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# Technical Report 65

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## 1 Introduction

As part of an interdisciplinary student research project the Virtual Logistics Lab (VLL) has been developed at the University of Bremen. VLL enables accessing the LogDynamics Lab – a logistics research laboratory – via Internet and will provide a community platform in the future. Experiments shall be conducted, recorded and analyzed with no need for researchers to own corresponding testing equipment or to travel to existing labs. Instead VLL allows remote access to virtual and real interconnecting research infrastructures to run corresponding tests and to act as a study- and development-object for students. The VLL will provide open interfaces and thereby enable other labs to become part of the community. Virtual Research Environments (VRE) have been researched in detail in the past years in different disciplines such as automation and chemistry – but not in the field of logistics. However, connecting real and virtual worlds has been a major logistics research topic referred to as the “Internet of Things”. VLL relates both fields of research and searches for synergies through a distributed logistic research lab environment utilizing Internet of Things technologies. This report contains student papers related to VRE and the Internet of Things which were presented in a poster session of the first international conference on the “Impact of Virtual, Remote and Real Labs in Logistics” 2012 (ImViReLL 2012). The conference took place as joint event of the “International Conference on Dynamics in Logistics” 2012 (LDIC 2012) between February 27th and March 2nd, 2012 in Bremen, Germany. The proceedings of ImViReLL were published as Springer Communications in Computer and Information Science (CCIS) Volume 282.

ImViReLL 2012 provided a venue for researchers from academia and industry interested in future-oriented logistics labs as a nucleus for innovation. The conference addressed research in logistics from a wide range of fields, e.g. engineering, computer science, distributed education and collaborative research.

The poster session at ImViReLL was solely organized by third year students of the one year interdisciplinary teaching project VLL2.0 as part of their computer science and systems engineering course of studies. The project follows a researching studying approach.

The students had on one side to apply scientific methods of research as well as literature reviews supported by using Mendeley ([www.mendeley.com](http://www.mendeley.com)) and on the other side understand the application domain of the real lab environment as provided by a previous student project (VLL 1.0<sup>1</sup>). Furthermore the process of Peer Reviewing using the EasyChair conference and review system was practiced by the students and their supervisors from the Computer Science and Production Engineering faculties.

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<sup>1</sup> <http://www.virtual-logistics-lab.de/index.php?id=3&L=2>

## 1. Introduction

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After a double review process the students prepared the posters as included in this report as one-pagers in time for the ImViReLL conference and after a third review and feedback from the conference visitors the papers are now ready for publication as full papers in this report. For us as supervisors this was also a firsthand experience and we would like to thank all authors and reviewers for their work: You can be proud to have made your first scientific publication.

March 2012

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# Artificial Intelligence in Logistics Labs

## Current Approaches and Future Opportunities

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**Abstract.** Artificial Intelligence is a very important element of computer science which opens up wide opportunities in usage for autonomous logistics labs. The Virtual Logistics Lab 2.0 (VLL 2.0) is a project developed in the University of Bremen. This Lab offers an environment for the test and development of new kinds of logistical approaches which should be improved by an artificial intelligence. In this paper we discuss in which fields of the VLL 2.0 the use of an artificial intelligence is necessary. Therefore several intelligent systems as well as scenarios are examined and useful references to possible solutions are presented and explained.

## 1 Introduction

When looking on the preparation of information the information technology has a very important status. The complexity of problems increases continuously. Therefore software solutions also have to get more intelligent. Artificial Intelligence (AI) and moreover systems which use AI are the most important objects we have to analyze. We can use these information obtained by this analysis to improve our Virtual Logistic Lab 2.0. Previously the Virtual Logistic Lab 1.0 (VLL 1.0) was developed and its main objective was the creation of an integrated platform to control different devices via remote access over the internet. [5] So in the project time of the VLL 1.0 a monitoring system was developed. This system can not give solutions or a decision support for problems the user wants to solve. It only displays data given by the project environment. Hence a lot of preparatory work and achievements are given and we are able to use a functional setting which contains a high bay racking as well as a conveyor band with a integrated balance, a palletizer, a forklift, a RFID-reader and several light barriers. [6] The access to the enumerated components is widely implemented. At the moment we don't have access to the light barriers and the palletizer via webinterface. So our aim in VLL 2.0 is the improvement of the already existing monitoring system to get a system which can give decisions on base of knowledge or even uses agents to act autonomous after the user has send his order to the environment via web-interface. Fig. 1 shows the achievements gained in VLL 1.0 and the

future aim sought by VLL 2.0. This improvement needs significant upgrades in controlling and managing scenarios in reference to the handling and usage of the components given for this project. At the end of our project the system has to act intelligent when getting instructions from a person using the web-interface. Furthermore this intelligence has to respond to additional modifications effected by the user via web-interface and moreover to unscheduled errors. So the following sections will give an overview of already existing systems which use AI like expert systems (decision support systems) or agent systems on the one hand and also reflections of detailed scenarios in which the use of an AI will be necessary for our project on the other hand.

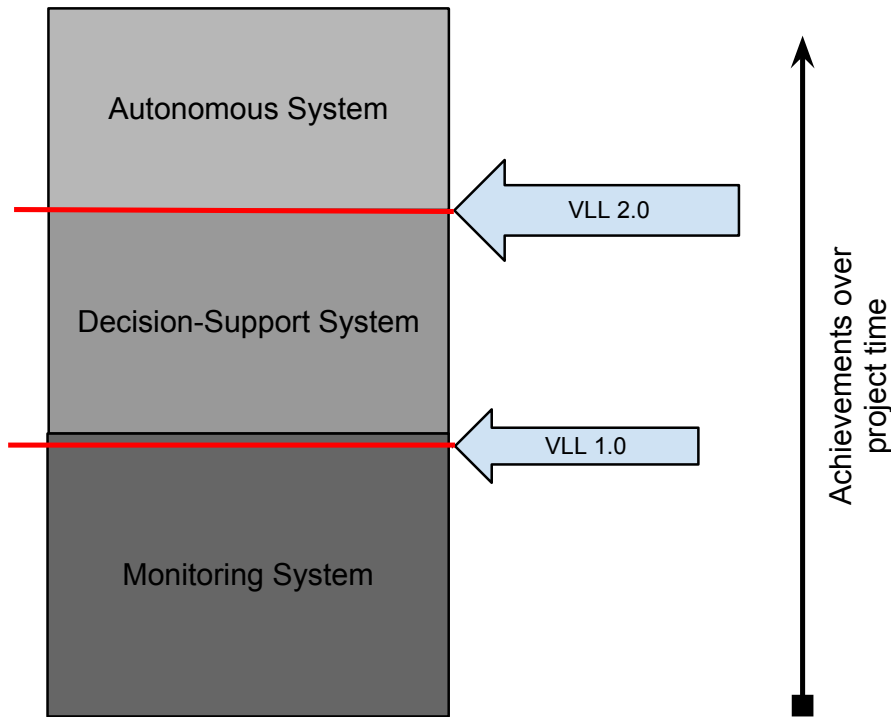


Fig. 1: Achievements over project time

## 2 Types of Intelligent Systems

In order to explore the wide field of systems using an artificial intelligence and also for getting a well founded overview of the opportunities which are given by AI, it is necessary to look at already existing systems using knowledge for

managing a huge amount of processes.

An expert system (ES) is an example for these kinds of systems which is moreover a decision support system. On closer examination Expert Systems can be divided up into two different types of managing and gaining knowledge. On the one hand there are systems using a huge specific, pre-programmed knowledge. This knowledge enables the system to reason and to perform actions like a human expert. To guarantee a well-founded and also well-modulated expertise different forms of facts, heuristics and relationships are constructed and pre-programmed. The acquisition of knowledge gets obtained by experts via information sourcing methods like protocols or analysis. In addition semantic nets or frames are used to display the knowledge of the system. However using production rules (“if-then”) is the most common technique. Though expert systems cannot be regarded only in a positive way, because updating the knowledge of an ES for example causes a lot of problems. Furthermore the system is not able to learn autonomously by experience and in addition it is unable to respond to unexpected errors and incorrect or rather inaccurate problems.

In a broader sense another type of ES are systems which use a pre-programmed knowledge in combination with artificial neural networks (ANN). These kinds of systems do not have a very specific modulated expertise but a huge amount of complex relationships between data achieved by experience. An ANN can be described as a network consisting of working units called neurons. These neurons enable the system to learn by example. Furthermore they prepare a “black-box” transformation of incoming data to outputs by using previous experiences learned during previous actions. So a system using ANN offers the advantage of operating with incomplete data and besides demonstrate apparent intuition. [3] [4]

The second important type of systems using an artificial intelligence are intelligent agents. An intelligent agent by definition is “a computer system situated in some environment, that is capable of autonomous action in this environment in order to meet its design objectives”. [7] An agent combines the amount of specific knowledge with experiences gained by formerly performed actions. It is able to affect objects for getting a solution for its tasks. Besides intelligent agents can be modified dynamically. The knowledge of an agent enlarges by learning and also by collecting information of actions which are performed by other agents in the system. So a system of agents can act autonomous. Another advantage of these systems is that agents are capable to generate a huge amount of different perspectives for the same situation. This ability in turn enlarges the amount of wise solutions. So the process of decision-making is of high-quality. [3] [1]

So with these types of knowledge-based systems in mind it is possible to take a straighter look on special scenarios given in our Virtual Logistic Lab 2.0.

### 3 Scenarios

The Virtual Logistic Lab 2.0 offers a lot of different scenarios which were managed to get an usable work environment. These scenarios are processes and sequences the machines have to fulfill. The following sections will present detailed information about the possible usage of artificial intelligence in different components of the setting used for our project.

#### 3.1 Packing-Solutions (Palletizer)

The palletizer is used for packing an amount of packages on a pallet. In our current environment the palletizer is able to arrange four packages on a pallet using a pre-programmed packing pattern (Fig. 2). For using this packing pattern the size of these packages has to be equal. As the objective of our project is to upgrade the given environment the scenario we want to observe is the possibility to have different packing patterns which have to be created by an AI. Therefore it is essential to discuss whether it is useful to have a larger amount of pre-programmed packing patterns of which the AI has to choose one pattern or whether the AI should calculate a fitting solution.



Fig. 2: current packing pattern with 4 packages

**scenario:**

An amount of packages have to be placed on the pallet in a space-saving way.

All packages are of the same size.

If all the packages have the same size it is definitely expedient to use pre-programmed packing patterns which fill the pallet in a space-saving way. One possible packing pattern for the size of packages which is currently used in our system is given in Fig. 3. For more complex packing patterns a modification of the grapppler is necessary.

**scenario:**

An amount of packages have to be placed on the pallet in a space-saving way. All packages are of different size.

If all the packages have a different size a calculated packing pattern via AI is needed. In this case pre-programmed packing patterns cannot be used because the amount and also the size of the packages are variable. Algorithms solving these calculations are very complex and difficult to analyse. To guarantee for an space-saving arrangement of the packages on the pallet slicing packing methods are useful approaches. The advantage of these methods is a rapid calculation via algorithms without degradation. [2]



Fig. 3: current packing pattern with 6 packages

Only an expedient arrangement of packages result in a maximum of effectivity and saved space on the pallet. Now the question lasts which type of intelligent system gives the most capable solutions for our packing problem. A system of intelligent agents is the most profitable system we could use. These systems offer the opportunity of communication between the different components of our device environment. So the palletizer gets information about the amount and the condition of the packages which have to get palletized. Thus the agent which is responsible for the palletizer can analyse the information and calculate the best possible solution for the arrangement of the packages. All in all a system made of agents offers an extensive amount of information because of the communication among the agents and the fact that every agent build up on the knowledge of the other agents. For this reason the use of an expert system is not advisable.

### 3.2 Packet Tracking (Conveyor Band, Light Barriers, RFID-Chips)

The conveyor band is used to transport packages throughout the delivery circuit to the different components in our environment (high bay racking, palletizer ect.). In this process light barriers are passed. These light barriers are used to locate the actual positions of the packages in the circuit. Furthermore every package can be localized with the aid of a RFID-Chip inclosed in the label. The objective of our project is a package localization in the delivery circuit controlled by an Package-Management-Intelligence. Thus it is possible to get the information where a certain package is located and the system is able to send up the information to other components within our setting, but only if it is a necessary information for the particular component.

#### **scenario:**

A package passes through the delivery circuit and is sent to the palletizer.

As aforementioned the palletizer has to know the information of a package which is ordered to get palletized. The main information the palletizer has to know are the actual position as well as the size and conditions of the package. If the conveyor band contains a larger number of packages and multiples of them should be palletized the palletizer has to know how many packages he will get for palletizing. Of course the conditions of the packages have to be send to the palletizer as well. So the best solution would be that the conveyor band has to collect all the needed information of the packages by communicating with other components within our setting. As an expert system has to be modelated in an extremely complex way to fullfill these functions mentioned above a system of agents again would form a more comfortable opportunity. Agents do not have to be very complex. By communicating with other agents they are able to establish an also very complex network which would gain the same achievements as an expert system with a lower input. A possible conveyor agent would get the information of a package by asking other agents like for example the balance agent for details. After that the information he gained can be send to the palletizer. There the palletizing agent can evaluate the given information and calculate possible packing

patterns. Certainly this course of action can also be projected on other scenarios like the transport of packages via conveyor band to the high bay racking.

## 4 Discussion

All in all the exact observation of relevant scenarios for the future gives us an extensive outlook on the potential our intelligent system must have for getting a high-quality logistic lab. The different aspects of expert systems and systems using intelligent agents were compared. To our opinion both systems give interesting solutions for the problems we have to solve in our project. However the more advantageous system is a one using intelligent agents. An expert system has to be extremely complex for implementing all the opportunities that we would imagine for realizing the given scenarios. Furthermore the serviceability of an ES is very difficult due to the fact that all information and knowledge exists in a central system. Also the possibilities of reacting to an error are limited. [3] But all these possibilities are to be contained in our future logistic lab. In contrast to this an agent is a very simple construction. The complexity of an agent system is generated by the communication which takes place among the different agents. By creating multiple perspectives of the same situation an agent system also is able to find more possible problem solutions as an expert system. To reference to our Virtual Logistic Lab 2.0 an agent for every component of our environment can be modulated. With these agents the communication among the different components can be achieved. So for example the palletizer receives all the relevant information needed for calculating the packing pattern by receiving information from other agents (conveyor band, light barriers). Moreover previously calculated packing patterns can be used for future palletizing orders made by the user. Thus the agents can call up information given by previous actions they were performing.

Recapitulating the information we gained with the aid of the reflection of intelligence systems and the scenarios it is clear that the most advantageous system for our VLL 2.0 is an agent based one.

## 5 Conclusion and future research

As this paper has shown artificial intelligence is a very important element of computer science. There is a wide amount of fields of application and scenarios for artificial intelligence in our project. With all the information obtained by research it turned out that implementing a system which uses intelligent agents is the most advantageous way to equip our Virtual Logistic Lab 2.0 with an artificial intelligence. Agents will afford high-quality solutions and achievements. An agent system is able to act autonomously and that is the objective which shall be achieved in the future. Eventually the time which is given for the VLL 2.0 would not be enough to fulfill all the possibilities an agent system offers us

for improving our logistic lab. However a partially implementation of an agent system would produce a huge improvement. Upcoming research has to be made in the field of the forklift and the configuration of its intelligence. Also scenarios for the forklift have to be examined. Furthermore the packing algorithms which should improve the palletizing process have to be described in detail and it has to be discussed how complex these algorithms will be. At last the tracking opportunities have to be examined to find a necessary solution for a tracking intelligence.

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# Autonomous Logistics

## Potentials of Multiagent-Systems and advanced Scenarios for Virtual Logistics Lab 2.0

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**Abstract.** In this paper a concept of a multiagent system in the context of a logistics system will be presented. It shows which advantages such an autonomously and decentralized working system provides in comparison to centralised systems. In particular it will be tried to apply a multiagent based approach to the current LogDynamics Lab<sup>1</sup>, a logistics laboratory consisting of different demonstration machines for materials handling, of the Virtual Logistics Lab<sup>2</sup> project to ease the usage of the system for the end-user. Another goal is to extend the system so that it will be possible to test more complex scenarios.

**Keywords:** Virtual Logistics Lab, Agents, Multi-Agent System

## 1 Introduction

A centrally managed, hierarchical control strategy is (a) unresponsive in the face of disturbances such as rush orders, breakdowns, supply stockouts, and (b) cumbersome to reconfigure for new products, new manufacturing technologies or different line configurations [1, 2, 5, 15].

Intelligent products are a promising new approach for product monitoring and product lifecycle management [4]. Particularly agent technology has been considered as an important approach for developing industrial distributed systems (e.g. intelligent manufacturing systems). We try to attach intelligence or intelligent agents to product individuals, which can utilize the real-time information about the product itself [9, 10, 14]. A key feature of this approach is the replacement of conventional centralised decision-making systems with distributed but interacting decision-making software modules (software agents) which correspond one-for-one with the physical products and resources in the manufacturing environment. In such a system, control strategies are resolved by negotiations between these distributed software entities acting on behalf of their physical

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<sup>1</sup> <http://logdynamics.biba.uni-bremen.de/> call date 02.01.2012

<sup>2</sup> <http://www.virtual-logistics-lab.de/> call date 02.01.2012

counterparts. This approach permits increased adaptability of the control system in the face of disruptions or reorganisations, as well as not letting local disturbances to spread out [4], and promise to provide a "deregulated" control system for supporting the rapidly customised products and self-organising production, distribution and inventory systems [3]. The product individuals are themselves in control of where they are going, and how they should be handled, so that they need to know what needs to be done with them and are able to communicate the information to different supply chain members [3]. This way we get what Kärkkäinen et al. [6] call "inside-out control" of the supply chain deliverables. By definition a software agent is a distinct software process, which can reason independently, and can react to change induced upon it by other agents and its environment, and is able to cooperate with other agents [3].

In this paper we will show how a cooperative multiagent system can be applied to the Virtual Logistics Lab (VLL)<sup>3</sup> in order to ease the usage of the system by providing an automated inventory management.

### 1.1 Current Status in the VLL

The Virtual Logistics Lab<sup>3</sup> is a project that concentrates on combining several demonstration machines for materials handling which are part of the LogDynamics Lab<sup>4</sup>. Currently it consists of a high rack, a conveyor band with light barriers and RFID readers, a Reva Server (a middleware to cross-link RFID readers), a palletizer, a weighin machine and a labeling machine. It is possible to control the LogDynamics Lab<sup>4</sup> through a webinterface to test single machines or to execute successional scenarios.

It is possible to test scenarios which contain the movement of packages through different handling points. The scenarios are scripted sequences of actions in XML format that are performed. To solve complex problems it is necessary to create very large XML files. In addition a quite high knowledge of the machines is needed. [13] To solve these problems an approach which allows intelligent control of the operating procedures could help.

## 2 Requirements for advanced Scenarios

A new approach for process control should be goal oriented. It is also important that it is easy to create complex scenarios. A new system should not depend on hundreds of lines of source-code. One line for each operation should be enough. The LogDynamics Lab<sup>4</sup> with the new system should realize at least the following points:

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<sup>3</sup> <http://www.virtual-logistics-lab.de/> call date 02.01.2012

<sup>4</sup> <http://logdynamics.biba.uni-bremen.de/> call date 02.01.2012

### **2.1 Order/Insert multiple Packages**

The system should be able to handle multiple packages with different products. A user should be able to easily order many products with the same destination and target. Furthermore the system should also be able to handle many of those requests simultaneously. For an advanced system it should be important that the user who is creating a scenario, does not need to know technical details of the hardware. These operations should be abstracted by the system itself.

### **2.2 Simulation of different Repositories**

To realize more complex scenarios, virtual repositories would benefit the system. This could be realized by splitting up the physical repository into two or more virtual repositories. In this way more complex orders could be realized without massive manual interaction (inserting packages that have been delivered again and again) with the system. Also it's not necessary to change the physical layout of the demonstrator system.

### **2.3 Localization of every Package and Status of every Order**

A user needs the ability to send a query to the system to get the current status of his order. This means that the system has to know where each package is and what the current status of the whole order is (e.g. *in progress, delivered, etc.*).

### **2.4 Automated Error Handling**

The new system has to handle all errors that can occur. For efficient tests, this will require forced errors via the implemented software (for example to send packages to a wrong destination) and errors that will be created manually by a person (e.g. to simulate a package that falls of band).

### **2.5 Flexibility**

The new system should be able to react on changes in the environment and still work in the preferred way. If for example a new repository is included into the Lab the system should still work as it is supposed to.

### **2.6 Direct Access**

Last but not least, the system has to still be able to handle requests to the hardware directly. This is very important to test new features explicitly. Maybe this will be realized via an Interface to the old System, or as an alternative the system could be able to explicitly access single hardware during an order/insert.

### 3 Multi-Agent Approach

To realize the desired improvements described above, it will be necessary to re-implement the whole Scenario-System. As an alternative to the current design, the system would benefit from an implementation as *multi agent system*(MAS). In this section we describe how such an implementation should look like and how this kind of implementation would benefit the VLL.

#### 3.1 Benefits of a Multiagent-System

The main benefits of such a multiagent-system would be a more dynamic implementation of the scenarios, a much higher abstraction from the user level and the ability to design new scenarios much easier. Users will not have to care about error handling and so on, because this responsibility is delegated to the agents themselves.

#### 3.2 Implementation Issues

A new multiagent-system could be designed as shown in figure 1.

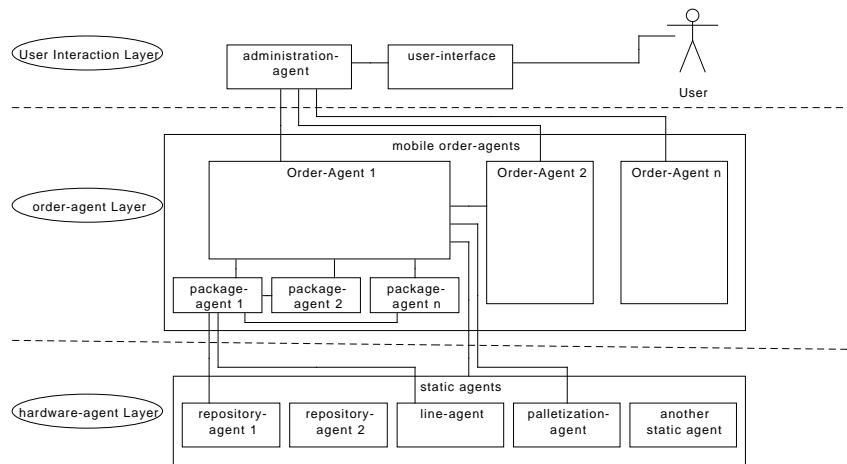


Fig. 1: Multi Agent Structure

The system is divided into three different layers *user interaction layer*, *order-agent layer* and *hardware-agent layer*. These Layers have the properties described in the following paragraphs.

***user interaction layer*** This layer implements an interface to the users and administrates the order-agents in the layer described in the next paragraph. The orders send by the user could be implemented as described below:

```
public UUID order(Destination from,
                 Destination to,
                 HashMap<Product_ID,int> ordered_items)

public UUID insert(Destination into,HashMap<Product_ID,int> inserted_items)

public UUID force_error(int error_code,List<Object> params)
```

A complete scenario could look like this:

```
order(LAGER1,LAGER2,[(1234,3)]);
order(LAGER3,PALETTE,[(5678,3),(1234,2),(345,1)]);

insert(LAGER3,1234);
```

***order-agent layer*** This layer contains one agent for each instruction. These agents communicate with each other and with the agents from the *hardware-agent-layer* and decide autonomously what they do next. They are calculating the best routes for each package and should be able to change those routes in order to prevent congestions or overfills. Each of these agents behaves intelligent if an error occurs and tries to complete its task. The order-agents should be mobile agents, this means they could be send from one lab to another and continue there work on another platform.

An order-agent should serve as a container for lower level package-agents. These package-agents communicate directly with the devices in the hardware-agent layer. They decide when to enter the next node and may ask the corresponding order-agent for alternative routes if a node is overloaded.

***hardware-agent layer*** This layer contains *hardware-agents* which are attached to one device/part of the lab. These agents collect data from the devices they are attached to and communicate with the agents which declared interest to this hardware. Examples for these agents could be repository-agents, line-agents, packaging-agents and so on. Each of these agents needs at least a list of contained packages and a list of entry and exit points. These abilities will be implemented in an abstract super-class to make it easy to include new hardware dynamically. These entries and exits are important to realize virtual repositories and lines. These virtual agents can take complex routes, this way it could be realized that a package which is delivered from repository A to E will need to be send over the repository C and the lines B and D. The way of packages will calculated by the order-agents.

## 4 Use-Cases

The following paragraphs describe how the system takes care of specific simple tasks. In more complex scenarios these tasks will be combined.

### 4.1 Ordering of multiple Packages

This use-case describes how the system handles an incoming request for delivering a list of packages with the ids:1,2,3 from a destination A to a destination C.(figure 2)

**administration-agent** The administration-agent gets an input from the user-interface and checks its syntax, this also includes a check if the provided static-agent-IDs and product-IDs are known to the System. If this check is positive the administration-agent creates a new order-agent which will handle the request autonomously.

**order-agent** The order-agent calculates the best route for the packages and sends a request to the corresponding static-agent. If the package is currently unavailable or the static-agent is busy, the order-agent will wait for a trigger from the static-agent. As soon as a package is available the order-agent will create a sub-package-agent which handles direct movement of the package.

**package-agent** The package-agent will request space on the next device it wants to access and initiate this movement. If there is no space it waits a few seconds and then tries again to access the device. If a serious error occurs, the package will try to find a new route by communicating with the direct neighbours of the device. It may also try to communicate to other packages from the same order to speed up this process. If the agent can't find a short way to the next device it will ask his corresponding order-agent for an alternative route. Each time an agent accesses a new device it will check if it arrived on its target device. Otherwise it will repeat the process until it arrives the final destination. In this case the administration-agent will be asked to inform the user and the package-agent will terminate after it informed the order-agent about its arrival.

### 4.2 Inserting of multiple Packages

This package describes the time/command flow of a package insert command. In this case the package will be inserted to the repository directly.

A sequence diagram of the process is shown in figure 3.

After the user-command has been parsed the administration-agent will create a new order-agent which will handle the insert process. This order-agent calculates the best route and registers an insert request to the corresponding static-agent

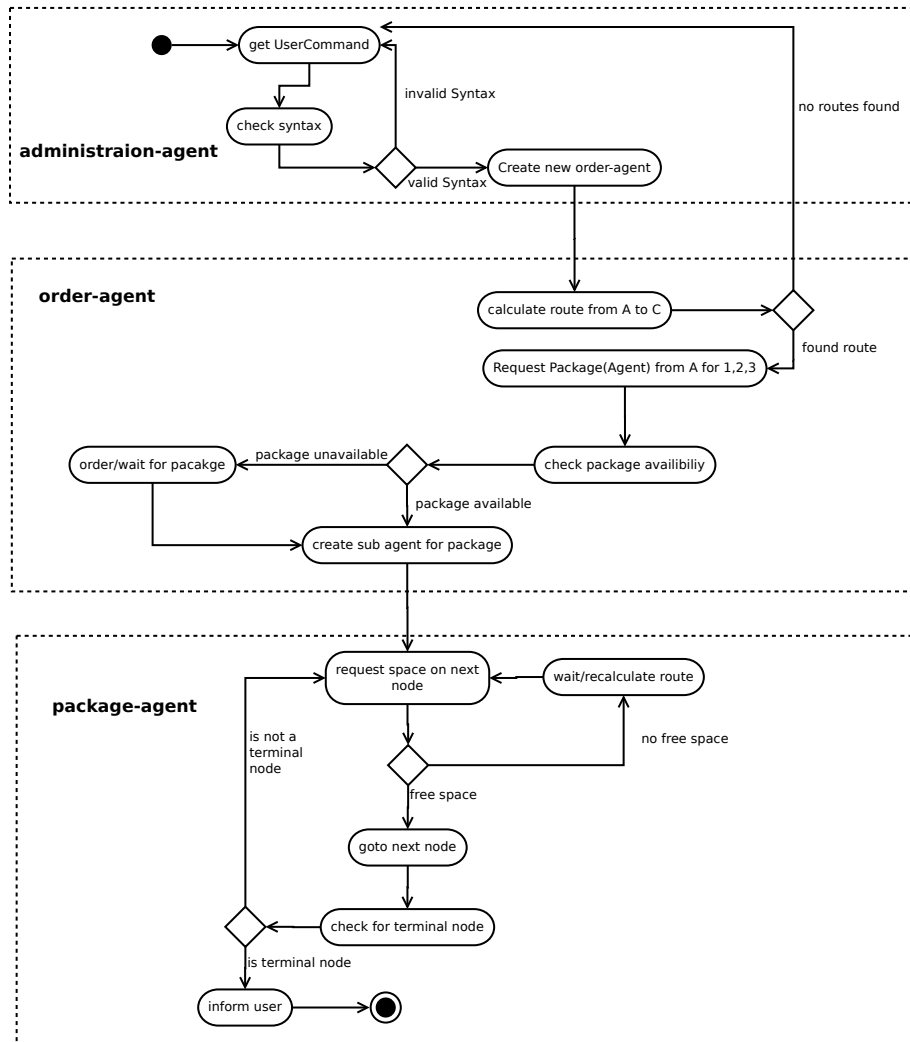


Fig. 2: Order/Send packages

that will handle the inserted packages in a first in first out (FIFO) query and will inform the order-agent as soon as its package is in turn. At this point the order-agent creates a package-agent for the inserted package. From this point the package will send its personal information to the device to get the right label. After that it will move to the next device and will request space on it. This device will inform the package as soon as there is free space so it can continue its way. In this case our package has reached its destination and the repository-agent will insert it to a preferred place in the repository. In more complex scenarios the package may need to communicate with more agents to reach its destination.

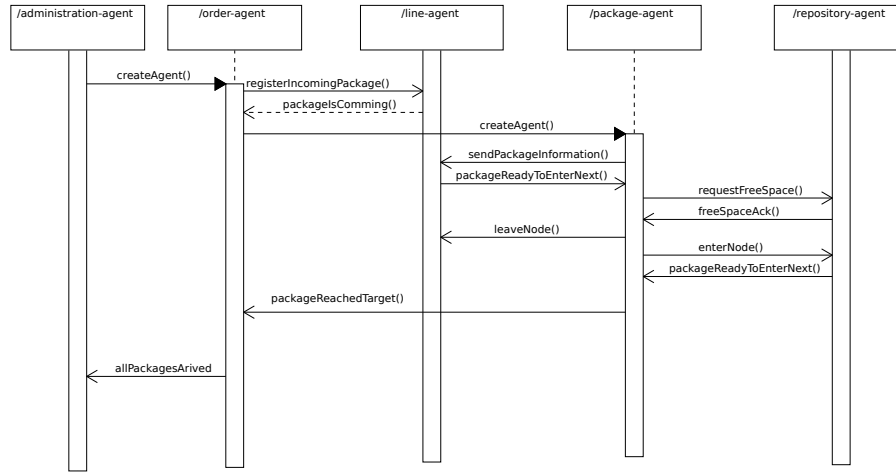


Fig. 3: Inserting packages

## 5 Outlook

It is planned to implement the multiagent concept with the *Java Agent DEvelopment Framework JADE*<sup>5</sup>. The system will be tested in a completely virtual Environment which will mirror the physical logistics laboratory to recognize weaknesses before the physical objects are affected. This Environment will be created with **PlaSMA** (*Platform for Simulations with Multiple Agents*)<sup>6</sup> which is a software project within the Collaborative Research Center 637 Autonomous Logistic Processes (SFB 637) at the University of Bremen).

To implement the system on the physical logistics laboratory, the LogDynamics Lab<sup>7</sup>, it is necessary to create hardware interfaces for some of the components in the lab.

## 6 Conclusion

The multiagent approach given in this paper has shown that it is possible to ease the usage of a centrally controlled system, which is accessed via static process plans, for the end-user by providing certain actors in a logistics system with intelligent behaviour.

The new approach eliminates the need for large process plans like they are used in the first approach of the VLL project and provides a more dynamic system which can react much better to exceptions and errors. The simulation of certain actors, as virtual ones, gives the possibility to create more complex scenarios,

<sup>5</sup> <http://jade.tilab.com/> call date 02.01.2012

<sup>6</sup> <http://plasma.informatik.uni-bremen.de/> call date 02.01.2012

<sup>7</sup> <http://logdynamics.biba.uni-bremen.de/> call date 02.01.2012



which is a great benefit particularly for a test environment like the LogDynamics Lab<sup>8</sup>.

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<sup>8</sup> <http://logdynamics.biba.uni-bremen.de/> call date 02.01.2012



# The Internet of Things and Logistics Research Improvement Opportunities for Virtual Logistics Lab 2.0 through RFID-based Internet of Things and Autonomous Control

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**Abstract.** This paper presents the benefits of introducing the concept of RFID-based Internet of Things to the student project Virtual Visual Lab 2.0 at the University of Bremen. Accordingly, it aims at showing optimization possibilities gained after shifting from the current system to a self-organising, decentralised one.

**Keywords:** Information Technology, Internet of Things, Logistics research, RFID

## 1 Introduction

In the context of the economic globalization of trade, logistics management requires process automation. Logistics management research needs effective package flow control and data collection based on real data. The concept of the Internet of Things (IoT) based on Radio Frequency Identification (RFID) technology can be an important tool in enhancing the student project Virtual Logistic Lab 2.0 (VLL 2.0) of the University of Bremen. The System that VLL 1.0, as a predecessor of VLL 2.0, has developed represents a central controlled system, that uses webinterface to surveil the machines at the LogDynamics Lab at BIBA through webcams and to operate them through static scenarios created beforehand, which sequence the steps that have to be taken.

In this paper a possible concept of RFID-based IoT through Autonomous Control is introduced to VLL 2.0. After a brief description of the current state of the project, the authors illustrate the benefits of RFID-based IoT by describing its application within a practical scenario. Finally a conclusion is drawn as to its applicability to the students project and the future possibilities for extending the functionality of the LogDynamics Lab with integrated RFID technology are outlined.

### 1.1 Current Status of Virtual Logistic Lab 2.0

At this stage the already installed RFID System has not yet been integrated and the packages are tracked and handled through barcodes. Accordingly EPC

## 2. RFID based Internet of Things and Autonomous Control Internet of things

Global have not been introduced to VLL either. Furthermore the present system does not output any package relevant data. The aim of this paper is to present the potential positive effects on VLL 2.0 by introducing the concept of RFID-based IoT together with Autonomous Control, in order for live relevant data retrieval to be achieved. Currently different types of logistics machinery (high rack storage house, conveyour belt, electronic scales, inflation pressure labeler and robot-palletizer) can be remotely controlled “by hand” via webinterface. The purpose of VLL 2.0 is to extend or replace the present remote controlling system with optimization features such as autonomous handling and more precise tracking of packages.

## **2 RFID based Internet of Things and Autonomous Control**

### **2.1 RFID Technology**

RFID technology enables item identification within meters of range. On the market there are different types of RFID Transponders (also called Tags), but at present the passive RFID Tags are most cost efficient and interesting for businesses. They function without possessing an energy source. By having a high frequency radio signal rayed on them, the RFID Tags are able to decode the signal by magnetically inducting the energy needed for sending an answer message back to the source. Within seconds a couple of hundred-bit-long message can be sent.

On the other hand there are some drawbacks related to the introduction of RFID technology. In the following section the negative RFID signal affectors are listed:

- noise signals from near by located radio equipment
- frequency shifts
- not enough reading distance
- facility specific signal-reflexion or -absorbtion
- labels that are thorn or defected in a way they could not be read properly

On that basis a parallel 100 % RFID Tag reading cannot be ensured.

### **2.2 Internet of Things through RFID**

The concept of the Internet of Things refers to designing objects with embedded logic components and sensors that can “see” their environment and respectively transmit information upon it [2, 3]. It stands for an advanced, comprehensive and complex information network system. In logistics it targets a construction of network of physical items, which having been virtualised could share information about their status in real time.

The information technology needs to provide a single global unique identification code for items using Radio-Frequency Identification (RFID) technology

and wireless data communication based on the use of global integrated standards (EPCglobal Network) [2]. The aim is to enable the global identification and tracability of every single product.

### 2.3 Autonomous Control

The IoT defines an autonomous, self-controlled transport of logistics objects from sender to receiver [10]. This concept could be represented as a stream of logistical objects that achieve standalone seek-and-find in inner and outer enterprise networks, that decide over nodes what is the most favorable way to continue and request necessary resources if needed. The objects will be armed with embedded intelligence (RFID) that allows them to communicate not only with the controlling units of the whole system but with themselves as well. The IoT thus permits the transition from the current central controlled system to an autonomous, multi-agent system (MAS). This decentralization is trying to meet the local requirements inside the logistics system, which on the other hand would reduce load in the main system.

This decision making in the environment of the objects and on the level of the objects themselves contributes to increase of availability of data and robustness in the logistical processes, which directly impact the level of agility according to D. Uckelmann [10].

## 3 How the Internet of Things and Autonomous Control could affect VLL 2.0

### 3.1 Introducing Autonomous Control and the Internet of Things to VLL 2.0

The idea of optimization through Autonomous Control lies in the transition from manual or central controlling to smaller groups of autonomous decentralized controlling. Thus the cost for manual update in item flow control for example in case of system adaption is lowered.

There are three methods of combining RFID with agents: ID on Tag, data on Tag and a whole agent on Tag. Since the RFID Tags used at LogDynamics Lab are passive RFID Tags with small storage capacity the ID on Tag method is only applicable to VLL 2.0. The other methods require more storage capacity on the RFID Tags themselves.

With the ID on Tag method an EPC is saved on the Tag, which is reference to the agent that is responsible for item carrying this EPC. Other Information is stored by the agent in EPCIS(EPC Information Service) Repository. The following practical scenario aims at showing the work process of an IoT based multi-agent controlled VLL 2.0 system and refers to Brieber and Szymanski's paper [4]. Here the package flow is controlled by software agents representing machines and packages that communicate with each other (concept of IoT) as referred from Meyer [9]. There is an agent for every package and machine. In 1

a user wants to transport a package with a particular EPC using the conveyor belt. Firstly an agent is initialised that is in control of that package. The agent gets the status of the package using RFID reader. It stores the new status as EPCIS (EPC Information Service) in a repository and additionally creates an assignment with the regulations input by the user through the WebInterface. This creates an agent for the conveyor belt that communicates with the agent of the package and obtains information on destination etc. Then the agent starts the motors of the conveyor belt and the package starts moving. The package agent sends status information to the web interface. Once the assignment is done the agent for the package is erased. It makes evident that MAS can execute scenarios dynamically, store and send data back to the user, which is not possible with the current system.

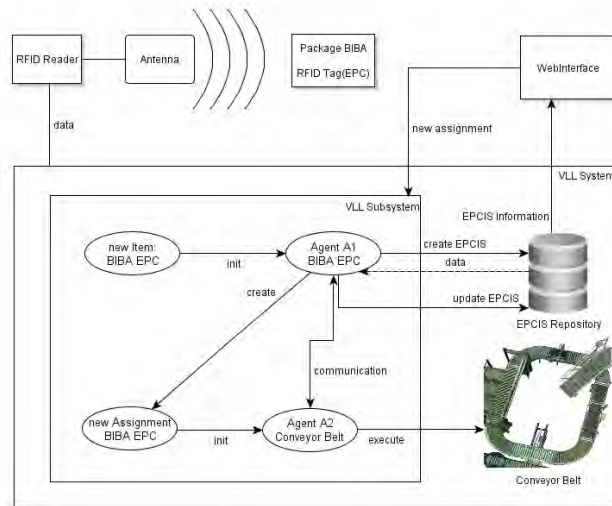


Fig. 1: Funktionalität von MAS basierend auf einem Paket auf dem Förderband

### 3.2 The benefits of RFID-based Internet of Things for VLL 2.0

In the following section some main points are distinguished, that could positively influence the efficiency of the VLL 2.0 package flow system.

Guenther and Hompel [7] shows possible areas for self-organization that could optimize specific logistical processes: performance, robustness and availability for data.

In this manner **logistic performance** can be measured in work-in-progress, parameters flow rate, workload, time and schedule reliability [11]. The importance of these parameters depends on the type of application. Nevertheless, there

is some evidence that self-organization does not have global effect on logistics performance [1]. Show in a study that a agent-based decentral control for the baggage handling system of a major airport shows similar throughput times as conventional central controls. This shows that any central algorithm can be decentralized and vice versa.

Firstly it is widely acknowledged that **robustness** in autonomous controlled systems is increased [1,5].According to Di and Serugendo [5] a system is robust, if it has the ability to provide a service under conditions that are outside its normal area of operation.

Also Di and Serugendo [5] identify four attributes of a self-organized system that will increase efficiency of the robustness.

- **Convergence** - this attribute describes whether the system actually converges towards the desired goal.
- **Speed of Convergence** - how fast desired goal is reached.
- **Stability** - can the system maintain the reached goal.
- **Scalability** - how the system work with different numbers of agents.

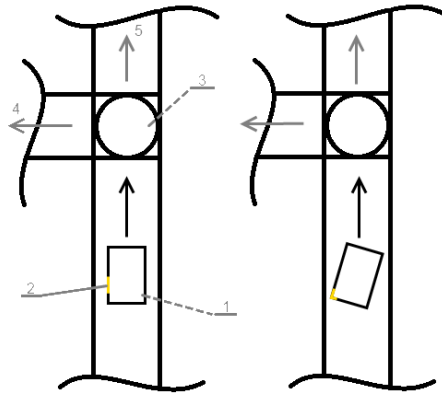


Fig. 2

Picture 2 shows possible problems in terms of the robustness of the system. 1 represents a package. 2 is a bar code sticker with RFID tag. 3 - a turntable. 4 - way to high rack. 5 - NIO-place(for packages that are not recognized).

In the left part of the image the normal sequence for storing a package is simulated. A package travels on the belt to the turntable and then it is moved to the high rack. In the right part of the picture, the package was incorrectly placed on the conveyor belt but still properly labeled. Now it is possible that the package gets stuck on the conveyor belt and locks the belt. The system needs to

identify the problem and reacts accordingly. In this case, the system reports the problem, blocks further processes that need the conveyor belt and waits until the package is manually removed from the belt and resumes to normal status so that further operations could be continued flawlessly. If the package arrives to the highrack without getting stucked, there will be a problem with storing the package. Since it was not labeled properly, it can not be read properly from a bar code scanner. In such a scenario a robustness of the system could be guaranteed through the RFID technology. The system could still store the package or reject it to the NIO place through acquiring data from the RFID Tag independent of its orientation.

Decentralization and a unified modularization usually simplifies significantly the control algorithms. For example the “Jahresbericht Fraunhofer Annual Report 2008” [1] shows that it is possible to control vast package handling system in a decentralized manner with only few lines of code. Therefore it seems reasonable that the a greater robustness of the self-organized systems is achieved through increased clarity and modularity of the control software.

The integration of RFID Tags in VLL could greatly increase the **availability of data**. Mannel [8] suggests the potential benefits in three dimensions, all pertinent to VLL:

- **process-level**: simplified inventory.
- **network level**: increases the predictability of future requirements, increased traceability of packages.
- **additional services**: real time information of package.

An application example of some of these points is tracking a package through the Internet. So it could graphically display the location of the package on a webpage. A better traceability in that manner could be achieved by increasing the number of RFID readers.

In the BIBA facility there is already a machine that labels packages with passive RFID Tags. Thanks to this packages could be located on relevant points in the BIBA facility and a tracking of package streams could be implemented. Thus a concept of Internet of Things using EPC Information stored on the RFID Tags could be implemented and integrated in the current system.

### 3.3 Future Perspectives

Apart from the already described benefits, such an infrastructure would furthermore allow a service and functionality extension for future projects. The following final paragraph gives an example of possible future applications.

Information stored on RFID-Tags could be used for other purposes on the facility in BIBA. For Example depalletizing funktion performed by the existing robot palletizer. Since VLL 2.0 has a vision of scenario based palletising of items or packages on a pallete through a web interface [6], a further step would be to use the information stored on the RFID-Tags for other processes. For Example depalletising process through the same robot palletiser. This function could be



used for further packaging, distribution or storage purposes. This in turn could be achieved if the availability of data is guaranteed. This would mean that the information about the particular pallets and packages or items being stored in a central database (For Example: EPCIS Repository) could be read, processed and retrieved as data for research purposes. Also if necessary information could be transferred to the robot. A next step would be a sustainability collision checking system (on the robot itself) and a system that checks the package orientation through a webcam for example. A collaborative system of both would be enough to detect and compare the actual status of the packages on the pallet and one the simulated and expected by the system. Thus an autonomous, human-error-free logistical process as shown on 3 could be achieved. Such a functionality could be easily integrated into the system due to the suggested modular structure.

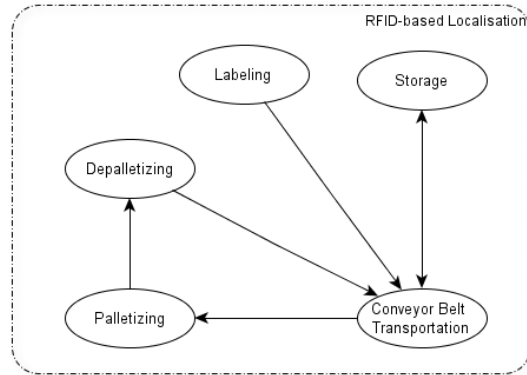


Fig. 3: Use Case: Package Flow at the BIBA Facility with a depalletising option

## 4 Conclusion

The aim of the paper was to briefly present the RFID technology and its benefits for VLL 2.0. It showed that the Internet of Things through Autonomous Control is a prerequisite for an optimisation in logistics management research and is thus highly relevant to VLL 2.0. So far a concept of package flow control with MAS and a practical scenario were introduced. It was described how improvement in performance, robustness and availability of data could be reached [7]. Subsequently a future perspective is introduced based on a scenario. It presents the implication of the introduction of RFID-based IoT to VLL 2.0 and how beyond that this concept could positively affect the project. To this end a step towards decentralized infrastructure is necessary.

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# Web-interface for controlling a robot palletizing cell

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**Abstract.** Virtual Labs are getting more and more importance for research and learning. Many universities and research centres are implementing or already have virtual labs. This concept opens new ideas for experiments, extending the possibility of tests with a real system without the need of being physically near the facility. Most of the robot palletizing cells are found in industries or logistics distribution centres, the access of such a system remotely for firstly academic purpose, opens the opportunity for students and scientists to learn, test and improve such systems without impacting production. This paper is going to discuss the implementation of a web-interface in a real robot palletizing cell in an academic environment.

## 1 Introduction

This paper is about the concept of a web-interface to control the palletizing cell from the Virtual Logistics Lab(VLL), at the University of Bremen in Germany. The Virtual Logistics Lab is a student project supported by two institutes at the University of Bremen, BIBA - Bremer Institut für Produktion und Logistik GmbH and TZI - Technologie-Zentrum Informatik & Informationstechnik.

The student project started with a group of students and tutors in winter semester 2009, called VLL 1.0. By the end of the two years project, new students assumed the project in winter semester 2011, giving sequence to the work started in 2009, calling it VLL 2.0.

The Virtual Logistics Lab at BIBA is mainly composed of a high rack, a conveyor belt, a balance, a labeling machine and a robot palletizing cell. The system reproduces the functionalities of logistics centres, it swaps out, identifies and palletizes packages. The system may be operated locally or remotely by a web-interface. After evaluating the achievements from the last group, it was decided for extending the palletizing cell functionalities.

There are available softwares in the market for robot web-interfaces and simulation [9]. Despite of their powerful features, they do not have the flexibility required for the specific application into the VLL environment, like creating different packing patterns and interacting with other machines.

Industrial robot palletizing cells are used for loading or unloading objects from or to a pallet. They can be found in many different types of industry. By the use of robot palletizing cells it is expected to increase the production rate, the reliability, the flexibility in a sense of handling different objects and also making the work environment safer by avoiding humans to carry excessive weights [1].

Through a web-interface for the palletizing cell at VLL, scientists and students will have the opportunity to perform remotely their experiments in the facility. The proposed interface will have features that includes the simulation of the palletizing cell with the robot, generation of new robot trajectories and new palletizing patterns. The main challenges about collision checking and security of the web-interface are also going to be discussed in this paper.

The web-interface for the palletizing cell will be integrated to the actual web-interface of the VLL, allowing also experiments with the whole facility. The design of the web-interface will be based on the model proposed by von Borstel and Gordillo [10] for robotics virtual labs.

## 2 Goals

The development of a web-interface for controlling the palletizing cell at the VLL facility has two main goals. At first the technological, of developing a remote tool to control and program a complex system based on a robot. The development involves different fields of knowledge like robotics, network connectivity of industrial devices and web programming.

Besides the technical aspect of the realization, the web-interface will give the possibility for researchers and students to run and evaluate their experiments. Different scenarios are going to be offered for the users, though the focus will be the remote programming of the robot and the different palletizing patterns. iot

## 3 Challenges and possible solutions

Many challenges arise by the use of a web-interface for controlling a robot. The most important ones are going to be described and discussed in this section.

### 3.1 Integration in the former system

The palletizing cell isn't fully integrated in the VLL, in a sense that the available information is not shared among the subsystems (balance, high rack, labeling machine). For example informations sampled during operation from other subsystems are not shared with the robot palletizing cell. Though the palletizing robot disposes a file transfer protocol (FTP) server, which enables a data transfer among systems, it is not used and it is not appropriate for online operations such as required for VLL.

### 3.2 Availability of the system

The equipment is susceptible to common failures, for example a circuit breaker shutdown by an over-current which would lead to the loss of data. The availability of the entire system as well as the consistent remote operation by means of a reliable communication is crucial for the success of the remote control of the palletizing cell.

In order to minimize the downtime of the facility and to accelerate the startup, regular configuration backups are going to be made and directly loaded in a case of a failure.

### 3.3 Security

The protection of the system against unauthorized access is an important task due to the value of the machines and the damage a malicious minded user could cause. If the palletizer is pilot in a incorrect manner, it can damage packages, gripper, the cage and itself. The common web technology offers a method to verify users by the Hypertext Transfer Protocol (HTTP) authentication mechanism, where the users authenticate themselves by a name/password combination. To avoid the effort of administrating a separate user list for the VLL and maintain it, the existing infrastructure can be used and the authentication can access, for example, a Lightweight Directory Access Protocol-Server (LDAP).

These are likely to encounter in most kind of environments and can be integrated in many authentication systems.

The complete communication will be encrypted with the secure socket layer (SSL), that is just another layer on top of HTTP that is used for the communication, and offers a transparent and secure encryption that is supported by all clients.

### 3.4 Time scheduling for performing experiments

As just one physical system is available, it allows just one experiment to run at the same time. So a scheduling system must be implemented to prevent the lab of being occupied for too much time. This could be easily done in our concepted web-interface, where users may follow the current status of the palletizing cell and request booking for new experiments.

### 3.5 Simulation and Robot Programming

The simulation of the palleting cell enables the user a more comprehensive view of the system and its functionalities. A great challenge is to incorporate the simulation environment into the web-interface. The idea of the simulation is to serve the user with the visualization of the palletizing cell with the robot and its components and gives him the possibility of testing different trajectories for the robot and palletizing patterns.

By doing so, the user will be able to evaluate the general movement of the robot and the work-flow before testing the experiment in the real system.

Two software tools are being evaluated for the simulation, Easy-Rob [5] and Roboguide [9]. For both tools a correct model of the system is required, which must be validated with the physical system during the implementation phase.

### 3.6 Collision

Collision is one of the main problems that arises when a robot trajectory is being planned. As the web-interface will provide the user the possibility to remotely program the robot, the collision checking is strongly necessary. Simulation tools like Easyrob and ROBOGUIDE, are useful in a first approach to verify possible collisions, but it may not avoid them completely, as the verification is just visual and so it would be susceptible of a human failure.

As the user cannot be responsible of the full collision check, a more intelligent system will be considered. There are three main types of methods that can be used for dynamic collision checking: feature-tracking, bounding volume and swept-volume methods.

The bounding-volume method was already studied for another robot system developed at BIBA, the Parcel Robot, [6]. It is most probable that this method is going to be used to accomplish the collision checking.

The bounding volume method is applied by approximating the robot axis, joints and obstacles to a simple geometry, like spheres and boxes. In order to check a collision, the distance between objects is determined by the minimum of all distances between all relevant points of the two objects. With this distance it's possible to check how much an object must move to cause a collision.

### 3.7 Palletizing patterns

The former system can not palletize parcels of different size in one pallet. In the same way, the palletizing patterns are previously defined by the Intellware Patternmaker software and must be loaded by a USB stick directly into the robot control unit. The web-interface of the palletizing system gives the user the possibility of loading existing patterns or to create new ones. We are considering the possibilities of using the Intellware Patternmaker integrated in the web-interface or developing a software for palletizing patterns.

### 3.8 Delays

While performing online experiments, delays will be present. In the implementation phase delays will be measured and types of experiments that demands rapid feedback are going to be limited. account of order, visible package side, applied load on packages and balance point of the palette, would be a significant improvement but are complex systems due the many factors they have to account.

## 4 Examples WebRobots

There are many virtual labs in operation, mainly in university institutes. Much attention is paid to the user interface, where the user specifies what experiment he wants to perform, after it a set of limited parameters are given for interaction.

Marin and León [8] describe the UJI Industrial Telelab in Spain which enables students to learn and practice their robotics knowledge in situ or remotely. The facility allows students to remotely program and control two robots, composed of a robotarm, a camera system and a conveyor belt.

Another interesting approach from UJI Industrial Telelab is that the sensors, the conveyor belt, the camera and the robots are all interconnected by an ethernet network, by the use of a Simple Network Robot Protocol(SNRP) that allows the integration of robot systems with elearning platforms.

The users can program control algorithms in Java through a web-interface and sent them to the lab.

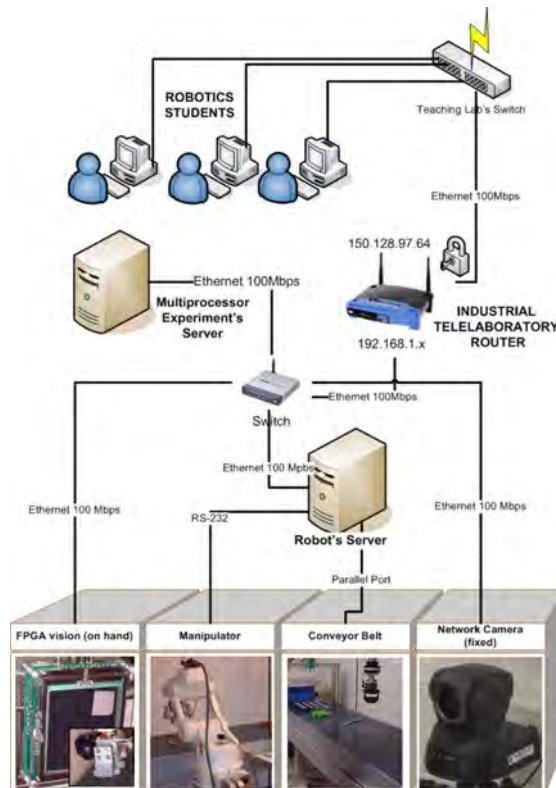


Fig. 1: UJI Industrial Telelab structure [8].

The figure 1 presents the network connectivity of the UJI Industrial Telelab where students can access the lab through a private network and perform their experiments.

The Automatic Control Telelab at the University of Siena in Italy, provides a set of remote experiments from the position control of a direct current motor until a experiment with four mobile robots following a square path, [3].

At the University of Illinois in the USA, an inverted pendulum experiment is available, where the controller has an algorithm to detect unstable conditions that could damage the experiment or due to malicious attacks, switches to a backup configuration, [2].

Another interesting robot application can be found at the Biorobotics Laboratory of the University of Washington in the USA, they developed a 7 degree of freedom cable actuated robot system for open and minimally invasive surgery, the Raven Surgical Robot. The system can perform teleoperation experiments over the world by the use of a single bi-directional UDP socket via a remote master device, [7].



## 5 Why A Web Interface

A web-based interface has some advantages over proprietary programs, like the often used remote procedure call (RPC) of the Java-platform. They use open standards like extensible markup language (XML) or JavaScript Object Notation (JSON) to communicate between server and client, which are proven technologies and widely supported. There are many tools and implementations to choose from, so there is no need to rely on proprietary softwares, while all the features of modern web technologies can be easily used.

One of this technologies may be SSL, an widely used encryption standard, to protect the connection against manipulation. Also well working authentication systems are usable, without the need to implement them. In modern web applications is only one small static HTML file with JavaScript or Flash that have to be loaded once, all the information is dynamically fetched and send via a technique called asynchronous javascript and XML (AJAX).

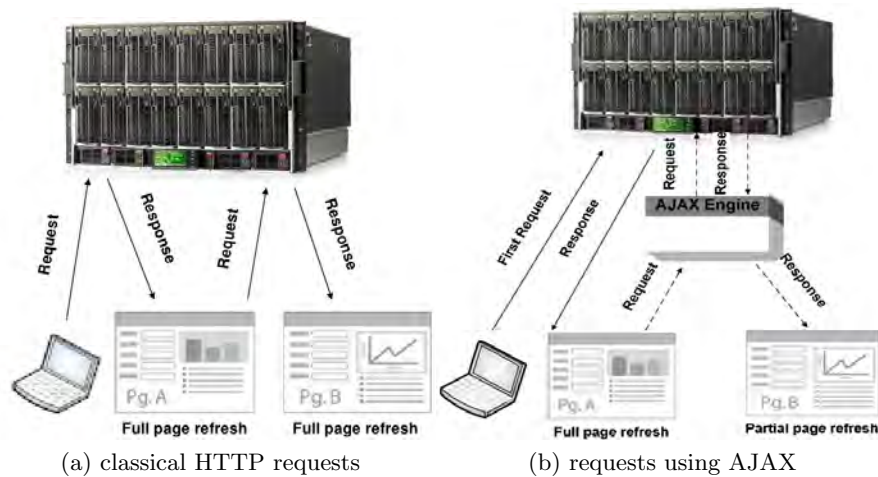


Fig. 2: difference between classic HTTP-request and one with AJAX [4]

One of the biggest advantages of the web-interface, is the separation between representation and logic, all the laborious tasks are done in the server, while the client can access a slim interface. As the web technology is usual and well supported by various devices, many clients may interact. These could be PC's or even Smartphones. The client-software can satisfy many use cases, like showing the status of the robot palletizing cell, showing error-messages or if a pallet is ready or full.

The web interface has the advantage, that it is not limited to be used with a browser, but can also be used to let other machines of the VLL facility communicate with the palletizing cell, by offering a slim high level interface. Information like parcel size and weight could be exchanged, in this case the client do not request the static HTML part from the server but uses the interface directly.

## 6 Facility Description

The Virtual Logistics Lab (VLL) at BIBA possess a robot palletizing cell. The palletizing cell, model I-PAL from the company Ivanhoe constitutes of a six axis industrial robot with a gripper for palletizing carton parcels(1), a control panel(2) with teach pedant(3), a conveyor access(4), pallet outfeed(5) and infeed openings(6).

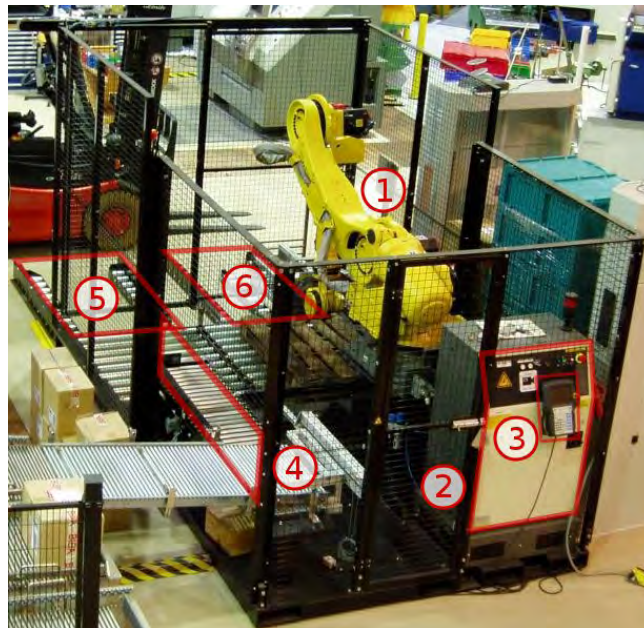


Fig. 3: Robot palletizing cell at BIBA

The pallet infeed opening receives empty pallets, outfeed opening returns full or partly full pallets with parcels, the conveyor access interligates the palletizing system with the rest of the VLL facility and the entrance door is mainly used for maintenance. The six axis industrial robot is from the company FANUC, model R2000iB.

The gripper must be mechanically adjusted for the parcel size. If a new type/size of parcel is used, another gripper configuration is required.

For controlling the robot the R-30iA Controller, also from FANUC, is used. It enables up-downloads of the robot programs, provides I/O functionality for the gripper and external tools and it also has a Ethernet 100 Base Tx communication interface. It is constituted of a cabinet and a teach pedant.

The workflow is shown by the simplified state machine at the figure below. It may be described as follows: parcels come from the conveyor opening, are detected by laser sensors, the parcel is taken by the robot and placed over the pallet inside of the cage. After finishing the placement, the pallet is forwarded to the outfeed opening. Then an empty pallet comes from the infeed opening and the system is ready for start palletizing.

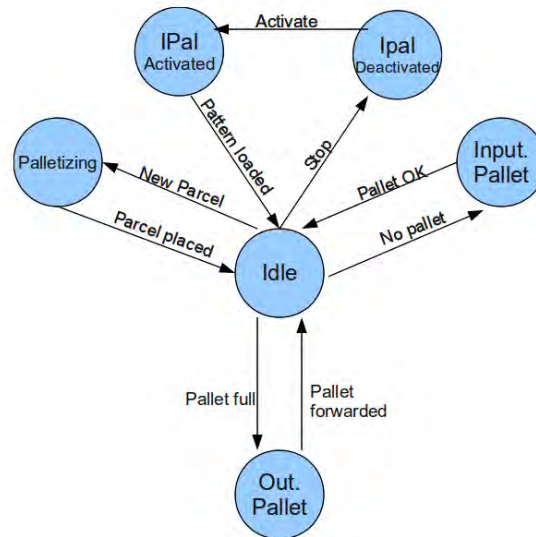


Fig. 4: Palletizing cell simplified state machine

At the moment the pallet package pattern and the robot trajectory for its completion are created by the software Patternmaker from Intellware. This software makes the arrangement of the parcels in regard of their sizes and quantity, then it generates the trajectory for the robot.

In order to start the palletizing system it is necessary to select a pattern, which could be already stored in the control unit or must be generated by the Patternmarker software and exported to the robot by a USB stick.

The safety of the system is based on a cage that isolates the robot preventing access while the robot is working. The entrance door is interlocked with the robot control unit which means if the door is opened while the robot is in operation, the system is going to be disabled.

## 7 Implementation

The implementation methodology of a web-interface for the palletizing system in the VLL facility will follow the model proposed by von Borstel and Gordillo [10]. Their model presented a reference framework and methodology for the development of a virtual lab for robotics and will be adapted for our case.

The overview of the system functionality is presented at the figure bellow.

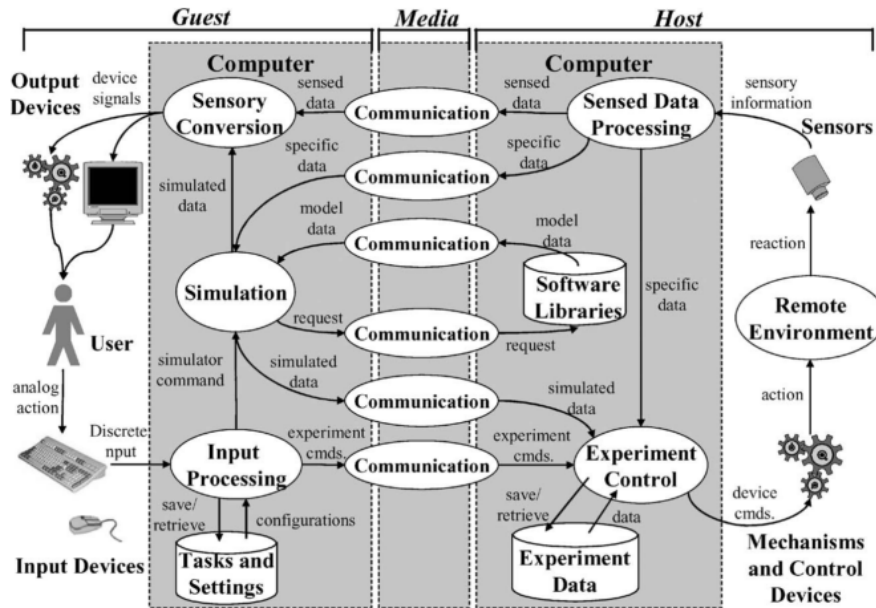


Fig. 5: Model for a robotics virtual lab [10].

The model shows a division in three main elements: guest, media and host. On the user side, guest, it will be possible to execute and evaluate the experiments. The host is the local computer based system where the requests of the user are going to be performed. Media will be the internet and the protocols used to transfer informations between guest and host.

Through this general overview we adapted the UML, Unified Modeling Language, framework of the model to our case, where we specify the main functions of the palletizing system that are going to be operated by the user with the web-interface.

At the next figure the functionality of the web-interface can be seen.

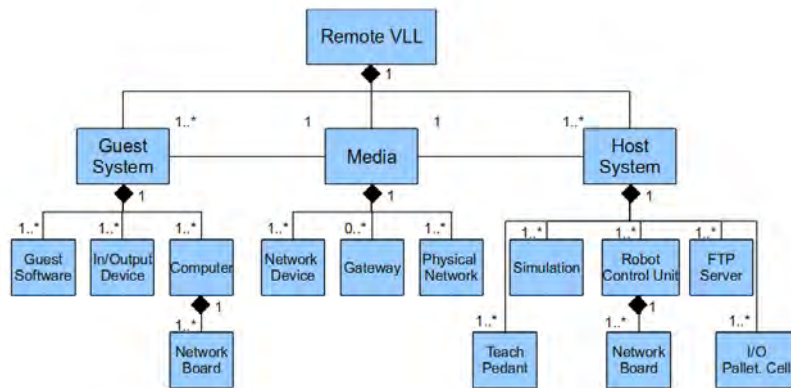


Fig. 6: UML model of the web-interface for the palletizing cell.

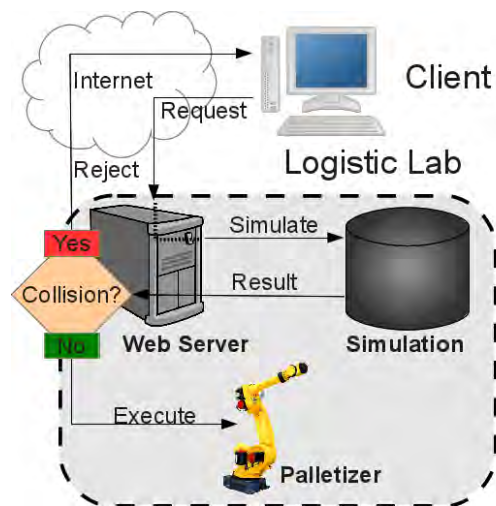


Fig. 7: Web-interface functionality for the robot palletizing cell.

The client may simulate the desired trajectory of the robot, the server will check if the trajectory is free from collision and will give a feedback to the user. After a positive feedback the user will be able to test his trajectory in the physical system.

## 8 Conclusions

The presented paper gave an overview of the actual robot palletizing cell in the Virtual Logistics Lab at the University of Bremen as well as the main challenges that are going to be faced by the implementation of the web-interface for the system.

Though there are many advantages of giving the user the possibility of programming the robot palletizing cell from a web-interface, some discussions were done about the limitations and requirements of it.

After researching the possibilities, it was decided for using the model proposed by von Borstel and Gordillo [10] to implement the web-interface adapted to our case.

The next steps will follow four phases; first the modeling of the system and its simulation, second the integration of the simulation in the web-interface, third the incorporation of collision checks for new trajectories and generation of patterns for palletizing and the final phase of testing scenarios.

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# Remote Testing of RFID and RTLs Scenarios: Opportunities and Scenarios for Remote Testing in Logistics

## Opportunities in VIRTUAL LOGISTICS LAB 2

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**Abstract.** The use of RFID (Radio frequency identification) and RTLs (Real time location system) grows continuously in the logistic. The validation of their performance in a real environment before any implementation is a rational Part of the researches at virtual Labs. This Paper proposes scenarios of RFID and RTLs remote Testing and its implementation in the LogDynamics Lab of the University of Bremen.

**Keywords:** RFID, RTLs, remote, Virtual logistic Lab

## 1 Introduction

The discussed case of implementation in this paper is a part of the student project VLL Virtual Logistics Lab at the University of Bremen with the use of the Platform of the Virtual Logistic Lab of the BIBA Bremer Institut fuer Produktion und Logistik GmbH, which is composed of high rack, conveyor band, robot palletizing, balance, labeling machine, five Webcams and a Reva server as a middleware for the connection of the RFID Readers. The project aimed to create an integrated platform to control different devices via remote access over the Internet. A central control system for all the connected machines of a lab had to be developed [1].

Ensuring the smooth running of any logistic assets circulation such as totes, racks, bins and roll cages, shipping containers, gas containers constitutes a pillar of the distribution in any production. This necessity is satisfied with the integration of automatic identification technology, especially, RFID.

RFID is grouped under the broad category of automatic identification technologies. The basic of the EPC / RFID standards is the Electronic Product Code (EPC), which allows a globally unique identification of objects (pallets, cartons, packages, consumer units, etc.) on the item level. Other positioning techniques like GPS, Infra-red positioning are also popular.

In despite in this paper a real time location system based on RFID technology called Mojix. Radio-frequency identification provides more advantages than other identification technologies such as bar coding and magnetic stripe. Their devices help locating and controlling the considered assets. This decreases the possibilities of damage or misplacement of the goods.

The shortlisted advantages of RFID are to encourage companies to integrate the technology that must be tested and analyzed in laboratory environments. The problem was how to design an effective and flexible test environment and conduct experiments efficiently with little effort as well as location-independent.

The purpose of this paper is to provide scenarios of remote testing of RFID in order to explore the optimum case of implementation of this technology.

This Paper comprises the following topics: Section 2 gives an overview remote Labs. Section 3 explain the functionality of RFID and RTLs . Section 4 describe The proposed System Mojix. Section 5 will describe the architectural approach of the implementation in the VLL2.0. Section 5 proposes scenarios of test of RFID. Finally, conclusion and a further outlook in section 6.

## 2 Overview about remote labs

The RFID Lab located in Parma, Italy aims to offer RFID vendors and end-user companies fully equipped facilities for developing their RFID deployments and products. The lab focuses on exploring the applications of RFID technology and the EPC system to business processes.

The MIT Auto-ID Laboratory is dedicated to creating the Internet of Things using RFID and Wireless Sensor Networks.

Villanova University Radio Frequency Identification Laboratory is located on the Villanova University campus. The main objective of this Lab is to become a leading provider of RFID research in the region and promote collaboration and partnership with RFID manufacturing industries.

The most research on remote labs is supported by using technologies ranging from LabVIEW and Matlab/Simulink to Java applet, Flash, Ajax and other techniques [2].

## 3 RFID and RTLS

### 3.1 Functionality of RFID

RFID system consists of tag, reader, and antenna. Tag which is attached to the object consists of coupling components and chips, and tag has a unique electronic coding. Reader identified tags with location information without contacting and it has two types handled and fixed reader. The data received from tags transmits to Data Processing Unit. Antenna is a component that transmits radiate signal between tags and readers [3].



The system principle is as follows:

1) Reader transmits a carrier signal; 2) tags in the field of reader antenna product electromagnetic power and transmit information to readers; 3) reader receives the signal and decoding; 4) the computer receives the data and performs data processing.

The work process of RFID is shown in Figure 1 [4].



Fig. 1: Functionality of RFID

**Standardization of RFID:** EPC Global is a major driving force in the RFID space and deemed to be as an industrial organization of standardization. Their concept through the EPC (Electronic Product Code) is to identify every item across the supply chain.

### 3.2 Real Time Locations Systems

Real Time Locations Systems uses transmitters for determining the real-time location. The network of readers installed in the area sends radio signals which activate the transmitters in regular intervals. There are RTLs based on the ISO 24730-standard defines two air interface protocols and a single application program interface (API) for use in asset management and other RTLs which are based on WLAN-infrastructure. It is used in e.g. hospitals and harbours to identify and track vehicles, containers and persons. WLAN is also used for wide-area positioning of WLAN-enabled devices, by exploiting information on the location of the access points.

## 4 RFID location with Mojix

The company Mojix developed the Mojix Star System which differs from other systems by using separate components to excite tags. This components are described as follows [5]:

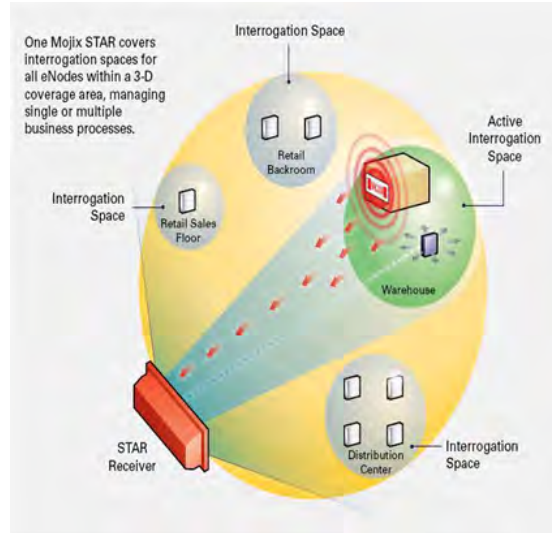


Fig. 2: Mojix components

*eNodes* : Each Mojix eNode excites all passive RFID tags within its designated interrogation space and can be fixed, wireless or handheld, and can be deployed as needed to shape discrete, overlapping or contiguous interrogation spaces, as well as to create virtual fences for securing tagged items.

*STAR receiver* : The STAR receiver functions as a single point of data collection, provisioning, command and control, and integration with enterprise systems. With the ability to detect extremely faint signals and free from conventional RFID's line-of-sight restrictions, the STAR receiver works in concert with its satellite eNodes to support one or many business processes across the entire coverage.

The STAR Receiver utilizes classical, fully active, phased array antennas for enabling the visibility into the space dimension. The smart array approach adopted by Mojix is based fully on digital processing techniques, thereby providing very high resolution for estimation of direction of arrival of the signal of interest (SOI), enabling the system to provide accurate location information on the tag position in the three dimensional Euclidean space.

*STAR interrogation spaces* : Fixed or mobile, STAR interrogation spaces are business process-specific and can be optimized for tag density or coverage. Each individually controlled interrogation space is created by the deployment of single or multiple eNodes and is dynamically sized by the STAR system, which controls each node's power output.

*Master Controller* : The STAR-1000 STAR Receiver signal processing platform is linked to an edge appliance called a master controller, and communicates via a standard Ethernet 10BaseT (RJ45)-connector. The controller can drive an arbitrary number of STAR-1000 systems and includes interfaces to the enterprise middleware.

## 5 Architectural approach of the implementation in the VLL2.0

This Section will despite how to access to the laboratory to run the machines remotly and proposes an architecture for the integration of the Mojix System into it.

### 5.1 The remote access to the Lab

To control the machines in the Lab via web interface a connection to the BIBA network is necessary. In this case it is not possible without this connection to access remotly the lab.

The Use of a login-system will allow also other users to use this plattform. The demonstrators have their own plug-ins that are integrated into the web interface. In the plugin the address of the device in BIBA is specified so that a connection can be established. In the individual plugins are stored actions that have been programmed for the demonstrator. Example: "Conveyor.On" starts the conveyer. The action has an existing connection through the IP address and then sends a message to the device. The scenarios are generally sequence of actions which are listed in an XML file [6]. The Mojix RFID middleware is connected to the open source Fosstrak EPCIS software. Fosstrak is an open source RFID software platform which implements the GS1 EPC Network specifications and thus allows us to work on the current standard. The for us relevant Components of the EPCIS repository Fosstrak are an EPCIS Query Application EPCIS Capturing Application and the EPCIS Repository that stores the data of read tags. The data for this purpose are read and written to the repository through EPCIS Capturing Application via the Mojix middleware.

### 5.2 Architecture of implementation of the Mojix system

The User can define an event that can be transmitted to the RFID-Middleware. To write an event to the Fosstrak repository a capturing application muss be implemented. The Fosstrak ALE contains such a capturing app that should be

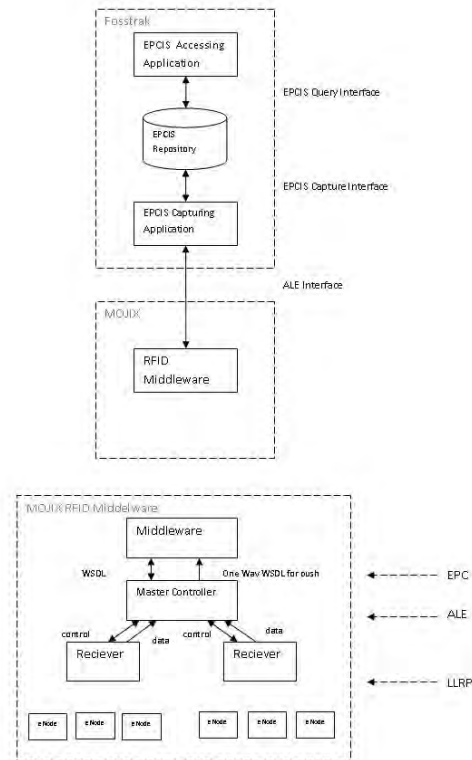


Fig. 3: Architecture of integration of the Mojix system

customised for our own requirements. The read data are disposed on Fosstrak. The user can request information about the reading tags in form of queries at the ALE Client through EPCIS Query Application.

## 6 Scenarios of RFID test

The following scenarios discuss the location and identification of packages on conveyor. The conveyor serves to transport the packages between the difference devices in the Lab.

With the Mojix System will be possible to cover all the Lab space where the tracking and location of the packages are desired. For example the split of the conveyor circle in areas such as 4 lines and 4 corners could be possible with the instalation of two 4-port eNodes to detect the splited areas with 8 anteenas such as shows in the follwing figure with the yellow rectangles as eNode and the red ones as antenna.

Detect the location of packages on the conveyor circle. run the convoyer more times for example 3 times to capture deviation with 2 or more packages. The

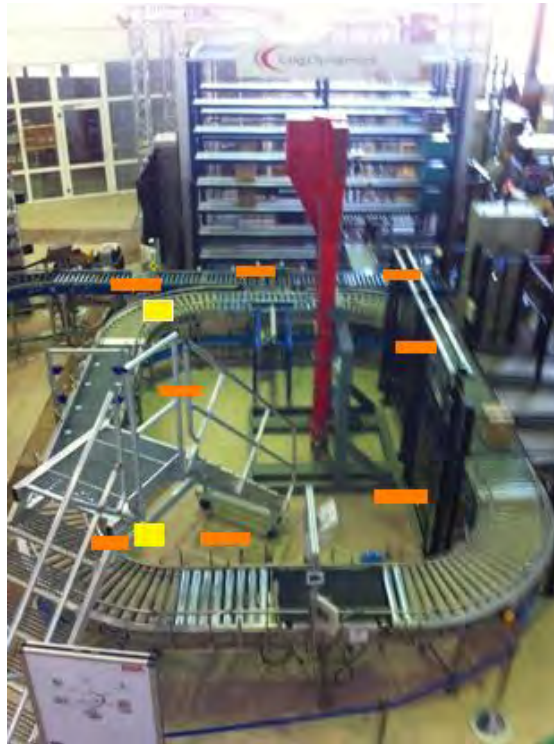


Fig. 4: Placement of the Mojix eNodes on the conveyor circle

tag will be read and the identifier number such as the coordination Posx, Posy and posz will be saved on the fosstrak repository.

Avoid double labeling of packages on the conveyor. If the packages have already got a tag, it must be possible to locate them on the conveyor before they pass again through the labeling machine. To achieve this Goal and to test if the antenna is able to allocate the tag in this area, an antenna must be installed before the labeling machine and to run the conveyor for example 3 or 4 times with packages with integrated tags.

Detect the location of packages on the conveyor. Packages are on conveyor. The location of the packages on the conveyor should be detected. In this case with the installation of 3 single eNodes at three choke point: an antenna at the balance and an antenna at the labeling machine and an antenna at the end of the conveyor. on the conveyor it is possible to compare the RFID data with the state of the package at this points like Packet on conveyor or Packet on high rack and to compare if the assigned antenna has detected the package on the

right location.

Can packages be distinguished from another? Run the conveyor more times with 2 Packages near to another and change the distance between them to test whether they will correctly be identified.

## 7 Conclusion

To reach the desired level of flexibility, VLL is based on a dynamic plug-in system. It allows loading and unloading of device drivers at runtime. The driver implements its functionalities as Actions that can be invoked by a VLL user as a part of a larger scenario remotely via login on the Web-interface. Certainly aspects like user rights should be considered.

The Mojix System discussed in this paper can cover through its capacities many of our requirements for tracking and location of packages. Further idea is to assure a system of location and tracking in the Lab that use other devices as the RFID readers already implemented there and the light barriers to get more precision of the obtained data.

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# Virtual Research Communities and Research Collaboration Platforms

## Current State and Potentials for further Improvements in the Virtual Logistics Lab Development

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**Abstract.** Collaboration and working by the internet are getting more important for research in the last years. Furthermore the paper shows the possibilities of a virtual collaboration platform on the Virtual Logistics Lab 2.0. This is a successor of the Virtual Logistics Lab, which implement a remote laboratory, on the University of Bremen The paper shows the opportunities of the internet for research and teaching and discusses a representative selection of integrated solutions from other projects like Deusto Web and explains, how the Virtual Logistics Lab 2.0 can use these technologies.

**Keywords:** remote access, virtual laboratory, Virtual Research Environment, Research Collaboration Platforms, Opportunities of Web 2.0, Virtual

## 1 Introduction

The paper is part of the Virtual Logistics Lab 2.0 (VLL 2.0) <sup>1</sup> project at the Center for Computing and Communication Technologies (TZI), University of Bremen, Germany.

VLL2.0 is a remote laboratory, which is used at the Bremer Institut für Produktion und Logistik GmbH (BIBA)<sup>2</sup> department. The laboratory contains machines from a logistic scenario. A few of its components are a high rack warehouse, a palletizer, a weighing machine and a conveyor. These machines can work together. Via web access it is possible to control the machines. The user can start a scenario, which models a part of a typical intralogistic process. It is only possible to model a part, because there a many different processes and the laboratory is only a equipped model for a few of them. By webcams the user can see the running scenario on a screen.

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<sup>1</sup> <http://www.virtual-logistics-lab.de/> call date 03.02.2012

<sup>2</sup> <http://www.biba.uni-bremen.de> call date 03.02.2012

The remote laboratory is integrated in a website. From there the functions and scenarios can be started. The access is available from the BIBA network, so it is necessary to connect to this network. There is no opportunity for other users to see the web platform and to control the laboratory.

The platform is only designed for control the laboratory and has no community functions. Furthermore the platform does not store the result of experiments. It is not only important to store results but also events and performance measures throughout experiments. With a login-system the platform can be transformed into a collaboration platform. The researcher can collect data, use the logistics lab and communicate by using this platform.

The purpose of this paper is to identify, how the project can learn from related researching. In particular the paper describes the setup of a community of logistics labs for collaboration in research. The paper is supposed to show the opportunities of internet technology in combination with research.

The remainder of the paper is organized as follows: First, section 2 gives an overview over the different types of laboratories. In section 3 collaboration is the main point. Section 3 gives an overview over different remote laboratories. At section 5 we explain the example of Deusto. In section 6 the context between Deusto and the VLL is explained. Then, section 7 is about the conclusion. At last, section 8 is a chapter about future work.

## 2 Different Types of Laboratories

At the moment there are three different types of laboratories, that have big differences in requirements, but of course mixed designs are possible.

First there are the traditional "hands-on-laboratories". Their operation requires a lot of space and funding, because of the required equipment. This laboratory is a real existing one. So on the one hand side real data will be produced, sometimes virtual data are not good enough. But on the other hand side it is possible to make real damage, because it really exists. And a perfect workload of the laboratory is not usual, because most of them only work during "normal times", that means they will not work at night.

The second type of laboratory are "remote laboratories". Remote labs are nearly the same as the hands-on-laboratories, but the controlled experiment is not at the same place as the controller. Today, the usual access method in remote laboratories is achieved through the internet [2]. Of course this kind of laboratory is more expensive than a hands-on-lab, because they need all things a traditional laboratory needs plus the remote access option. In theory it could be cheaper because three working shifts of 8 hours could work with the same laboratory. At night a person from another mainland could work. But this is utopian. So it is more expensive to operate with. Another possibility is that a researcher can rent a remote laboratory for the time he needs it, because this is cheaper than a hands-on-laboratory if it is sporadically used. And it does not need so much space, by the user. It only needs a computer and internet, because the real laboratory could be at another place [6]. Moreover this design



produces real data and this is very important in research. But of course, that means that it could cause real damage too. Obviously a remote laboratory has all the positive aspects of a hands-on-laboratory. But it does not have the most important negative aspect, because the user do not have to have enough space for building a traditional laboratory.

The third type of laboratories are the "virtual laboratories". These designs are expensive in setup, because to install this is very much work [6]. But after that it is much cheaper than the other designs. In addition it is not possible to cause damage by using it. And it only need a good computer, so it is space saving in comparison with the other types. But a problem is that the resulting data are also simulated, and not real. That means that the data could be different, because of that in a few parts of research it is not possible to work with virtual laboratories [6].

All of these possibilities have pros and cons. But for teaching all of these are equal [6]. The ability for research could not be generalized, because it depends on the case. But this problem is only relevant for the virtual laboratories, because this can simulate and does not need real data. The problem of simulation is that not all problems in this case are solved, so it is not sure that the simulated data is the same as the real one. From there the hands on laboratory and the remote laboratory are nearly equal in research, but using the simulated could be dangerous. By reason that it is not sure that the data are equal [6].

The VLL2.0 projekt is a remote laboratory, because of that most of the following aspects are about remote laboratories. But a few aspects about are about virtual laboratories.

### 3 Collaboration

The Internet offers many options for virtual research. The technology has developed very fast and with the Web 2.0 it is possible to interact between users or objects directly. In former times the researcher exchanged data with letters or at a meeting. The problem was the distance. The internet revolutionized this fact. Nowadays it is no problem, to contact a researcher and send him research data by mail or allow him to get access to the data directly.

Cooperation, communication, data exchange, and acquisition of knowledge are the main points in virtual and remote research [10]. Research projects often take place in different places and the cooperation is necessary to continue the project. Universities can cooperate in projects, to get better results. In a network, based on the internet, the universities, companies and other participants can get involved in a project. In a project communication is a very important point, which can decide about success and failure. Before the days of the internet it was a big problem in international projects to collect information from all members, working on a common project. Today there was more opportunities for data exchange. Often this function contains a history, that saves changing data like changed date or changing person. It is an easy way to work together on a document. Possible technologies are stored repositories, version control and cloud

storage. All knowledge will be collect on a central platform. Basically everybody can use the knowledge and make his own knowledge available. All in all the internet has developed into a very important factor in projects. Particular in research everybody concerns himself with the internet and uses it every day [10].

### 3.1 Useful Technologies for Data Exchange

The internet provides many technologies, which are useful in research. From chat rooms to simply message systems we can find a lot of helpful components [10].

A revolutionary innovation was the email system. First it was used at a mailbox system in X.25 for example. Later on the RFC 822 [3] displaces the X.25, when the internet was growing up. And this is the ancestor of the modern email. We can write an email to send a text with attachment. It is easier and faster than a letter with some kind of data storage. You can send one email to many addresses, which makes the text communication comfortable. The email was, like the letter, an asynchronous communication medium. One aspect of Web 2.0 is the chat technology, which provides the opportunity to communicate in a synchronous way. The constraint is, that all communication partners have to be online at the chat system at the same time, but that is normal in synchronous communication like phone calling or video conferences.

Another technology for written text are wikis. Wikis are used for writing documents in a group. At a wiki any user can work together on a text. One person starts a wiki and writes a text. Another one changes the text. A wiki always provides the function to restore an older version. A wiki is an easy way to work out a text in a group. A special add on is the version control.

A further communication medium is a forum. The typical purpose of a forum is to collect questions and answers. Forum users debate on questions or other things in the topics. A forum displays a platform for asynchronous communication. The platform is sorted and divided in logical groups. So the user can discuss about many topics and everybody will find the relevant answers in this topic. The topics are clearly arranged and archived. The users can search in the forum to find older topics and the answers.

By using internet technology, security is an important point. VLL2.0 has to be protected against attackers. It has to guarantee three points: availability, integrity and confidentiality. Concerning availability we were not able to do so much, because a "denial of service" attack will always be successful for example, this is fact because there are no defense possibilities against that [8]. For warrant integrity we have to use a secure access method and force the users to use strong passwords. For safeguard confidentiality we will use a good encoder before transporting the data across the internet.

### 3.2 Opportunities

The technologies afford a lot of opportunities for the researcher. Interaction is important point in research and study [7]. Some research facilities are expensive. One university could not finance all research equipment, so it is necessary to build

a network between the research institutes. The internet gives the opportunity to get a remote access to the research equipment. That is an important advance for the international research. A researcher can control machines from different place and get the information of the experiments on his display. The researcher can see his actual experiment through a webcam on his screen. So he can get the conditioned results and evaluate them. Later on he can give a feedback. It is possible to control a big research experiment over the internet. Furthermore the user, who starts the experiment, does not need a contact to the other side. The process runs automatically with the inputs of the starter.

Off course the remote access is not possible with all machines and equipment, but often it is a good opportunity. An university does not have to buy a machine, but they need access. Consequently they will rent an access to the machine. And if the distance is wide it is a good opportunity to have an access over the internet. This remote access can be useful in studying. Universities can show a live experiment over the internet in a lecture. The students can see a live experiment, which was executed in a different place in the world. They can change the parameterization of experiments data and run it, perhaps in real time, again. Furthermore the experiment can be shown in different lectures. They can agree on an appointment and the students can watch the experiment on the internet. Maybe they can discuss in a chat.

It is also interesting for professors. They can do it the same way. One tutor makes a experiment, which needs a live handling at the machine. The tutor wants the opinion of other researchers, so he can show the experiment on the internet. Then it is one way to discuss the experiment directly by a video or audio conference. Later on the professor can save the video of his experiment in the internet and open a forum or wiki to collect more opinions and ideas.

That were only a few examples: The internet and especially the remote access give a lot of opportunities for research.

### **3.3 Components of a Virtual Research Environment**

A virtual research environment (VRE) is based on the internet technology. The main point of a VRE is the collaboration [10]. The internet gets more and more users and the research should use the opportunities of the internet. A VRE should allocate all necessary things for the collaboration in research. The section 3.2 show the opportunities of the internet and the technologies in the internet and all things can be used in research.

It is difficult to combine traditional research with the new technologies. On the one side books, magazines and live experiments are research practices that have existed for a long time. Every researcher has to document his references and saving notes or comments. On the other side there are good tools on the internet, which alleviate and revolutionize the research. Google developed a special search Google Scholar, which only searches in areas relevant for science. Of course this is not part of a VRE but it is a very good tool for searching the internet for information in research areas. The libraries have their own website to find a

book. It is easier because you can search for a key word or an author. There are databases in the internet, which save many science articles and references.

The basics of science did not change because of the development of the internet, but science became easier [7]. Today the methods start with a search on the internet.

Remote access can also be a part of a VRE. Remote access is not as popular as used machines, but it is a logical reaction. When all technologies establish on the internet, remote access will be an important part. This part can be used for practical research and experiments.

## 4 Remote Laboratories

The development and exploration of the web-based remote technology has become increasingly important in recent years. Many universities and research institutes deal with this issue and are constantly developing new concepts and ideas, and to improve old technologies to make the cooperation between the companies as effectively as possible.

However, the basic idea of all these developments is the same: The goal is to create a user-friendly web application that allows authorized users to carry out experiments easily and efficiently over a remote network.

In our search for these technologies, we have encountered on numerous projects that deal with this issue. The current status of these technologies is now well advanced. “Global Knowledge”, (the largest private provider of IT training, enterprise learning solutions and software solutions) and the largest partner of Microsoft and Cisco, has created already in 2007 a unique remote training laboratory, replaced the existing Cisco laboratory and made worldwide its users possible to to Cisco advanced technologies<sup>3</sup>. By using the remote connection to the Cisco technology, trainings can take place anywhere in the world, also directly in the companies. For companies, this also means savings in cost and time resources. The trainees must not travel and are also available during the training period.

The concept of any kind of remote lab systems is based on data transmission over the Internet. The transmitted data is exchanged between an experiment-side and a user-side computer [4]. To realize this, both computers need a coordinated software. From the tasks that both computers must comply, a division results in two fundamental components of all remote technologies: A measurement- / control-interface and a user-interface. The measurement- / control-interface assumes an important role: It handles the exchange of data between the Internet and the control- / measurement-output of the experiment. The user interface represents all received data graphically from the Internet and saves it finally. Also, a graphical user interface provides to the user to enter tax data, to send it and to check the condition of the experiment.

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<sup>3</sup> <http://www.globalknowledge.at/neuigkeiten/pressemitteilungen/presse%20archiv/remote%20labs.aspx>. (call date 03.02.2012)

The idea of remote technology opens up numerous application areas, such as universities and schools. Experiments, which are extremely costly, time consuming, too complex or even life-threatening, could not be performed in traditional laboratories by these reasons. However, with the integration of a remote lab they are easily available for the teachers and students and experiments can easily be carried out from anywhere.

Another interesting tool of the remote technology is the online platform WALC (Web Assisted Laboratory for Control) [1] which was developed as a dynamic learning tool for students and facilitates the remote access to several virtual and remote laboratories.

Below, we illustrate a brief overview of all remote labs we consider at our research and then we respond to the benefits in the next chapter, which affords us this technology for the project VLL2.0. This we will illustrate by the example of WebLab-Deusto.

Remote Lab	Location
LiLa project <sup>4</sup>	University of Stuttgart
NetLab <sup>5</sup>	University of South Australia
Labshare <sup>6</sup>	Australia (Australian Government)
MIT iLabs <sup>7</sup>	Massachusetts Institute of Technology
WebLab-Deusto <sup>8</sup>	University of Deusto (Spain)

Table 1: Remote Lab Overview

The labs in table, constitute paradigmatic examples for remote labs. An interesting of these is the "LiLa Project" (Library of Labs). It enables online collaboration by integrating remote experiments and virtual labs into a collaborative environment. It also links existing virtual labs all over Europe, providing a better utilization of resources. As with most other labs, teachers and students are primarily focused users. This offers teachers the opportunity to find remote and virtual experiments and to integrate them into their courses.

"NetLab" was originally developed with the same idea to support lectures and students at their work by an attractive GUI (Graphical User Interface). Using this GUI, the user is operating real instruments which are set up in a laboratory and the output they see on their displays is not a simulation of these instruments, but data collected from the instruments in real time.

<sup>4</sup> <http://www.lila-project.org/> (call date 03.02.2012)

<sup>5</sup> <http://netlab.unisa.edu.au/> (call date 03.02.2012)

<sup>6</sup> <http://www.labshare.edu.au/> (call date 03.02.2012)

<sup>7</sup> <http://icampus.mit.edu/ilabs/> (call date 03.02.2012)

<sup>8</sup> <https://www.weblab.deusto.es/web/> (call date 03.02.2012)

The "MIT iLabs" and Labshare projects both aim to develop a technical infrastructure and a sustainable organizational strategy that will support ongoing sharing of remote laboratory facilities and resources. iLabs allows its users to access MIT equipment to conduct science and engineering experiments remotely from all over the world. The aim of that project is to provide many services and development tools for its users and to reduce development and management effort for users and providers of remote labs. iLabs also seeks to allow universities and institutes with different kinds of network infrastructures to share access to its physical lab infrastructure.

VLL1.0 is a young project, which is still in its development. To use the equipment of his laboratory, the first step is the access to the PC of the laboratory. The user can establish a VPN connection in the network from BIBA and login via the IP on the PC of the lab. This ensures that there is a legitimate user. To access the device from any point of view and to allow the control of the experiments via the Internet, a concept of a remote lab is essential. Now, in the next chapter we want to agree to the benefits of remote labs for VLL2.0 (by the example of WebLab-Deusto), which gave us the most information at our research.

## 5 WebLab-Deusto

### 5.1 Introduction: WebLab-Deusto

In this chapter we want to focus on a remote lab of the University of Deusto (Spain) called "WebLab-Deusto". First, we explain technical possibilities related to this lab. Subsequently, we focus on the specific advantages and possibilities, given to us by this lab useful in the context of our project VLL2.0.

The platform of WebLab-Deusto was originally designed as an open-source distributed remote lab and it is used and continuously developed since 2005. The reason for the development of this lab was to enable the accomplishment of diverse, real experiments on any kind of devices (such as FPGA, PIC microcontrollers, etc.) on any computer network, such as the Internet for a specific group of users. In other words: Using this lab, an experiment can be accomplished over a communication network by a specific user with respective rights. Figure 1 illustrates the approximate architecture of this new concept.

So, to realize this remote-communication, it is necessary to take a look at the technical aspects of this lab, which are listed at the following subchapter in a general way.

### 5.2 Overview: technical possibilities of WebLab-Deusto

- **Administration:** The web-based administration tool of WebLab-Deusto enables creation and management of experiments and user profiles. It is also able to check the status of remote labs and also to show, which profile is just

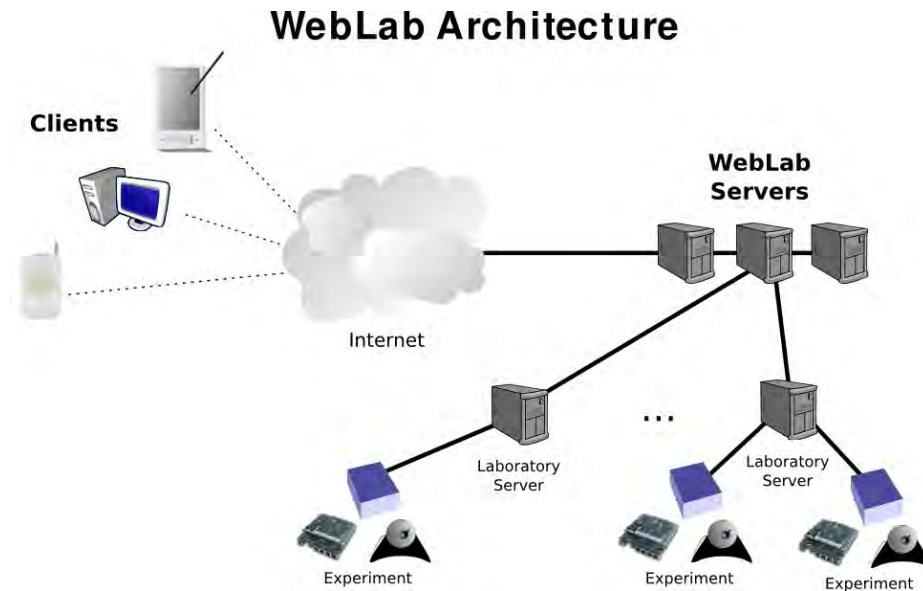


Fig. 1: Weblab Deusto [5]

using this lab. Also, it is possible to get different kind of information about all uses in the past within a specified period. This is done through log files, which are managed by the administrator.

- **Authentication:** With an extensible authentication system it is possible to verify the identity of each user. On the one hand it is achieved by a verification of the respective IP adress of the user and on the other hand by using a remote LDAP (Lightweight Directory Access Protocol) server. It is also possible to store username and password in a database.
- **Queue management:** The idea of a queue management system of WebLab-Deusto is to coordinate the order of the work on certain platforms (devices), if there are multiple users who want to work on the same device. For this purpose, the system assigns users their respective priorities that will coordinate the sequence of use.
- **Scalability:** The system of WebLab-Deusto is horizontally scalable. The scalability refers to the number of users and the number of experiments. It is now easily possible to integrate new servers for processing experiments and thereby to enhance the performance and efficiency in processing, as well as to allow much more users to work on devices at the same time.

- **Deployment:** The latest deployment system of WebLab-Deusto makes it possible to configure new experiments. To realize this it requires a configuration of the server and client. The client can be configured by creating a new entity in the configuration.js (JSON-file), where the server needs a change of its .xml-file, which is easy to read.
- **Security:** The safety system ensures a safe protection against unauthorized access by foreign users by storing the access data on a separate login server. In addition, the “wrong” use of experiments can never affect the whole remote system, because the system manages all components (depends on this experiment) independently. The cause of these incorrect use can always be traced back through a log file.

All further information and details about the possibilities and use of this architecture can be taken from the website of WebLab-Deusto<sup>9 10</sup>. This contains a vivid documentation of the individual components, a demo to try out this lab, as well as various install guides that will simplify the installation and use of this system for beginners.

### 5.3 Conclusion: WebLab-Deusto in connection with VLL

In this section we discuss the opportunities that would be offered to us by WebLab-Deusto in connection with VLL2.0.

At the present time it is only possible to work on the devices of VLL in the traditional way or with VPN. As a result, it makes the collaboration and cooperation between the developers of this project very cumbersome and difficult. To change this, it is necessary to take a look at a new concept of a remote laboratory such as WebLab-Deusto and to provide it finally.

Also, the main aspect that speaks for using this lab is the ability to perform various experiments remotely and thus to enable the collaboration and cooperation by working on the same project from different parts of the world, to make the work more efficient. The idea behind this collaboration is to give the project partners user rights on the project and create appropriate user profiles for them. The parties would be able to perform various experiments on the devices of VLL2.0 over the Internet. That need to configure the respective files on the side of the server and client for creating a new experiment (as described on the website of WebLab-Deusto) and subsequently it is necessary to execute them. The coordination of these experiments is the task of WebLab-Deusto.

This lab would have the opportunity to coordinate the use of the devices with the queue management system, which uses an internal priority queue, if a capacity utilisation by too many users would happen. Even the generic reservation system may also take over the coordination of the experiments, by reserving every available experiment for a certain period of time.

<sup>9</sup> <http://code.google.com/p/weblabdeusto/> (call date 03.02.2012)

<sup>10</sup> <https://www.weblab.deusto.es/web/> (call date 03.02.2012)



The possibility of scaling would allow more concurrent users in VLL2.0. Simply, additional servers could be added and thus to distribute the load of the users more efficiently. For example the devices are fully utilized with 40 concurrent users. Now, if we add three other servers with the possibility of scaling, the load of each server could be reduced to ten users per server and thereby, the experiments could be processed much faster. Scaling is a feature that can only be used on virtual machines.

Furthermore, WebLab-Deusto can be easily integrated into facebook. The user has the possibility to provide the credentials of the lab to link the facebook account with the account of the WebLab-Deusto or to create a new user with the same rights of a demo user. To realize the integration it is necessary to create a facebook application that can be done for free. Than, it is necessary to configure the login server <sup>11</sup> This feature would increase the flexibility significantly by using WebLab-Deusto in VLL2.0.

## 6 Comparison of the Laboratories

In the following table we set the new concepts and technologies developed in this paper in relation to VLL1.0 and give an outlook for our new project of VLL2.0. The table illustrates four columns: VLL1.0, WebLab-Deusto, research and VLL2.0. For each column there is an own line with a particular content for each lab. If you compare the columns of VLL1.0 and VLL2.0, you see the improvements of VLL2.0 effected by the presented labs in this paper (WebLab-Deusto and more general research). The major improvement occurs in the login-system and the extension by a community platform.

	<b>VLL1.0</b>	<b>WebLab-Deusto</b>	<b>other laboratories</b>	<b>VLL2.0</b>
<b>type of the lab</b>	remote lab	remote lab	remote and virtual labs	remote and simulated labs
<b>community</b>	external with mendeley	integration in facebook	different realization	community platform with a integrated access to the lab
<b>used technologies</b>	web-based VPN method for access	web-based login-system	web-based login-system	web-based login-system Plasma

Table 2: Comparison of the laboratories

<sup>11</sup> [http://code.google.com/p/weblabdeusto/wiki/4\\_0M1\\_Facebook](http://code.google.com/p/weblabdeusto/wiki/4_0M1_Facebook) call date 21.02.2012

The table 2 shows the different points in the components. The next capture brings these points together and describe the conclusion for the Virtual Logistics Lab 2.0.

## 7 Conclusion

The Virtual Logistics Lab 2.0 should be developed into a collaboration platform. The users can communicate, see and use the lab. The platform should be more interactive. For this concept it is necessary to make modifications. At the technical side the complicated access by VPN has to be changed into a web access with a login-system and a user administration. Of course that includes access authorization and a strong security. There were different user groups like an internet forum. The users needs different access levels. So for example some researcher of the BIBA institute and the University of Bremen should have more rights, because they were involved in the project. Furthermore it was an important point to think about the payment by using the Lab. The platform should have more parts. One part should be the control of the lab. Another part should be the community. It should be a place for researchers who are interested in this topic. Probably we will have at least two categories. The first who has the access to the lab control and a second with an access to the community platform. The system has to develop so dynamically, that the groups can switch.

The community group should not be isolated from the Logistic Lab. An opportunity should be to get access to the Logistic Lab in agreement with the responsible persons. The users can see videos from experiments and get results, which he can use for his research. On the website the users can see appointments for the next live views of announced experiments. All the time there are webcams, so the user can see the Lab and imagine the system. Those things should form a special community.

The technologies of Web 2.0 should be integrated. Webcams and interactive functions should influence the platform. In a forum the users can discuss experiments and other topics. Some topics can elaborate scenarios, which there want to see at the Logistic Lab. In a first step they could be a function to place an advice and the responsible persons can see it. In a second step they can rent the Lab and control the scenario by themselves. And the other involved users can watch it over the webcams.

At a live experiment there should be a function to communicate synchronously. On the one side should be the stream and on the other side a chat system. It is possible to have an audio or a video conference, so the users can discuss in a synchronous way.

Some methods in research will never be changed. These traditional science methods are something like reference administration and saving notes. In the past the researcher has been working with pencil and paper. The new technologies especially the internet afford great opportunities to save the data in the internet. This function is need by all researchers and so it should be a part of the VLL platform.

## 8 Future Work

With the Virtual Logistics Labs 2.0 the research should be shifted to the internet. The special point of this platform should be the access to a real Lab over the Internet. So it should be possible to work with all functions of the platform with an internet connection and a web browser. The goal of VLL2.0 is to provide a unique web-based infrastructure to enable collaboration between and remote access for researchers in logistic around the world.

A further idea is to integrate a system for project management and coordination. The users can upload files and write texts in a wiki. So it is possible to collaborate on the platform. The users can link the other parts of the platform like results of an experiment or documents. So teams can research at the platform, collect results and discuss topics.

The implementation of the points in this paper should be integrated in the existent system of the Virtual Logistics Lab from the first project. They have developed a web interface. On the website somebody can control the components on the lab. VLL 2.0 wants to integrate the ideas in this platform. In the first step the login-system should be realized. So it was probably possible to change the access with the VPN. After that the project can start with the other points. The project members have to design an user administration with different rights and access opportunities. Than the communication platform can be created around the remote laboratory.

Another point to improve the VLL Platform should be the integration from other systems. On the internet are systems for research, which are very popular. So it makes sense to use their functions. For example Google Scholar<sup>12</sup> is a search machine for searching in science articles. Furthermore there are ordered and managed science papers in the Mendeley platform<sup>13</sup> in witch Google Scholar searches. Many websites have an access to databases with articles or books in libraries. The VLL 2.0 platform should use this possibilities, because the user should have the opportunity to connect these functions with the VLL functions.

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<sup>12</sup> <http://scholar.google.com> (call date 03.01.2012)

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