Diary of an apple tree

Green Farming: sensor-based management,
seamless monitoring of supply chains, and sharing
of acquired data with consumers.

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Total area of Germany: 88,222,057 acres

Fruit
- Fruit cultivation in Germany overall: 146,716 acres
  → Organic farms: 25,833 acres (approx. 18%)
- Fruit cultivation companies: 8,479
- Fruit harvest yield: 1,289,905 tons
- Fruit trees by federal state:
  → Most: Baden-Württemberg: 45,245 acres
  → Fewest: Saarland: 393 acres

Vegetables (including mushrooms & strawberries)
- Vegetable cultivation in Germany overall: 321,520 acres
  → Organic farms: 46,089.6 acres (approx. 14%)
- Vegetable cultivation companies: 10,162
- Vegetable harvest yield: 4,930,645.38 tons

Overall
- Fruit and vegetable cultivation: 472,236 acres
  → Organic farms: 46,089.6 acres (approx. 15%)
- Fruit and vegetable cultivation companies: 18,641
- Fruit and vegetable harvest yield: 6,220,550.24 tons

Source: Federal Statistical Office of Germany

New, science-backed green-farming projects are proving that the collaboration of research and agricultural production can bear fruit. The idea behind it was to create highly automated, interactive systems for food production. A number of different applications are possible here, for example, in urban areas where there is little room for cultivable land.

Greenhouses and plantations are also benefiting from green chains of traceable sustainability.

Controlling fruit and vegetable cultivation by means of sensors in order to influence product quality and share data with growers, producers, and consumers – how does it all work?

The perfect interplay of cloud, IoT data, and blockchain is essential here as a means of providing transparency across the entire production and supply chain – from cultivation through to verified sales and what consumers see. A plant diary is being created. This tracking process therefore also meets new legal requirements. But how do you win consumer trust? What added value can be gained from these "monitored" plants?

The eternal battle: Population growth and food supply

Helping mother nature grow and thrive is an age-old endeavor. People have always developed new concepts – such as granaries, the three-field system, the use of wind and water mills, and modern agricultural technology – to ensure food supplies and thereby prevent famine. But of course, the growing population across the world calls for more and more food. Shortages and famines continue to be an unresolved problem to this day. Over 800 million people are still starving, and almost 2 billion suffer from malnutrition.

One reason for this is our dependency on properly functioning supply chains. The main challenge is to reduce disruptions and make design infrastructures less dependent on climatic and geopolitical influences. However, this cannot be achieved with complex supply chains and products that have travelled across the world.

Changing the way we think and creating transparency: Continuous tracking of supply chains

Decentralized, regional approaches are changing the way we think. Regionally sourced products have shorter delivery routes, which in turn reduces carbon footprint – the necessary CO_2 emissions generated from production and transport. New communication channels are now enabling consumers to digitally check the shortest possible distance travelled by their product in a closed loop.

A blockchain provides all of the information gathered about the product. The starting point may be the regional organic farm, but the tracked journey continues with transportation and sale right through to the consumer's table. Consumers scan a QR code to obtain data about when a product was harvested and produced, and who produced it. But how secure and reliable is this?

Plant monitoring allows diseases to be detected and treated in good time, which creates a better crop in terms of quality and quantity.

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Establishing trust: Blockchain links up product waypoints

The information recorded in the blockchains cannot be changed. Once activated, they provide reliable information arranged in a chain through a consensus that is transparent for all participants. The information is not checked by a central authority, but organized as a decentralized registry, which contains all the transactions for a block, and links the blocks together in chronological order – across the entire value creation chain for all operations and people involved.

Tamper-proof time stamps and digital signatures ensure protection against forgery. All participants can see any changes and therefore keep each other in check. Which blockchain solution can achieve this?

Energy-efficient collaboration: T-Systems with Ethereum and tDAO

T-Systems has used blockchain solution tDAO to create a registry which enables access to the separately stored information about the delivery item, as well as certificates and detailed product information. Participants can specifically release the read access to this. They are then free to provide only the necessary information to trusted auditors – or, in a bid to guarantee maximum transparency, ensure the public has a full insight into a product's origin and supplier relationships. This extends to organic farmers just a few miles away.

By using open blockchain Ethereum as a basis, as well as tailored smart contracts and APIs, tDAO is supporting various company philosophies, marketing strategies, and security requirements. T-Systems acts as the gatekeeper by protecting access to this blockchain solution, reducing the risk of misuse even further.

Tracking with maximum transparency: Scan QR codes here

In partnership with tDAO and Ethereum, rather than requiring high levels of energy like well-known crypto currencies, the transactions can be posted very efficiently, making the solution sustainable and energy efficient. This is ideal for associations of smaller growers and producers that want to position their products on the market in a sustainable, transparent way. This creates collectives, which meet consumers' needs regarding sustainability and traceability in supply chains. But what kind of technology is needed to do this?

IoT devices for checking supply chains

The use of IoT in supply chain management makes it possible to gather data for better inventory management, transport, and incident response. IoT devices collect data about the location or temperature during transportation. This allows the consistency of cold chains to be monitored.

The sensors are comparatively low cost and can be easily fitted to euro-pallets, for example, during transportation.

In other words, IoT devices provide supplier management with fast-response equipment that saves time and money and responds flexibly to incidents. Transportation is monitored and swift action can be taken in the event of disruptions, for example, with automated replacement orders. But traceability is not the only advantage of the sensors. They can, in fact, work small wonders in small spaces during production.

Red-hot: Chilies and coffee beans in the Connected Greenhouse

Patrick Köhler from T-Systems has managed to grow chilies and coffee beans in one of these small spaces by using sensors. The mini greenhouse features at the Innovation Center in Munich. The Con-

nected Greenhouse use case is a great example of what is possible today. The aims were to maximize yields and consume as little energy as possible in the process. Integrated IoT and blockchain make it possible to grow food much more efficiently in a small space by means of vertical configuration.

Optimum growing conditions and a highly reliable supply result over the course of a year. This use case won the ISG Paragon Award. But that's not all. The greenhouse makes it possible to influence the quality and properties of the plants.

What'll it be? Influencing size, color, and taste

The latest research projects in close collaboration with the agriculture industry are showing that the combination of IoT, blockchain technology, and machine learning is well proven on a grander scale.

> " By controlling the environmental parameters, such as irrigation, light, fertilization, temperature, and air humidity, we can grow plants in an optimum way. This isn't enough, though. We therefore have the option to influence the speed of growth, the fruit-ripening process, and even the final taste. We are therefore essentially writing a diary for our plants, which allows us to produce specific crops. Less is thrown away and we all end up with more.

Patrick Köhler, Senior Innovation Manager, T-Systems

Added value

More than just a future vision: Decentralized, transparent, and sustainable food supply

The new digitalization technology has further fanned the flames of the change in thinking within the agriculture industry. "From farm to table" has become an important buying incentive for consumers. Decentralized company alliances are playing an ever-more important role in food supply. The carbon footprint is traceable thanks to the use of trustworthy blockchain technology and the monitoring of IoT devices, which extends fully and continuously to include transportation. Growers, producers, logistics companies, and consumers benefit from the flexibility and consistency of the solutions used. Thanks to vertical farming and greenhouses in extremely small spaces, as well as large, sensor-based monitoring of crop growing, there are now options to ensure food supply for a growing population. Geopolitical conflicts and local events mean that we are currently discovering just how susceptible we are to disruptions in supply chains.

This is a good reason to think outside the box when it comes to food production and to utilize the possibilities of blockchain and IoT technologies.

A lot of value can be realized from remote monitoring of crops.

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T-Systems managed to grow chilies and coffee beans in one of these small spaces by using sensors.

Working together in field research: Interview with Viola Süss, Chair of Information Management, Leipzig University.

EXPRESS, an interdisciplinary research association that brings together the expertise of different institutes, focuses on the added value digitalization brings in wine and fruit cultivation. Viola Süss, research associate at the Information Systems Institute and professor of Information Management at Leipzig University, talks about the focus of her research in close collaboration with farms.

Which projects on wine and fruit cultivation are you currently researching?

We work with small and medium-sized agricultural businesses, researching the challenges associated with constant increases in efficiency, product improvements, conservation of resources, and sustainability, which can be supported with innovative technologies. Often, conventional methods that are already established offer no further potential for improvement. This is precisely where EXPRESS comes in. We put this to the test through the direct use of new technologies and by working with our agricultural partner companies.

We have the following research focus areas:

- **Water stress:** The multi-scale monitoring of climate and water ratios in the fields by means of a sensor net. In other words, how do we treat plants in different locations, such as on a hillside, precipice, or at ground level with too much or too little water, and what does optimum irrigation look like?
- **Abiotic factors:** Automated monitoring of environmental factors using sensor technology and their influence on growth and plant health. This data allows meaningful information to be gathered and forecasts to be made.
- **Transparency and tracking value chains**: Regionality through blockchain as a technological trust anchor.
- **Virtual reality**: Using AR and VR to create a digital twin, which will allow farmers to assess the health of their plants in the field from their office, and to enhance the visual display with useful information.
- **Data integration**: Data collection from many different heterogeneous data sources, such as sensor technology, IT systems, and agricultural equipment, and creation of a useful format for farmers.

Please briefly describe your partnership with Obstland Dürrweitzschen AG; what did you focus on?

We conduct our research on test areas provided by Obstland Dürrweitzschen AG, Schloss Proschwitz vineyard, and the Global Change Experimental Facility (GCEF).

At Obstland Dürrweitzschen AG, which has around 3,700 acres of cultivable land, our focus is on fruit cultivation, and specifically apples. We're concentrating on transparency and traceability using blockchain technology.

How do you support growth and production? What can digitalization contribute to this?

We support growth and production at all levels. For example, we offer our technological expertise to our partner companies. EXPRESS works with its partners to help the development of feasibility calculations, innovative business models, and prototype implementation, and demonstrate potential areas for improvement.

What are the specific benefits of blockchain?

These lie in the technology itself, as it combines various information technology features, creating a trustworthy overall system based on decentralization, transparency, and tamper protection.

This creates trust (which is often lacking) in the regional supply chain:

- In arable farms through certification of pesticides, for example, organic certifications
- With logistics companies through on-time delivery, undamaged goods, and a flowing cold chain
- With consumers by means of digital transparency and fast traceability of food

What added value can be achieved? Is it possible to increase quality and quantity, or reduce waste?

Firstly, we strive for a sustainable, ecological symbiosis of farm and digital technologies. What we have achieved and strive for so far:

- Plant monitoring allows diseases to be detected and treated in good time, which creates a better crop in terms of both quality and quantity.
- We gained a great deal of experience with regard to water stress, particularly in Saxony, where we are currently seeing the most severe groundwater drought in 100 years. Sustainable irrigation is extremely important here, in order to increase yields.
- With regard to pesticide application, multiple rows of crops can be sprayed with automated, specific on-and-off functions, which saves time, for example, by means of a spray drone in viticulture over precipices and terraces.
- A trailer spray device with a three-row spray can cover three rows at the same time within a matter of minutes, which reduces the workload significantly.
- However, aside from spray equipment, we can treat pest infestations, such as those caused by codling moth, with beneficial organisms in a natural way. Moreover, the plan is also to use sensors and AR/VR to detect pests.
- Additionally, AI leaf-condition detection is used to predict crop yields, while data is collected for forecasts and the expected water requirements determined.
- Weather phenomena and vegetation-related variances can be identified more precisely.

Can the technology be used on a large scale?

Using the sensors across larger spaces is currently difficult for us to achieve due to interruptions in the technology supply chains. But it is feasible. However, we're usually just covering a small area and then interpreting it as an example.

For example, we are analyzing one field with multiple stock units, and taking account of different geographical properties, in order to obtain an extensive database, and gather and analyze it. Ultimately, the findings will enhance the new technologies, such as AR/VR or AI detection. ■