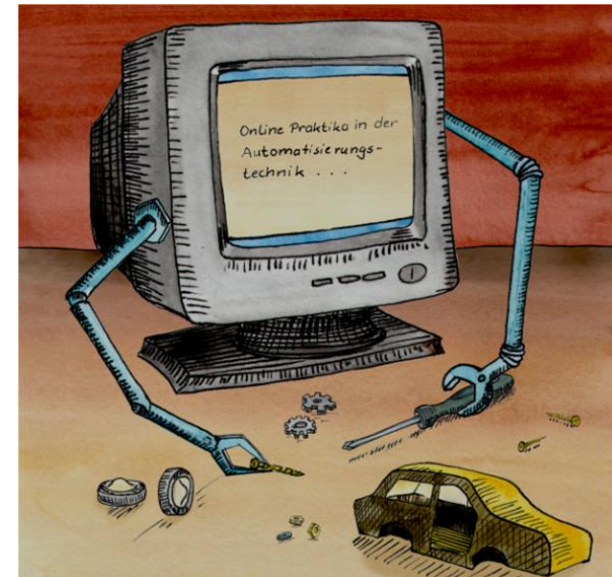# Remote Labs & the Industry 4.0 project

- **Industry 4.0 – The Future of the Production Process**
- **Remote Labs in the light of Industry 4.0**
- **Open & Fixed Remote Labs 4.0**
- **Example: Fixed I40 Remote Experiment**
- **Experiences & Evaluation**
- **Problems & Conclusions**
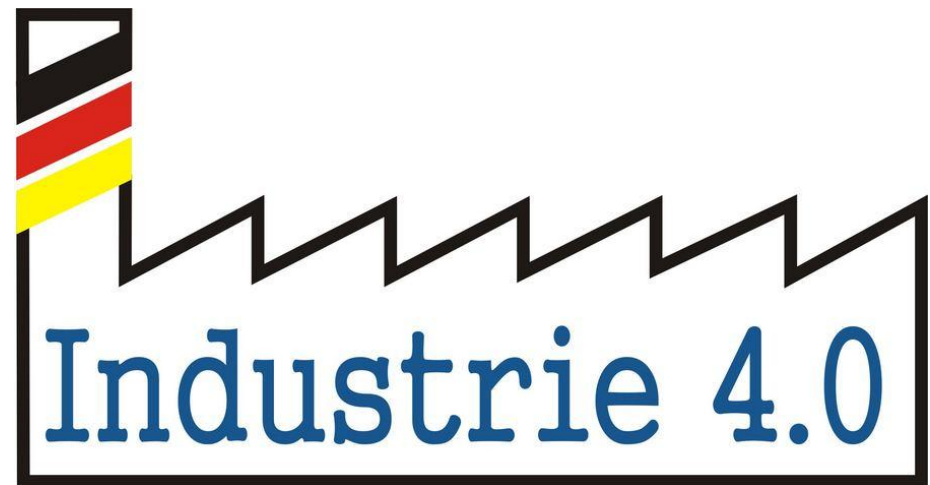
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# Content

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# What is Industry 4.0?

The Industry 4.0 project (short: I40) was launched in 2012 on the basis of an recommendation by a research union of business and science to the German federal government. I40 should ensure Germany's future as a production centre. Similar projects also exist in other high-tech countries.

**Industry 4.0:**

The merging of modern information technologies with conventional industrial processes. This results in Cyber-Physical systems (CPS), which are expected to have a revolutionary effect on industry.

**Cyber-Physical Systems:**

CPS are characterized by linking of real (physical) objects with information-processing (virtual) objects via open, sometimes global and always interlinked information networks [according to Research Agenda CPS]

The essentially **new aspect**:

Networking is realized via global information networks (i.e: the Internet).

Industry 4.0 – The Future of the Production Process

# CPS in Industrial Production

The high degree of networking and the ubiquitous availability of data and services opens up new possibilities for automation. This results in the vision of adaptive, self-configuring production systems. This vision is referred to as Cyber-Physical Production Systems (CPPS).



Automation hierarchy *

CPS-based Automation
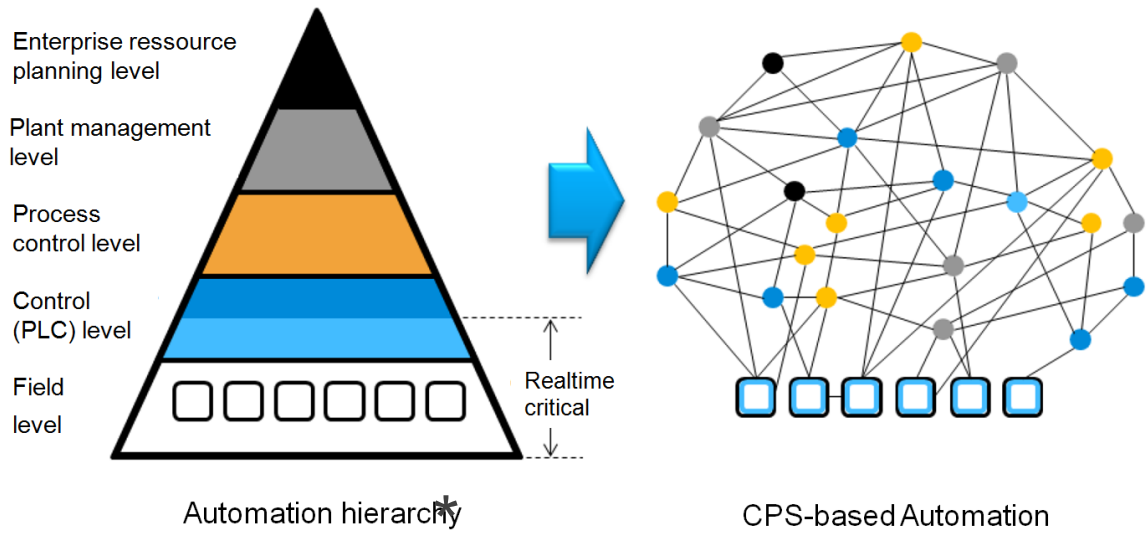
In a CPPS, data, services and functions are stored, called up and executed where is the greatest benefit for a flexible and efficient production.

The classical hierarchical automation pyramid is transformed into an automation "cloud" (automation from the cloud)

Industry 4.0 – The Future of the Production Process

* Figure from VDI/VDE-GMA, "Cyber-Physical Systems: Opportunities and Benefits from the Viewpoint of Automation", Theses and Action Fields, April 2013

# Content

**AUTOMATION SYSTEM**
From the Cloud
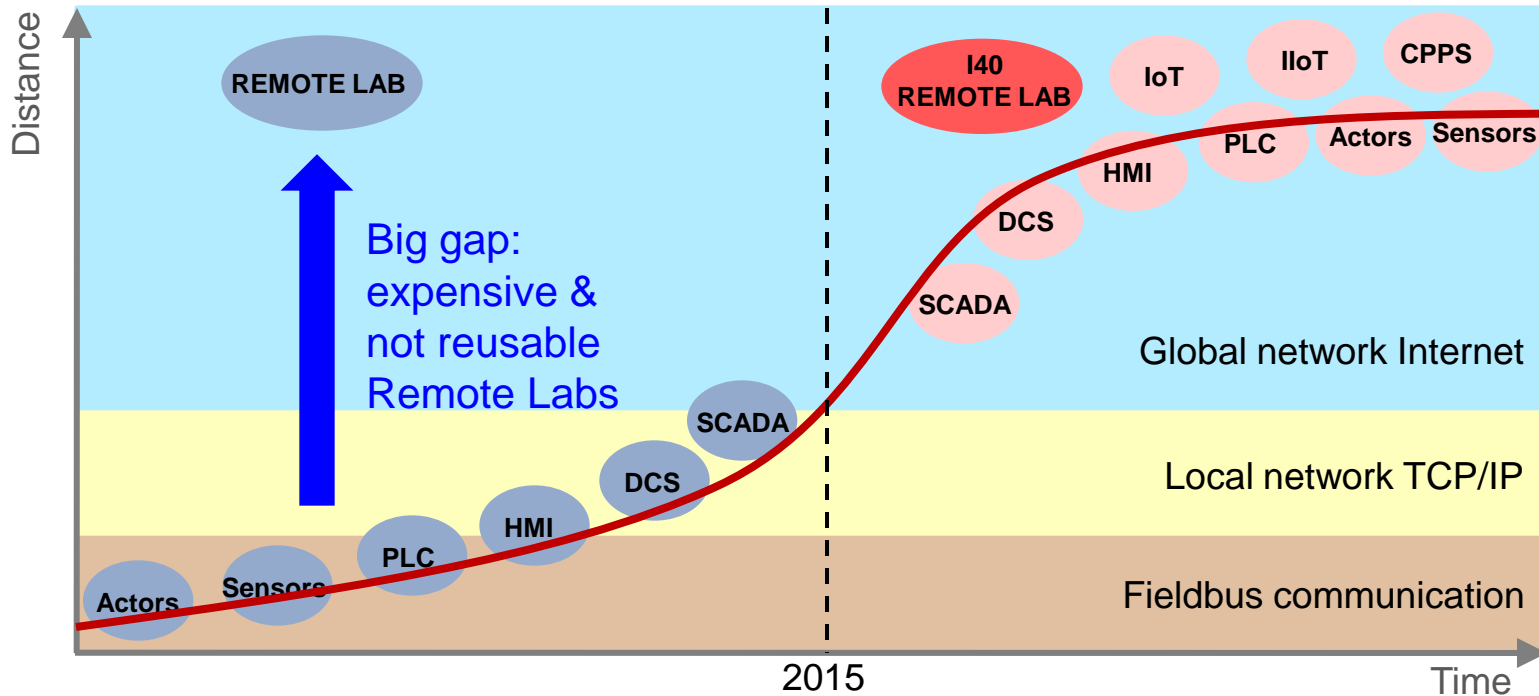
**WEB-ORIENTED**
Automation services

CCAD

# Remote Labs meet Industry 4.0

At present industrial automation systems or automation devices/equipment are not connected to the Internet. We have a big gap between the possibilities of industrial products relating the distance access and the requirements of a Remote Lab.
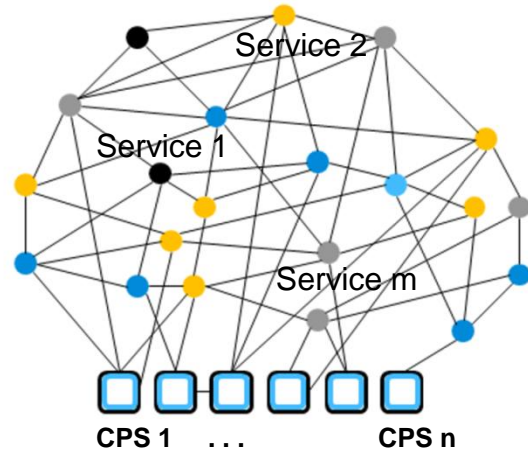


In the Industry 4.0 world a Remote Lab can use industrial components and systems
→ **I40 Remote Lab.**

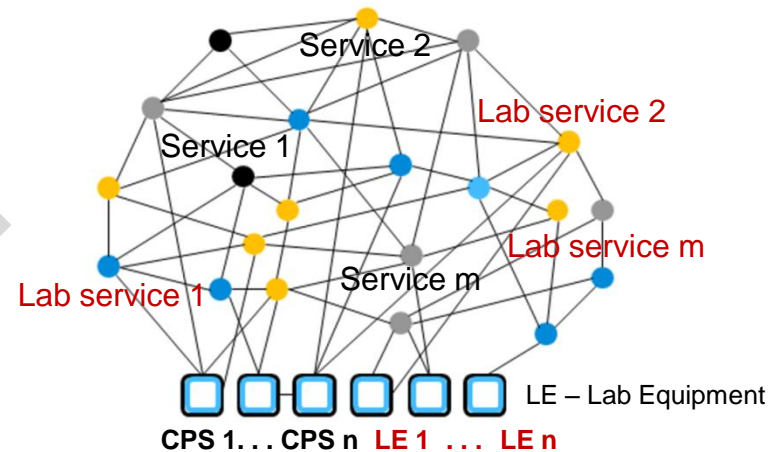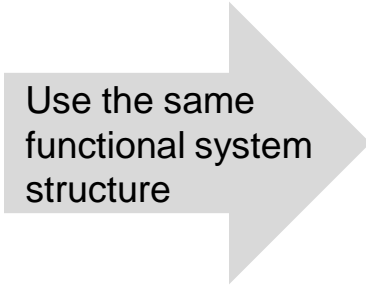Remote Labs in the light of Industry 4.0

# CPS-based Remote Labs

Considering the I40 principles a Remote Lab can be build by using a CPS-based automation system.



Use the same functional system structure

CPS-based Automation System

CPS-based Remote Lab

LE – Lab Equipment

### What do we need:

- Lab equipment/devices as CPS components or I40 components
- Free accessible industrial services
- Additional educational services
- Web-based CPS integration platform (for composing & exploitation)

Remote Labs in the light of Industry 4.0

# Content

# Open Remote Lab in Automation Engineering

In Automation Engineering we can distinguish two kinds of Remote Labs:

## Open Remote Labs

- An Open Remote Lab is an open environment for composing and operating of a functional system. It is comparable with a free accessible local hands-on lab.

- A learner has all possibilities for creating a desired system. The learning task and associated instructions are described in didactical documents.

- The teacher escorts the learner by tutoring and supporting information (face-to-face or by a collaboration tool).

- The learner uses industrial and standardized methods/tools for the solving of the learning task.
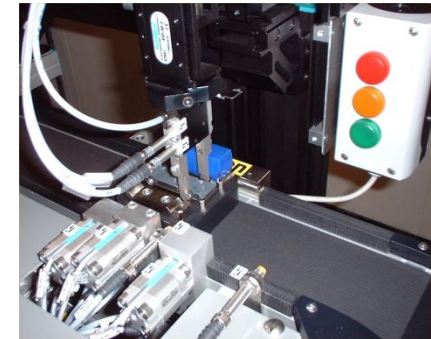


Design and operating of a HMI for an assembly station for model cars

Open and fixed Remote Labs
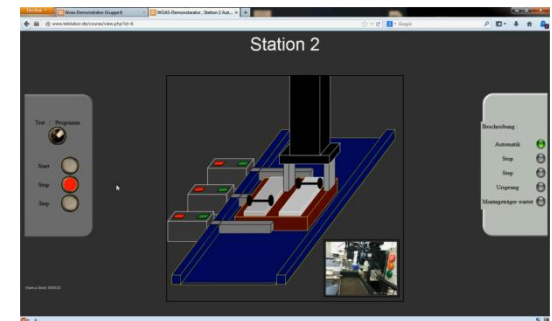
# Fixed Remote Lab in Automation Engineering

## Fixed Remote Labs

- A Fixed Remote Lab is a predefined didactic-specific environment in which a learner can work remotely and can solve fixed learning tasks.

- Normally the Remote Lab uses special hardware and software components in order to give the learner a good didactic learning environment.

- The establishment of a fixed Remote Lab needs an expensive development effort and special knowledge.

- A teacher can only integrate these Remote Labs in the curriculum and give some recommendations. He can't change the structure of the lab.



PLC Remote Lab



Programming and test of an assembly station for model cars

Open and fixed Remote Labs

# I40 Remote Labs

## What do we need for a I40 Remote Lab?

■ Lab equipment (devices) as an I40 component or CPS component. New industrial IoT gateways can be used.

■ A CPS integration platform in order to compose services with devices (equipment) to a functional system. If available, a industrial platform should be used.

■ A video server for watching the lab equipment.



Rasperry Pi
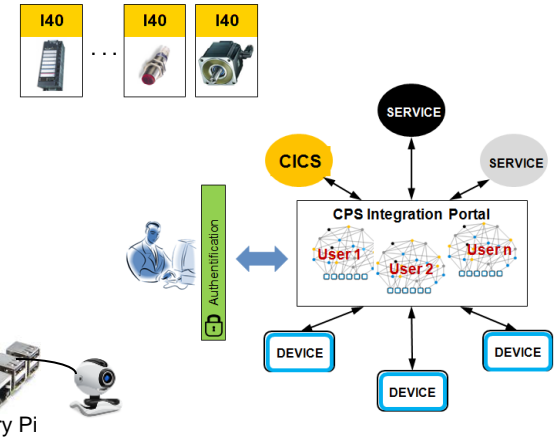
Differences between an open and fixed I40 Remote Lab

**Open Remote Lab:** A learners has an admin right and can compose a functional system according the task.
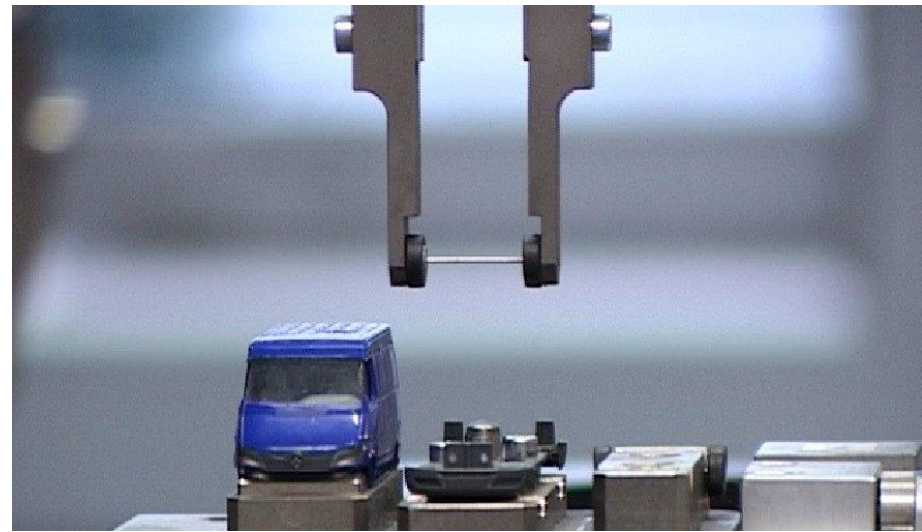
**Fixed Remote Lab:** A learner has only a user right and can solve the given task. A teacher has an admin right and can create a new lab

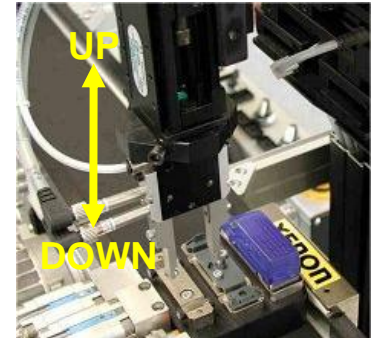# Content

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# Task and pre-conditions for the example

## Task

In a course „Pneumatics" the student should measure the movement time of a pneumatic valve and give recommendations for an optimization of this time.

**Equipment:** Station 2 of an assembly station - gripper arm up/down



## Pre-conditions

- All sensors & actors of the Station 2 are accessible by the Web.

- An admin account (for the teacher) and an user account (for the learners) in the CPS Integration Platform WOAS* (WOAS portal) are available (`http://woas.ccad.eu`).

- A web cam is installed on Station 2 to watch the station.



\* WOAS – Web-Oriented Automation System: R&D project of CCAD from 2011 ... 2914

Example: Fixed I40 Remote Experiment

# 1. Step – Integrate the lab device

## Select a Virtual Device
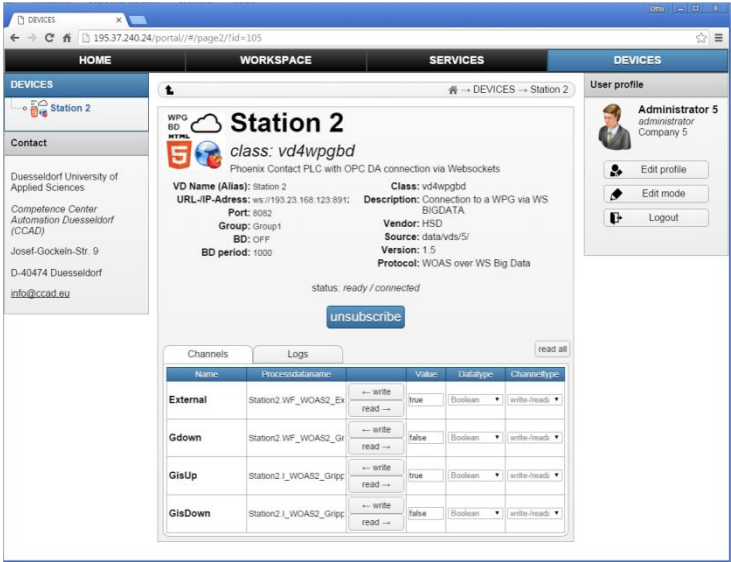


Several types of Virtual Devices are already available in the WOAS portal:.

- The Station 2 is controlled by a Phoenix Contact PLC and the process data are accessible by an OPC server.

- A Device Gateway for OPC is used as a WebConnector.

- The Virtual Device `vd4wpg` is to select for the communication with the WebConnector.

## Configure the required channels

Based on the description of the OPC process data for Station 2 the required process data can be selected and described by alias names.

| Name of OPC variable | Alias |
|---|---|
| Station2.WF_WOAS2_ExternalOn | External |
| Station2.WF_WOAS2_GripperDown | Gdown |
| Station2.I_WOAS2_GripperUp | GisUp |
| Station2.I_WOAS2_GripperDown | GisDown |

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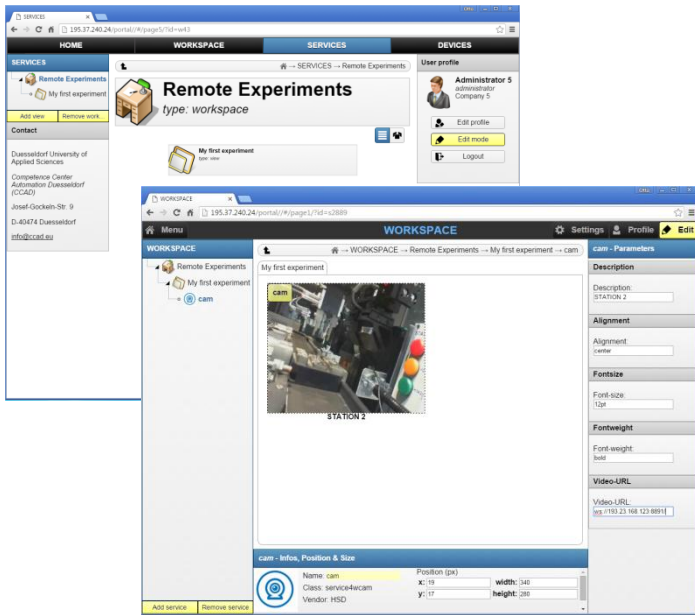
Example: Fixed I40 Remote Experiment

# 2. Step – Integrate the web cam

## Create a WORKSPACE and a VIEW



In the menu SERVICE you can create a working environment for the remote experiment:

- Create a WORKSPACE as an overall container for the experiment

- Create a VIEW as a web page for the experiment.

- Each WORKSPACE can contain any number of VIEWS.

## Create and configure a webcam service

The created VIEW is the work space for the composing of services. Here you can create a new instance of the web cam service by use of `service4wcam`. You have to configure the IP address of the video server.
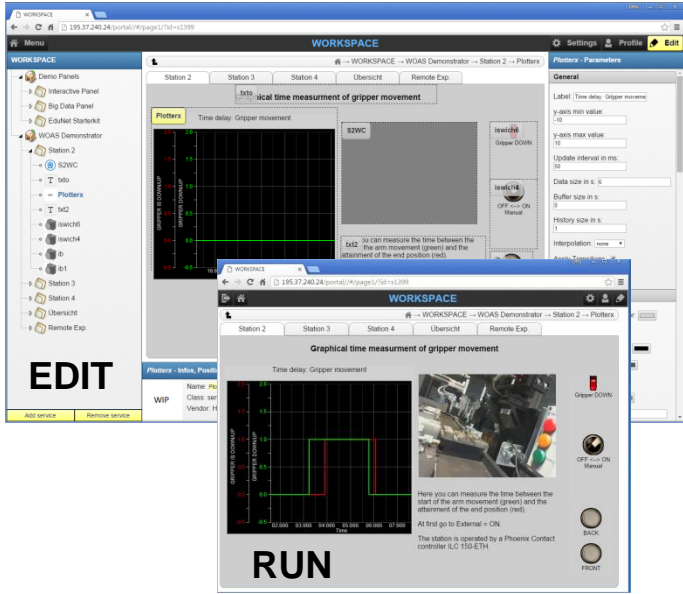
Example: Fixed I40 Remote Experiment

# 3. Step – Compose the lab experiment

## Create instances of services



**EDIT**

**RUN**

At present there are 26 different services available in the WOAS portal. The following services can be used for the experiment:

| Service class | Description |
|---|---|
| `service4iswitch` | Switch with feedback using different images for visualization |
| `service4svgplot` | Realtime plotter with two channels |
| `service4htmleditor` | HTML editor |

## Connect the service instances with channels of the corrsponding Virtual Device

Services and Virtual Devices base on a channel concept. Services have to be connected with VD channels or with other service channels. For the experiment the switch and plot services are to connect with the process signals from the Station 2.

Example: Fixed I40 Remote Experiment

# Content

# Experiences

CCAD tested an Open Remote Lab by use of the CPS Integration Platform WOAS (WOAS Portal) in the Winter term 2015/16.

**Course:**            Man-Machine Communication (Bachelor students, 5th semester)
**Course size:**            3 h/week; 4 credits
**Number of students:**     72 students organized in 18 groups each by 4 students

## Course structure

- **5 x 3h/week:**      Lessons for introduction to Automation 4.0 and the WOAS Portal

- **3 x 3h/week:**      Exercises in the WOAS Portal by face-to-face tutoring

- **20 h self-working:** Hands-on work in the Remote Lab (incl. preparation of a project documentation)

**In total:** 1.440 h working hours in the Remote Lab

## Project task

Design a PC-based & a mobile HMI for operating of the assembly station in the Duesseldorf Telelaboratory
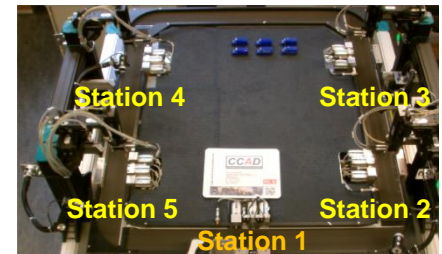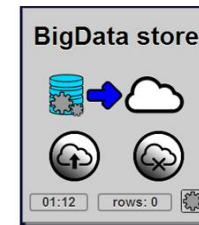
# Evaluation of the learning process

The WOAS Portal offers two Big Data (BD) services:

- **Big Data storing**: All process data changes of a Virtual Device can be stored in the Google Cloud

- **Big Data analysis**: Analysis of the stored process data.

During the entire semester an instance of th BD storing service was running in order to store all process data changes in the assembly station.
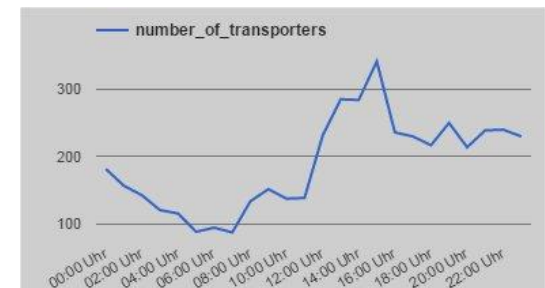
## Analysis of the student work in the Remote Lab

By the BD analysis service it is very easy to analyze the stored data relating different criterions.

Approx. 5 million process data sets are stored for the entire semester.

Analysis examples
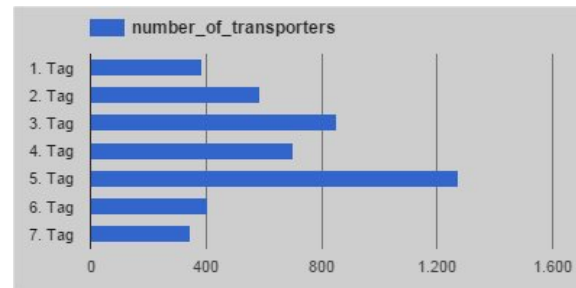
Working days of the students

Working time of the students

# Content

- Industry 4.0 – The Future of the Production Process
- Remote Labs in the light of Industry 4.0
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- Experiences & Evaluation of learning process
- **Problems & Conclusions**

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# Problems & Conclusions

## Management of parallel work at one station

1. Only one user can push the button. Therefore a reservation & scheduling system is integrated into the WOAS portal. A student can reserve a device for writing process data.

1. The learners have to use a chat service for the co-ordination of their work on the real stations.

2. The learners can us a special Virtual Device for simulation of the stations instead of the access to the real stations. This disburdens the station.

## Distribution of the operating life for the real lab equipment

The students work in the Remote Lab usually at the end of semester. This is a problem for the burden of the real equipment.

To reduce this burden we think about a special service by which a learner can request the access to the real lab equipment only for a short time (some minutes).

# Contact

**Thank you for your attention!**

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**EduNet**

**VFAL**

**http://www.ccad.eu**
**http://woas.ccad.eu**

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