TUCANA: A platform for using local processing power of edge devices for building data-driven services

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Abstract. In the age of mobile cloud computing web-based systems are often designed to transfer data to large scaling online storage facilities in order to persistently save and analyze it with complex algorithms such as used in machine learning. These systems often require a reliable network connection, which does not hold for a variety of mobile business applications. As an alternative to traditional cloud-based systems the TUCANA approach makes use of the local processing power of mobile edge devices in order to come up with high complex AI pipelines processing data in real-time. By applying the idea of TUCANA to our service use-case called "nPotato" we developed an artificial, nociceptive potato that frequently measures and analyses acceleration data during the harvesting process of potatoes. In the given scenario sensory data is processed locally in real-time using the device's local computing power to gain higher productivity in the area of precision farming.

Keywords: Edge Computing, Internet of Things, Distributed AI, Web Technologies

1 Introduction

Mainstream mobile cloud computing architectures assume that local clients collect data and transfer this data to centralized data storage facilities. Major data processing is performed in these data storages and results are transferred to clients for presentation to users [1]. Examples are Google's Firebase or Microsoft's Azure.
These architectures normally assume high-speed Internet access so that data exchanges are performed without considerable latency. It also assumes that users are willing to transfer their data to centralized data centers, i.e. accept end-user license agreements (EULA) accordingly. These requirements do not always hold. In many areas, internet access is either unavailable or unreliable. This causes problems, for instance, for mobile business applications, such as used in farming.
With our new approach called "TUCANA" we aim at building a platform for the fast implementation of smart services that are working in closed local environments. This approach is based on modern approaches of mobile software development making use of distributed device capacities as given in the field of edge computing [2]. In this

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scenario the execution of a service in a closed environment implies that a service does not rely on a stable internet connection and a high availability of computing capacities in cloud facilities since data measurement and data processing both can be done using the device's local sensors and processing power.

Moreover, since the communication of analysis results is important for most of the cases, the architecture comes with the opportunity to connect several local environments for sharing data through a secured peer-to-peer network . Each TUCANA environment (T-ENV) acts as a peer in this scenario. With the feature of connecting several T-ENVs there also comes the opportunity of building data processing pipelines making use of the capacities of multiple mobile edge devices and distributing the execution of AI models and other functionality within a connected network. With this approach computational complexity can be significantly reduced for single devices in their local environments but distributed to a variety of available peers in the network.

Applied to the context of real-time decision making in the area of farming such as described in [3] this means that problems based on low availability of computing resources during farming processes can be avoided in many cases. For instance, during the harvesting process of potatoes, connectivity errors of mobile monitoring devices harvested together with the crop such as the "nPotato" can occur because of a changing environment. If a measuring device used for monitoring the impact within the harvester needs to transfer large amounts of raw data for analysis to a central server, the connectivity most likely is not sufficient and the feedback to a farmer or a driver of the harvesting machine is either significantly delayed or not given at all. By processing the data directly on the measuring device, just the analysis results are necessarily transferred in order to give feedback to the farmer or the driver of the harvesting machine. This most likely results in a higher availability of the analysis results and provides the opportunity of reacting quickly to changing circumstances during the harvesting process.

2 Proposed demo

2.1 Demo description

Our demo showcases a cloud-independent AI platform for high complex problems, all solved in a protected, local software environment. Combining the sensory data and processing power of multiple mobile devices, TUCANA is a platform for distributed, privacy protecting smart services. Following this approach, we built a TUCANA application for the service use-case "nPotato". In this scenario the application assists a potato farmer during harvesting with real-time damage analysis and financial forecasting for market prices, all carried out on commonly available devices such as smartphones and laptops and without any necessary cloud infrastructure.

Figure 1. nPotato prototype

For realising this use-case we use a standard smartphone as a measuring device in and run our TUCANA application in it's Google Chrome Web Browser. After the smartphone is set up and running we put it into a case built by a 3D printer as shown in figure 1. In order to visualize what is going on inside the potato case we use the same web application on a tablet PC's Chrome Browser that is connected to the nPotato smartphone as a peer. Data sensed and analysed by the smartphone inside the case gets transferred through a peer-to-peer network to the remote tablet by using a technology called WebRTC[1]. The user of the tablet PC, in our case the driver of a potato harvesting machine or the farmer himself, now has access to realtime information about the current quality of the crop as well as the total expected yield. These predictions are based on the analyzed sensory data of the nPotato phone and directly sent to the tablet PC. Additionally, the data obtained from several connected potatoes is processed further on the tablet by analysing it in combination with future potato price estimates in order to give a prediction about upcoming incomes for the farmer.

Figure 2. Reliability testing during potato harvesting

Furthermore, we already tested the reliability of the application in a real world setting by harvesting the artificial potato with a real potato harvesting machine as shown in figure 2. This picture was shot during potato harvesting at a local farmer. To show the system also in controlled environments we developed a demo case. The demo proceeds as follows:

[1] see https://webrtc.org/ for further details

1. The smartphone is inserted into the case and connected to the remote tablet PC.
2. The application is started remotely through the tablet PC.
3. The nPotato is dropped from several heights and communicates the analysis results to the tablet PC.
4. The user gets information about the status of the potato in real-time.
5. The data is further analyzed on the tablet and the estimated monetary income for a farmer is shown.

2.2 Requirements

The demo has only minor technical requirements. It needs a space for executing the fall experiments with the nPotato. We usually used a tapeline for measuring the fall height and a pillow for reducing the noise of the fall experiments. Additionally the devices need access to a wifi access point as a basis for the secured peer-to-peer communication. Optionally, a larger screen for our tablet PC could improve the demonstration for the visitors.

2.3 Interaction Possibilities

Visitors can interact with our demo system in several ways. We provide nPotato cases with smartphones inside, so visitors can test the damage and fall detection on their own. Since our application is built as a web application, no installation is required to use it. If someone is interested in connecting to our system either as a potato measuring device or as the remote device that gets analysis results from several potatoes he or she can either use his or her own smartphone (Android required) or one of our phones we use to demonstrate the technology to interact with the system and process and transfer data on the device.

References

1. Dinh, H. T., Lee, C., Niyato, D., & Wang, P. (2013). A survey of mobile cloud computing: architecture, applications, and approaches. Wireless communications and mobile computing, 13(18), pp. 1587-1611, (2013).
2. Hu, Y. C.; Patel, M.; Sabella, D.; Sprecher, N.; Young, V.: Mobile edge computing. A key technology towards 5G. ETSI White Paper, 11 (11), pp. 1 - 16, (2015)
3. Maaß, W., Shcherbatyi, I., Marquardt, S.: Real-time Decision Making with Smart Farming Services. Proc. of 75th International Conference on Agricultural Engineering (AgEng), (2017)