Improving IoT Data Transmission via Context-aware Edge Based Mechanisms

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***Abstract*—This thesis work is dedicated to the analysis and development of a more robust support for Internet of Things data transmission, in particular, for personal Internet of Things environments, where data is more volatile and where devices exhibit highly mobile patterns. The thesis expects to contribute to context-aware edge computing mechanisms that lower latency in particular in environments where the user requires frequent feedback.**

***Index Terms*—IoT, edge computing, context-awareness, network architectures.**

I. Introduction

IoT scenarios are today regularly integrated into the daily routines of people, involving a wide variety of embedded hardware, as well as personal devices, such as smartphones. Moreover, in personal mobile devices sensors such as accelerometer, GPS, microphone, or camera bring in the possibility to exploit new types of data as *smart data* or *small data*, derived from the tracking process of different aspects of the routine of citizens.

While such sensorial capability is giving rise to new types of data and services, it also brings in new challenges from a network operation perspective. The IoT communication architectural models that are being applied to support such data transmission are not be able to cope with the properties of such traffic (e.g., high volumes of small data packets), both due to a large number of devices and to a higher heterogeneity of hardware and software involved. Also, the different, richer types of smart datasets, require a complex processing which today is centered on the cloud. Aspects such as where and when to classify and to store data are today being revisited both in terms of which algorithms to apply, and in terms of where and when to perform such computation. In the quest to assist smart data computation in IoT scenarios, there is the need to revisit networking semantics, and to consider how communication protocols can best serve smart data services, having in mind the mobility of devices; the need for data protection; the larger volumes of individual data streams to be analysed; and the requirements to handle such data. Context-awareness derived from physical network and device resources (e.g., available battery, CPU) as well as derived from human aspects (e.g., roaming habits) can be integrated into network mechanisms and protocols to improve the network operation. This is the core focus of this thesis, which is dedicated to the development of context-aware edge based mechanisms that assist the network in understanding when and where to transmit and to store data.

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II. Main Contributions

The motivation to develop this work concerns the belief that Personal IoT (PIoT) requires a different, more interactive type of communication to scale well in heterogeneous, mobile environments. Such communication includes feedback close-to-realtime to users.

This work is formulated around the following research questions:

1) How to better support personal IoT data transmission requirements, having in mind mobility aspects and the need to reduce latency?
2) How can contextual-awareness be applied on the network to improve data transport and data computation? Can it assist in a better support for bi-directional communication?
3) Is there a more adequate placement of networking functions? Which approaches should be considered?

Based on these research questions, the thesis has the following objectives:

1) **Objective 1**: To analyze the potential of current solutions for IoT data transmission, namely, IP-based and information-centric approaches.
2) **Objective 2**: to analyze the relevancy/potential of data analytics and contextualization to improve network operational aspects for personal IoT scenarios.
3) **Objective 3**: to devise algorithms and mechanisms that take into consideration context-awareness to reduce latency and packet loss, as well as to provide robust support to bi-directional communication situations (e.g., user feedback).

4) **Objective 4**: to validate the new mechanisms under realistic conditions, e.g., via the COPELABS IoT experimental lab, as well as via large-scale testing networks such as FIT-IoT.

The main technical focus is therefore on the development of edge based algorithms and mechanisms that rely on contextualization to best assist data exchange, taking into consideration the requirements of PIoT scenarios, of which Figure 1 aims to exemplify an IoT scenario where smart data collection and processing as well as feedback is required. The purpose is to explain requirements from a network perspective.

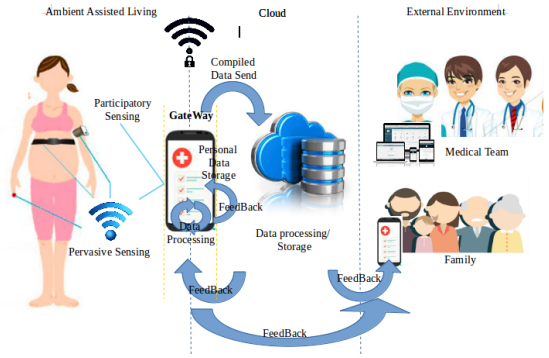

Fig. 1. SmartHealth use-case, pregnacy support on-the-go.

III. Advancement Beyond Statement of the Art

In search of a definition for the state of the art in the context of this work, the areas of research studied and their main references are: "IoT: Consumer and Personal; Industrial" [3], "IoT Communication Models" [4], "Contextualization in IoT" [5], "Feedback in PIoT" [6] and "Data Processing in the Network" [7].

This list summarizes a first set of results found by the study and analysis of the state of the art:

- There are today different network architectures for IoT, and there is yet no consensus on a "best" model for IoT. Therefore, based on the controlled scenario exemplified in Figure 1 and on other scenarios, one aspect to be worked upon is to evaluate different existing protocols (e.g., AMQP, MQTT) and architectures (e.g., cloud-based, cloudlet) in regards to performance aspects such as latency, packet loss.
- In regards to communication and standardization in IoT, interoperability with core networks is essential. In this context it is relevant to look into standardization entities such as *etsi*; *3GPP*; *ietf*. We expect to contribute to standardization by raising awareness on the need to integrate context-aware mechanisms for IoT environments.
- The publish/subscribe model, which is present in today's IP-based messaging protocols as well as in information-centric approaches is a natural next step to support IoT data transmission, as it provides better scalability than the traditional client-server model, through parallel operation, message caching, tree-based and/or network-based routing.
- PIoT may benefit from bringing data processing closer to the end-user - hierarchies of functions may be a relevant approach. Reliable data transmission in personal cloud (family, home or outside), to better understand how the information will be sent and received (feedback) by stakeholders in the system.
- Providing individual and collective feedback by a bi-directional communication to and from the cloud for the stakeholders, considering involved mobility are requirements that should be dealt with.
- To promote feedback close-to-realtime, contextual-awareness can assist the network in making decisions that improve the network operation. Identification of the advantages, disadvantages and challenges of such process is an aspect that will be worked upon.

IV. Status/Expected Results

Currently, to have a better understanding of possible communication architectures to support bidirectional communication a research on the impact of the use of contextualization to improve the functions of networks is being developed. We are therefore analyzing cloud computing vs. Mobile Edge Computing paradigms and how can context-awareness be brought to the network to best assist the network in making decisions on when and where to send data to. In this activity, IoT testbeds are being used to perform experiments. Experiments are being performed on a local testbed, the COPELABS IoT experimental project [1], as well as on FIT-IoT [2], using different data communication protocols, different network architectures and considering device mobility requirements as well.

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