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Quick Introduction to Quality of Context

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Agenda

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Introduction

In the last few years, the rising number of IoT devices began to motivate new works and research

It is estimated by Cisco that 50 billion IoT devices will be connected by 2020

Ranking and selecting adequate sensors from this huge number of devices is important for application developers

The concept of Quality of Context has evolved in order to tackle this problem

Quality of Context (QoC)

The idea of quality of information from context sensors has been discussed at least since the year 2000, as indicated by the paper "A survey of context-aware mobile computing research"(Chen et al. 2000)

The first time the concept was presented as QoC was in the paper "Quality of context: What it is and why we need it"(Buchholz et al. 2003)

This paper introduced ideas of how to describe quality of context information provided by sensors and which criteria to use in order to make this description

Quality of Context (QoC)

This description should comprise textual information about criteria such as precision, probability of correctness, trust-worthiness etc. that allows the evaluation of information provided by sensors

The paper also related Quality of Service(QoS) and Quality of Device(QoD) to QoC, showing their differences and the possible interdependence between them

Still according to Buchholz, context providers should make "agreements" with users according to QoC criteria

Quality of Context (QoC)

In the paper "A quality measurement method of context information in ubiquitous environments."(Kim et Al. 2006), a new criterion, "completeness", was introduced

This criterion should evaluate how many other criteria are part of the description

The paper also introduced the first mathematical approach to calculating values for each of the criteria in order to enable ranking

Quality of Context (QoC)

These definitions were revisited in "Middleware support for quality of context in pervasive context-aware systems"(Sheikh et al. 2007)

In this paper, it is stated that QoC for any given context provider should be assessed by obtaining a final value of confidence between 0 and 100%

Quality of Context (QoC)

In "When efficiency matters: Towards quality of context-aware peers for adaptive communication in vanets"(Paridel et al. 2011), it is stated that QoC should be evaluated and context providers ranked through a single value, obtained from the combined values of individual criteria

These ideas were the inspiration for the two methods to calculate QoC values that will be shown next in this presentation

Comparative Priority-based Weighted Index (CPWI)

Introduced in "Context-aware sensor search, selection and ranking model for Internet of things middleware"(Perera et al. 2013)

The method consists of plotting sensors as points in a multidimensional space, with each dimension representing a different context criterion.

An ideal sensor, with values informed by the user, is also plotted

The distances between this point and all others are calculated, and the closest points are ranked higher

Comparative Priority-based Weighted Index (CPWI)

Each of the criteria also has an assigned weight, informed by the user through slider bars in an interface, varying from "least important" to "most important"

The weight with the highest importance is assigned the highest value, and every other weight is then expressed as a fraction of this value, according to the position of their respective slider bar

The QoC value is then assigned by using the Weighted Euclidean Distance formula of CPWI

Comparative Priority-based Weighted Index (CPWI)

The original method presented on the paper had an error in the formula, presented in its corrected version here:

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

Where W_i 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.

Comparative Priority-based Weighted Index (CPWI)

This method is interesting because it allows the weighting of criteria in a fashion that doesn't distort the importance of the criteria considered.

It has, however, the disadvantage of considering closest matches as the best possible sensors, allowing sensors that exceed the required level of quality to be ranked lower than they should

General Weighted QoC Value Assignment (GWQoC)

Used in "Cuida: um modelo de conhecimento de qualidade de contexto aplicado aos ambientes ubíquos internos em domicílios assistidos"(Nazário et al. 2015), based on the work of Paridel et al. 2011

It is presented by Nazario et al. in a particular case where QoC values were used to indicate the best healthcare sensors for patients, using only a few criteria

General Weighted QoC Value Assignment (GWQoC)

This method however can be used for as many criteria as desired in its generalized version, presented here:

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

Where C_i is the quality value for criterion i and W_i is the assigned weight for criterion i

General Weighted QoC Value Assignment (GWQoC)

This method is simple and fast, since it's only the weighted average of criteria, and ranks higher sensors that exceed the required QoC value, but allows distortions in the final results because certain combinations of weights and obtained values for criteria might get a higher ranking than they should due to compensation. Example: $W_1=W_2=W_3=1$ and $C_1=0.4$, $C_2=0.9$ and $C_3=0.9$ for sensor 1 & $W_1=W_2=W_3=1$ and $C_1=C_2=C_3=0.7$ for sensor 2

QoC(sensor1)=2.2/3 = 0.7333
QoC(sensor2)=2.1/3 = 0.7

Sensor 1 gets a higher ranking than Sensor 2, but we can intuitively perceive that this relation doesn't seem right

Open Challenges

Giving mathematical definitions on how to value every criteria

Defining what criteria are essential for IoT

Finding and pointing out redundant criteria in the literature for QoC

Comparing methods for calculating QoC found in the literature

Implementing new methods that combine the strengths and remove the weaknesses found in the methods presented in the literature

Conclusions

Some of the fundamentals and a short history of QoC have been presented in the paper

Two methods, CPWI and GWQoC were presented, along with their strengths and weaknesses

Some open challenges in the area were presented as they were identified according to literature, and should motivate future work

Thank you!

Questions ???

My work

The idea is to try solutions for at least some of the open challenges presented, mainly the comparison of methods and the possible implementation of a new method or the improvement of current methods

Some approaches were studied and tried, mainly the use of Supplier Selection algorithms found on the field of Economics and methods used for selecting Webservice providers

Those approaches, however, were shown to not be adequate for IoT due to scalability problems

Validation for algorithms should be relatively easy to do compared to validation for other aspects (such as mathematical definitions for context criteria)

The End

Next Presentation