Quick Introduction to Quality of Context

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Abstract

With the increasing number of IoT capable sensors being deployed, the need for application programmers to be able to use easy selection methods in order to get adequate sets of sensored data providers to fulfill application requirements became a main concern. It's in this context that the concept of Quality of Context(QoC) arose. This paper aims to introduce some of the basic concepts of QoC, along with two methods used to calculate QoC rankings, as well as presenting open challenges in the area.

1. Introduction

In the last few years, the rise of IoT devices began to motivate new works and research. With estimations of up to 50 billion IoT devices connected by 2020 [3], it becomes especially important to understand the requirements for new applications taking IoT into account. In particular, the problem of selecting adequate sensors considering data sources amid billions of possibilities requiring the ranking of IoT sensors according to certain criteria and in reasonable time is one that must be faced in order to facilitate the implementation of applications capable of benefiting from IoT capabilities [8]. It was in this context that the concept of Quality of Context(QoC) was created.

This paper is organized according to the following structure: Section 2 introduces the basic concepts of QoC. Section 3 presents two methods for calculating QoC values. Section 4 discusses some of the open challenges in the area. Section 5 concludes the paper.

2. Quality of Context

Although the idea of evaluating the quality of information from context sensors has been discussed at least since 2000 [2], the first time it was presented as *Quality of Context* was in [1], where the ideas of how to describe the quality of context information provided by sensors and which criteria to use in order to make this description were introduced. According to [1], QoC should comprise information about criteria such as precision, probability of correctness, trust-worthiness etc. that allows the evaluation of information provided by sensors. It is also shown in [1] that the concept of QoC is related to Quality of Service (QoS) and Quality of Device(QoD), but differs from both.

In [4], a new criterion, *completeness*, was added, and a mathematical approach to calculating values for each of the criteria in order to enable ranking was introduced.

In [9], those definitions where revisited, and the definition that QoC should be assessed by obtaining a final value of confidence between 0 and 100% atrributed to the evaluated information provided by a given context provider was established.

In [6], QoC is also linked to the idea of not only having descriptive information about the quality of context data, but also a single value, obtained from the values of the criteria, that allows the ranking of context providers by quality of sensed data information.

Based on this concept, papers such as [7] and [5] implemented their methods to calculate QoC values. These methods are presented in the next chapter.

3. Calculating QoC

3.1. CASSARAM Comparative Priority-based Weighted Index(CPWI)

In [7], a method for calculating QoC based on the distance between a point given by the user and the sensors in a given set is presented. The sensors are plotted as points in a multidimensional space, where each space represents one of the context criteria and is defined in the space $\{0 \cdots 1\} \in R$). The user defined point is also plotted in this space, with values defined according to need. These values may vary in importance, given different weights through an interface where one can adjust sliding bars that vary from "least important" to "most important" in a gradual manner. The weights are then obtained by comparison of slider positions, the most important being given maximum weight and the others being valued proportionally according to this maximum.

That information is then calculated using the Weighted Euclidean Distance formula of CPWI introduced in [7]. The version introduced in that paper presented an error, omitting the first subtraction of the corrected version presented here:

$$(CPWI) = 1 - \sqrt{\sum_{i=1}^{n} \left[W_i \left(U_i^d - S_i^\alpha \right)^2 \right]}$$

Where *Wi* is the weight assigned through the sliders for criterion *i*, U_i^d is the user-defined ideal value for criterion *i* and S_i^α is the value attributed to sensor α (α being any sensor in the complete set of evaluated sensors) for criterion *i*.

This method is interesting because it has the possibility of weighting the criteria in a fashion that doesn't distort the importance of the criteria considered. However, it has the disadvantage of considering the closest matches as the best possible sensors, while sensors that exceed the required level of quality may be ranked lower.

3.2. General Weighted QoC Value Assignment (GWQoC) Method

In [5], a very simple method for calculating QoC is presented, based on [6]. It is not named in the original article, but will be referred to as GWQoC in this article. In the particular case presented by the paper, where QoC was used to indicate the best healthcare sensors for patients, only a few criteria were used, but the method might be extended to consider as many criteria as desired. The generalized version would be as follows:

$$QoC = \frac{\sum_{i=0}^{n} (C_i * W_i)}{\sum_{i=0}^{n} W_i}$$

Where *Ci* is the quality value for criterion *i* and *Wi* is the assigned weight for criterion *i*.

This method is simpler than the one presented in [7], but might allow distortions in the final results because the criteria are evaluated in a manner that allows criteria with smaller weight to compensate for criteria with higher weight. On the other hand, this method ranks sensors that exceed required values for given criteria higher than the ones which are found to be closest matches, which is an advantage when compared to [7].

4. Open Challenges

While the main aspects of QoC are well defined, and there are different solutions to calculate QoC, some problems haven't been solved yet. For instance, most of the literature presents solutions that use a given set of criteria and defines the criteria, but without a mathematical definition on how to value criteria, thus being an unadressed challenge.

Another important matter in this direction is to evaluate which of the criteria found in the literature are really important, and which ones might be presented as different criteria, but would be revealed as being the same thing if further analyzed.

Also, while there are some ways of calculating QoC, such as the two presented in this paper, there are no studies comparing these methods. It would also be beneficial to find a new method that combines the strengths and removes the weaknesses found in approaches such as [7] and [5].

5. Conclusion

In this paper, some of the fundamentals and a short history of QoC have been presented in Section 2, showing the need for methods that calculate QoC in a precise way.

Two methods, CPWI and GWQoC were presented in Section 3, and their main strengths and weaknesses were shown.

In Section 4 some of the open challenges were presented and briefly discussed. Those challenges include the mathematical definition of how to value the criteria presented in the literature, the analysis of these criteria in order to define which ones are important and which aren't, as well as finding redundant criteria to eliminate, and the comparison of methods to calculate QoC values, as well as the creation of new methods combining the strengths and removing the weaknesses of existing methods.

References

[1] T. Buchholz et al. Quality of context: What it is and why we need it. 2003.

[2] G. Chen, D. Kotz, et al. A survey of context-aware mobile computing research. Technical report, Technical Report TR2000-381, Dept. of Computer Science, Dartmouth College, 2000.

[3] D. Evans. The internet of things how the next evolution of the internet is changing everything. Technical report, Cisco, 2011.

[4] Y. Kim and K. Lee. A quality measurement method of context information in ubiquitous environments. In *2006 International Conference on Hybrid Information Technology*, volume 2, pages 576–581. IEEE, 2006.

[5] D. C. Nazário et al. Cuida: um modelo de conhecimento de qualidade de contexto aplicado aos ambientes ubíquos internos em domicílios assistidos. 2015.

[6] K. Paridel, D. Preuveneers, Y. Berbers, et al. When efficiency matters: Towards quality of context-aware peers for adaptive communication in vanets. In *Intelligent Vehicles Symposium (IV), 2011 IEEE*, pages 1006–1012. IEEE, 2011.

[7] C. Perera, A. Zaslavsky, P. Christen, M. Compton, and D. Georgakopoulos. Context-aware sensor search, selection and ranking model for internet of things middleware. In *2013 IEEE 14th International Conference on Mobile Data Management*, volume 1, pages 314–322. IEEE, 2013.

[8] C. Perera, A. Zaslavsky, P. Christen, and D. Georgakopoulos. Context aware computing for the internet of things: A survey. *IEEE Communications Surveys & Tutorials*, 16(1):414–454, 2014.

[9] K. Sheikh, M. Wegdam, and M. Van Sinderen. Middleware support for quality of context in pervasive context-aware systems. In *Pervasive Computing and Communications Workshops, 2007. PerCom Workshops' 07. Fifth Annual IEEE International Conference on*, pages 461–466. IEEE, 2007.