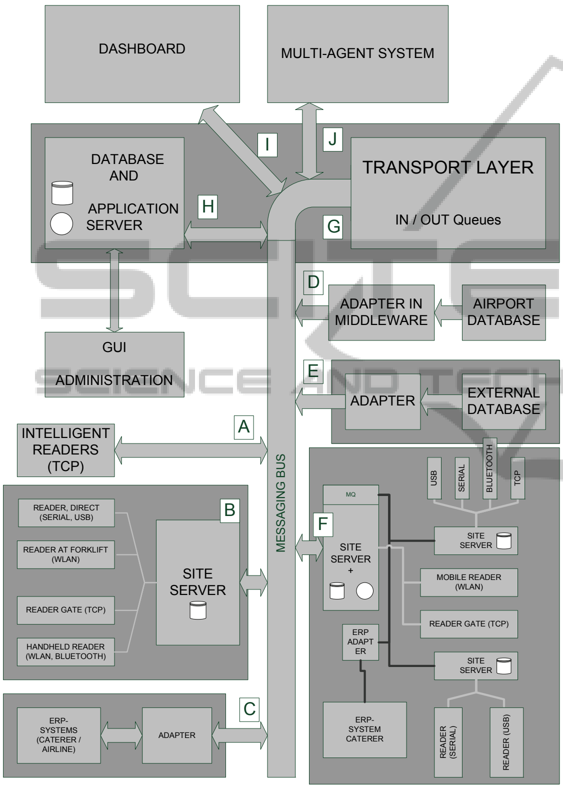

Figure 3: The system architecture of the integrated solution.

A: Intelligent readers which are directly connected to the messaging bus

B: Site servers which provide a connection to various readers

C: Bidirectional connection of external systems with local adapters

D: unidirectional pulling of data from external databases (adapter in middleware)

E: unidirectional pushing of data from external sources (adapter in source)

F: Site servers and independent middleware system for partners to allow autonomous and completely integrated work

G: The messaging bus for the transport of the information

H: The database and application server for processing events

I: The monitoring dashboard for the visualisation of the middleware (also see section 3.5)

J: The connection to a multi-agent system for economic analysis

3.3 XML Data Interchange Format

In the previous section, we depicted the software system to arrange the messages and their distribution between the participants of the system. In the field of airline catering, it means that for example an order for a booked flight now can easily be transferred from the system of the airline to the one of the caterer. We now want to show our suggestion for a standardised data transfer between the participants with the help of an XML-based data interchange format.

Electronic Data Interchange (EDI) is used as a transfer method of business data mostly established between business partners in both directions. EDI is structured in standardised formats for a seamless processing. Currently, the implementation of EDI in the aviation domain is not really considered, because the main data interchange is still realised with the help of paper-based lists. Fraunhofer IAO has developed the following XML structure for the establishment of EDI between the participants in the field of airline catering.

The root element contains the five main lists which base upon original lists used at airports nowadays in paper format:

The *Flight Schedule* with the exact flight data that will be transferred to the caterer.

The *Preflight Order* is an element developed in the project to order goods or services by the passenger from his home via internet.

The *Assembly and Freight Lists* are used to show the target loading of a flight and in consequence the realistic trolley assembly when the caterer has finished loading. It is also used for additional delivery orders which could appear if some of the trolleys are not loaded correctly.

The *Transfer Order* describes the data for the transport of the trolleys from the ramp of the caterer to the aircraft door using a highloader.

The *Ground Delivery* is a structure for pre-flight orders which will be collected at the destination airport by the passenger. This may be used to avoid bulky and heavy luggage.

The different structures enable some benefits for the process participants. The following scenarios point them out and show some examples how the XML files and the newly achieved paperless transactions affect the work in airports:

Order to Caterer: Current flight plans and orders from the airline to the caterer are sent weekly and via e-mail. The caterer then enters the data into his individual software and has to assign e.g. order to flights manually. The newly developed structures provide the caterer with the ability to receive orders directly and without media disruptions from the airport and airline system into the caterer system. All the necessary assignments can then be done automatically.

Freight List at On-board Server: Currently, the freight list and the trolley inventory are matched manually and the sales volume is recorded as a paper-based list or on a USB device. The XML structure makes it possible that the freight list now can be transferred to the server on board. When the RFID-tagged trolleys are loaded into the aircraft, a reader sends the loading information from the tag to the server and the freight list and the real content of the trolleys can be matched by the system.

Precise Transfer of Trolleys: The new XML structures allow a precise transfer of trolleys beginning at the ramp of the caterer. The operator of the highloader receives the data in form of the transfer order and can identify the trolleys with the help of the RFID tags. Mistakes in the correct trolley to flight assignment are now prevented.

3.4 RFID Tag Structure

Besides the structure of the distributed electronic XML files as a replacement for paper-based lists, the configuration of the content of the RFID tags is another important challenge for standardising the data flow in the whole catering process. The project uses a 96-bit UHF RFID transponder for every transport container and the high-value items (e.g. expensive duty-free goods) which are also equipped with an RFID tag. This allows the widest range of possibilities for implementation (e.g. because of the low price and high range). The following elements are part of the RFID structure used in the project (the complete structure is not shown due to the limited space):

Five bits are reserved for the type of container (e.g. trolley, item, and bag). Thirty bits contain the unique ID of the trolley. Two bits are reserved for the code, if the trolley has to be maintained or not. Further elements of the structure are the last maintenance date, the type of the trolley content, if the trolley remains in the aircraft or not, information concerning duty and additional information.

3.5 Event-driven Monitoring Dashboard

Finally, after we have shown the way we integrated the systems and the data between the participants, we want to show how to visualize the whole transaction cycle.

All the relevant objects identified by the central RFID middleware need to be illustrated and analysed in a monitoring dashboard. One of the main requirements is the customisation to the highly individual processes. Due to this fact, it is not possible to develop a standard dashboard. For an individual configuration, the knowledge about all the relevant performance indicators of the process is necessary. With the help of these performance indicators, the project team developed a monitoring dashboard for the tracking and tracing of the trolleys covering the whole catering process. This increases transparency, and several potentials for optimisation can now be discovered. If there are any bottlenecks or high deviations of the performance indicators from the expected values, warnings are displayed immediately in order to improve the reaction time along the process.

The target users for such a monitoring dashboard are airlines interested in a transparent catering process as well as caterers focussing on a visualisation of their own processes. For both parties, different dashboard views are available.

For the development of such a monitoring dashboard application, we used the commercial software Progress Apama (cf. http://web.progress.com/de-de/apama/index.html) which is based on a complex event processing (CEP) engine and additionally includes modelling and execution of an event-driven dashboard. This CEP platform is specialised for the analysis of a multitude of events with very low latency. It can react to these events immediately by using specified event processing rules and can visualise relevant metrics in a web-based dashboard. An event in the context of the project for example is the transit of a trolley through a gate or an alert which is generated by the system and shall be visualised in the dashboard. In contrast to traditional software architectures, an event-driven architecture is used because of the capability to react in real-time and a high performance in processing multiple events.

In the scope of the project Fraunhofer IAO has published a market overview with different CEP-tools (cf. Vidackovic, Renner, Rex, 2010). CEP is used to combine simple platform events into more useful, higher-level business events. In contrast to time-driven processing, generated reports and reactions are related to received events and not time frames (cf. Chandy, Schulte, 2010, p. 43, 47). A simple example in the aviation context is a generated warning as soon as the trolley stock falls below a pre-defined threshold. The Apama CEP engine uses a specific event processing language (EPL) to describe event patterns which should be identified from a multitude of received events and to execute necessary reactions. The dashboard communicates with the CEP engine for displaying relevant business events in real-time. Figure 4 shows the developed monitoring dashboard with the display of RFID events and the interchange of XML files.

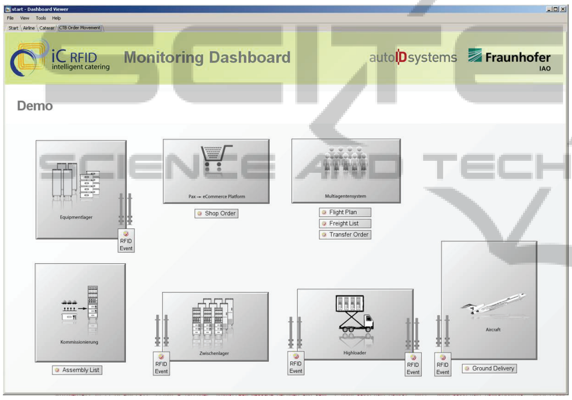

Figure 4: The monitoring dashboard shows the process cycle.

Figure 5 shows an example of the tracking and tracing of trolleys with the monitoring dashboard: the screen shows trolleys which are delayed including their last known position.

The developed dashboard solution supports the caterer for example by the following key performance indicators:

- Average cycle time of process steps
- Portion of wrong deliveries
- Lack of goods and bottlenecks

The airline gets support by the following example key performance indicators:

- Delivery reliability of the caterer
- Number of trolleys in flow, maintenance or store
- Flight delays and resulting lack of trolleys

For the scientific staff of Fraunhofer IAO, the development of the dashboard was the basic work for the research concerning a new monitoring concept for the introduction in business networks with several participants.

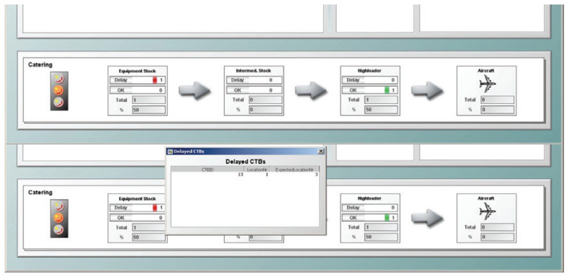

Figure 5: The monitoring dashboard shows tracking and tracing of trolleys.

4 DISCUSSION AND CONCLUSIONS

All the presented results and ideas were completely assembled for testing in a presentation hall at the aircraft constructor Airbus in Hamburg. The main goals of the tests were the proof of the system integration in a running environment. For this special scenario, the XML files and structures were slightly modified so that the project specific systems could be integrated as well. The concrete test of the whole system with a general system run has been operated in June 2010 including evaluators from the German Federal Ministry of Economics and Technology (BMWi). The positive result of the test performance will now be transferred to the interested public especially by the research partners. The developed prototypes will be developed into products and included within the portfolio of the business partners.

Furthermore, the concepts and solutions that are presented here could be transferred to other sectors than the aviation domain. The RFID solution can support every domain which has to deal with tracking and tracing of objects and its documentation. An obvious application area which also deals with the handling of trolleys is the catering in hospitals. The following solutions would be possible:

- Temperature control with RFID and sensors
- Assignment of medicine to patients
- The logistic process for important materials (for inspection, quality control and security)
- Implementation in lunchrooms of hospitals
- Anti-theft protection

Another sector for the implementation of the solution is the railway transport sector including the catering processes.

The paper showed a use case of an integration of various IT systems with different participants in a service network with a high demand of security and precision in the aviation domain. The complete system was assembled in a demonstrator this year and successfully tested. The final results will now be exploited in further scientific work.

REFERENCES

Chandy, K. M., Schulte, W. R., 2010. *Event Processing: Designing IT Systems for Agile Companies*, McGraw Hill, New York et al.

Dolenek, J., 2009. Container and Asset Management. In Bartnek, N., Klaas, V., Schoenherr, H., Weinlaender M. (ed.), 2009. *Optimizig Processes with RFID and Auto ID*, Publicis Publishing, Erlangen.

Garfinkel, S., Holtzman, H., 2006. Understanding RFID Technology. In Garfinkel, S., Rosenberg, B. (ed.), 2006. *RFID: Applications, Security, and Privacy*, Pearson Education, Inc., Upper Saddle River, NJ.

Hunt, V. D., Puglia, A., Puglia M., 2007. *RFID – A Guide to Radio Frequency Identification*, John Wiley & Sons, Inc., Hoboken, New Jersey.

Jones, P., 2004. *Flight Catering*, Elsevier Ltd. Amsterdam, Boston et al., 2nd edition.

Schnathmann, R., 2009, RFID at the airport. In Bartnek, N., Klaas, V., Schoenherr, H., Weinlaender M. (ed.), 2009. *Optimizig Processes with RFID and Auto ID*, Publicis Publishing, Erlangen.

Vidackovic, K., Renner, T., Rex, S., 2010. *Marktübersicht Real-Time Monitoring Software: Event Processing Tools im Überblick*, Fraunhofer Verlag, Stuttgart.