# Augmented Service in the Factory of the Future

Matthias Berning, Till Riedel, Daniel Karl, Florian Schandinat, Nicolaie Fantana, and Michael Beigl

## I. Introduction

Servicing the factory of the future raises challenges for the service teams and organizations. The industrial plant environment is changing rapidly due to the impact of the market and new autonomously operating information technologies such as on site information and communication services, an Internet of Things (IoT), smart sensors and intelligent automation devices as well as progress in conventional machines and technologies.

In the factory of the future vast amounts of data are linked to each machine and part for their entire lifetime, which stems from:

- machine identification e.g. via RFID
- existing factory automation systems
- wireless sensor networks (WSN)
- other enterprise systems via on site data links

Flexible on-site, ad-hoc data collection based on IoT and distributed sensors, done by the individual service worker, gives access to both context and equipment specific details. This proves helpful for diagnostics by increasing the information amount and therefore supporting better service decisions.

As shown in Fig. 1 the Field Service Engineer is the ultimate bridge between management and factory production. Thus he is able to validate the real installation on site and find the gap between the expected operation and the reality. On the one hand he collects important lifecycle data about equipment and parts. On the other hand he is dependent on fine-granular knowledge about the expected and current lifecycle of the installation he is faced with and on personal experience to generate a diagnosis or understand the available information.

Current studies show that huge saving potentials can be achieved by targeting the work of engineers on site [1]. There is still room for a 10-40% increase in work efficiency. However, an even bigger potential (10-50%) arises from relieving the work load. With more information sources at hand we might increase efficiency in the long run, but the

Manuscript received March 15, 2012.

M. Berning, T. Riedel and M. Beigl are with the TecO, Karlsruhe Institute of Technology, Karlsruhe, Germany (e-mail: first.lastname@kit.edu).

D. Karl and F. Schandinat are students at the Karlsruhe Institute of Technology, Karlsruhe, Germany (e-mail: first.lastname@student.kit.edu).

N. Fantana is with ABB Research CERC Ladenburg, Ladenburg, Germany (e-mail: first.lastname@de.abb.com).

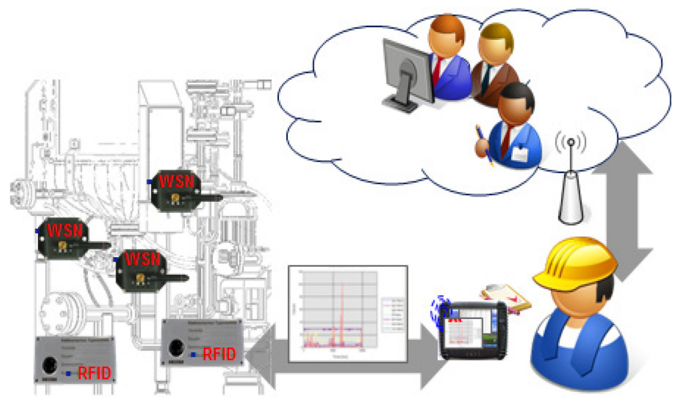


Fig. 1. The field service engineer collects data from heterogeneous sources on site and establishes a link between the business backend and the real world.

additional task of collecting and documenting fine granular lifecycle information will put more responsibility to each worker thus increasing their work load. Providing field service with information from an IoT provides great economic potentials, but clearly exposes the technical challenges beyond the availability of data on the machine.

This demo shows how a combination of lightweight service architecture and augmented reality (AR) interfacing can help to analyze data gathered from autonomous embedded systems onsite.

## II. Architecture

The system as depicted in Fig. 2 is based on a model-view-controller architecture. This enables the decoupling of information presentation, data aggregation and application control. The model gathers data from various sources. This is a wireless sensor network, in our scenario. The data source is only loosely coupled to the system. The architecture comprises a light weight ad-hoc web-service gateway that feeds events into the model, as described in the next subsection.

The primary user interface to the system is an augmented reality view that overlays the users view on a physical system, like a machine, with aggregated sensor data. The application controller uses the tracking component to acquire the real world view via the onboard camera and to identify object within the target area. This information is then handed over to the view component, which request available data from the model for rendering.

### A. Ad-hoc Web Service Infrastructure

The sensor network interface is based on the device profile for web services (DPWS). Existing low-level wireless networking and sensing standards did not match our efforts to

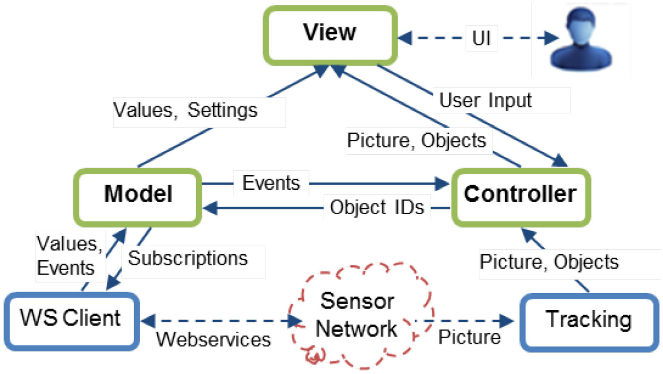


Fig. 2. Overview of the Model-View-Controller system architecture

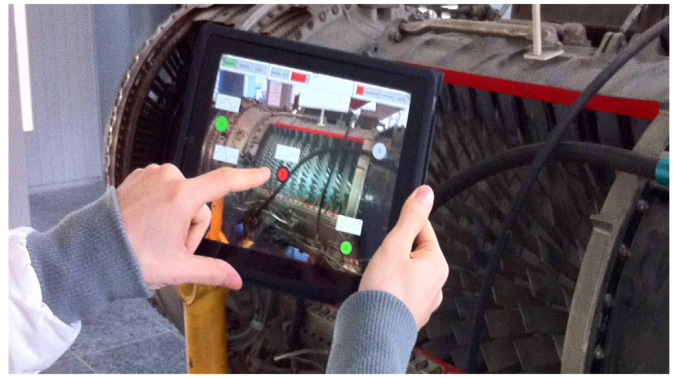

Fig. 3. Interface prototype visualizing data from a sensor equipped turbine

support diverse applications and setups (like WirelessHART [3]) or targeted only lower network levels of communication (like 802.15.4). Practically we are facing a vast number of application specific protocols, runtime systems and APIs.

This is a natural development for an area where the most powerful systems operate at hard constraints in terms of cost and run on very limited resources and optimized miniaturized hardware.

Based on a lightweight gateway system [2] we abstract the underlying IoT technology. Using multicast announcements the application can use infrastructureless ad-hoc discovery to connect to all devices in the vicinity. The DPWS device based metadata exchange clearly identifies model and device on the basis of common technology independent attributes. The functional capabilities and the interface of a node are encoded in WSDL as a service. The service interface contains all the static functional capabilities

The implementation uses the WS4D-JMEDS [4] client stack for discovering and interacting with the DPWS proxies. In the prototype we use Particle Computer catPart and uPart as well as Microstrain GLink sensor nodes as autonomous sensing devices.

### B. *Augmented Reality Interface*

The Field Service Engineer is often the only interface to reliable data on site. Even with a vast amount of information technology at hand reliable information about the "real" condition is only accessible via this "human interface". Previous studies have shown that user acceptance is heavily dependent on the ability of the system to adapt to the requirements. Most promising for intuitive hands free operation on site are augmented realities. For supporting maintenance and repair work, AR systems with head mounted displays were e.g. proposed by Platonov et al. [5]. Recently mobile devices such as smart phones or tablet pcs equipped with cameras have proven successful for implementing "augmented windows".

Especially markerless systems either need high computational resources or often do not work reliably enough for everyday use. This is why our prototype is built upon marker technology. We have implemented two different approaches. One utilizes the ARtoolkit [6] that can identify and track printed 2D tags. An alternative approach is using active infrared LED tags that can be coupled with the nodes.

We have implemented this using the WiiMote hardware for tracking of the tags. Identification is realized using a Hamming encoded sequence transmitted via the blinking LED at 50Hz. Bokode [7] shows another possible low cost implementation.

## III. CONCLUSION AND INITIAL RESULTS

A first prototype of our systems is depicted in Fig. 3. As expected, first tests have exposed critical performance aspects of the system. The reliability of the marker tracking technology is essential to practical usability. Especially on mobile devices processing power is still a critical aspect for any video based tracking. The IR based system works around these problems by using specialized hardware. Temporary failure of the IR system however leads to very limited usability, while the HIRO marker labeling can act as a human readable fallback.

The use of web services for interfacing embedded ad-hoc networked systems has proven to be a successful strategy for application development as it decouples specific client software from autonomously working resource constrained sensor devices. Furthermore it allowed a short development cycle. Performance benchmarks [2] indicate that the approach scales for the envisioned application scenario.

Overall this work demonstrates both the possibilities and challenges using and interfacing wireless sensor networks for servicing the factory of the future.

## REFERENCES

[1] W. Männel: "Metrics and measurement systems for maintenance controlling", 2001, Lauf a. d. Pegnitz

[2] T. Riedel, N. Fantana, A. Genaid, D. Yordanov, H. R. Schmidtke, and M. Beigl, "Using web service gateways and code generation for sustainable IoT system development," in *Internet of Things (IOT)*, 2010, 2010, pp. 1-8.

[3] WirelessHART, http://www.hartcomm.org/protocol/wihart/wireless_technology.html, 2010

[4] JMEDS Stack, http://ws4d.e-technik.uni-rostock.de/jmeds/

[5] J. Platonov, H. Heibel, P. Meier, and B. Grollmann: "A mobile markerless AR system for maintenance and repair", *ISMAR 2006*, 2006

[6] ARToolkit, http://www.hitl.washington.edu/artoolkit/, 2002

[7] A. Mohan, G. Woo, S. Hiura, Q. Smithwick, and R. Raskar: "Bokode: imperceptible visual tags for camera based interaction from a distance", *ACM Tranactions. Graph.*, vol28, issue3, 2009