2023 IEEE International Conference on Pervasive Computing and Communications Workshops and other Affiliated Events (PerCom Workshops): Demos

2023 IEEE International Conference on Pervasive Computing and Communications Workshops and other Affiliated Events (PerCom Workshops) | 978-1-6654-5381-3/23/$31.00 ©2023 IEEE | DOI: 10.1109/PERCOMWORKSHOPS56833.2023.10150387

Towards Deploying Advanced Context Provisioning for Surf Life Saving Use Case

Kanaka Sai Jagarlamudi, Arkady Zaslavsky, Kevin Lee
School of Information Technology
Deakin University
Geelong, Australia
{kjagarlamudi, arkady.zaslavsky, kevin.lee}@deakin.edu.au

***Abstract*—This paper presents Context Cost and Quality computational engine (ConCQeng), a system to enhance situational awareness in context-aware pervasive computing applications (CaPCAs) through effective context provisioning. ConCQeng selects the sources that deliver a quality-adequate and cost-efficient context in the data flows from stakeholders, assets and an array of sensors, using novel quality and cost-aware selection approaches. It further measures retrieved contexts' quality metrics for compliance and assigns a reasonable cost. We demonstrate the application of conCQeng to conduct effective search and rescue operations in surf life saving using a web application. Our demonstration proves that conCQeng exhibits a compelling performance in environments with distributed and diverse context sources.**

***Index Terms*—Quality of Context, Cost of Context**

I. Introduction

Context-aware pervasive computing applications (CaPCAs) deliver subscribed services to end-users; based on contextual information (or) context – represents the situations (e.g., crowd density, temperature) in the real-world entities (e.g., location or object) [1]. For example, applications like google maps add value to the end-users by providing ideal travel routes; through analysis of the context provided by smartphones.

CaPCAs can augment the services by collecting context from third-party context providers (services providing context) [2]. The context management platforms (CMPs) act as a bridge between the CaPCAs and such providers. For instance, a digital marketplace contains a list of diverse context providers; the CMPs provide CaPCAs with access to such a broad context range – removing the overhead of service discovery. Therefore, incorporating CaPCAs to enhance the surf life saving services (service that detects and responds to emergencies involving beachgoers) and powering them with CMPs contributes to effective search and rescue operations.

The CMPs may sometimes discover multiple context providers that deliver the required context. For instance, image-processing of visual streams from surveillance cameras and smartphone location data could relay the context that supports the crowd analysis on a beach. Nevertheless, the cost [3] and quality [4] of context (QoC and CoC, in short) – describing the contexts' retrieval cost and its usefulness to CaPCAs – may vary dramatically between these providers. Such a variance occurs due to sensing device cost and performance, network resources, weather conditions and demand. Therefore, we have introduced ConCQeng ("Context Cost and Quality computation engine") in [3]. ConCQeng enables CMPs with quality and cost-awareness in their context provider selection mechanisms to obtain QoC adequate and CoC-efficient context. It also measures the retrieved contexts' QoC metrics to ensure compliance with the CaPCAs' QoC requirements and assigns the context with a reasonable CoC.

This paper demonstrates that ConCQeng delivers QoC and CoC-effective context to CaPCAs used for search and rescue operations in surf life saving. The demonstration process includes simulating context-aware environments to handle life-threatening scenarios (e.g., drowning, overcrowding) using a web application. We then visualise ConCQeng's performance in obtaining QoC and CoC-effective context from the involved context providers, which are live and augmented context sources. The context resembles the crucial data for search and rescue in the surf life saving: weather, crowd density, responder position, and asset location.

II. Context-Aware Surf Life Saving Scenario

Surf Life Saving Australia is an organisation that handles emergencies involving beachgoers. It relies on personnel conducting surveillance and reporting via mobile and text-based communications [5]. This approach often leads to human errors when operators are fatigued or experiencing harsh weather conditions. So, this paper investigates how the CaPCAs in surf life saving can access context from multiple context providers, improving coordination and incident response.

As Fig. 1 illustrates, intelligent mobile and connected devices, such as smartwatches, can signal that a person is in danger. The video and thermal-imaging-based surveillance cameras in various locations (on-shore, underwater, and in surveillance vehicles) can target additional information, such as sharks or drownings - humans may not detect them. Furthermore, life savers can perform an effective resource deployment using location-wise crowd counting from smartphones or surveillance footage. Nevertheless, there will be instances where multiple devices provide similar context with varying CoC and QoC. For instance, a shark attack can be detected using GPS information from a diver or video feed from an Unmanned Aerial Vehicle (UAV). The video camera's accuracy could degrade due to obstacles; location data could be imprecise due to network issues. Moreover, the cameras' initial

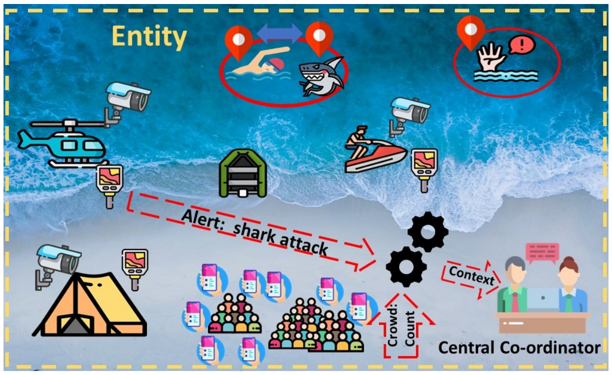

Fig. 1. Context-aware surf life saving system: shark attacks and drownings as context; mobile crowd sensing and surveillance cameras as context providers; a context Management Platform, indicated using gear icon, moderating the context.

context costs could be higher than other sources. Therefore, conCQeng can be used to determine the most optimal provider consistently; its context should ultimately reduce ambiguity and enhance surf life savers' confidence in relayed situations.

III. Related Work

Klein conducted studies highlighting emergency workers relying on contextual information improves their decision-making [6]; Manzoor reported that rescue workers planned effective rescue strategies for prescribed sites during floods (context) [7]. Hence, deploying a CaPCA-based system for surf life saving [5] leads to enhanced surveillance.

Using the QoC-aware selection models that rely on context providers' design time features [7], reputation among CaPCAs [8], and context filtering models [9] leads to QoC shortcomings and cost inefficiencies in the CMPs [10]. Work on CoC-aware selection is still evolving.

IV. Overview of ConCQeng

Fig. 2 depicts ConCQeng's architecture and internal and external data flow: Step 1 accepts the context request(s); step 2 selects a set of context providers (CPs) that offer an adequate QoC for each context request. Algorithms assess the QoC adequacy rates based on the providers' historical performance. In steps 3 and 4, the CoC-aware selection processor sorts these providers in their cost-efficiency order, stores them in a cache, and invokes the most optimal provider. It assesses cost-efficiencies through a Multi-Criteria Decision Making (MCDM) based approach, using providers' QoC guarantees, cost and QoC violation penalties; these details are found in providers' SLAs (stored in the repository).

In step 5, the QoC measurement and validation unit receives the invoked provider's SLA and in step 6, the context and metadata (or parameters) for the QoC metric measurement [3]. It computes QoC metrics and verifies their compliance with the context request, and returns to step 3 if it receives an invalid context. Next, ConCQeng uses these metrics to update the context provider's QoC adequacy rate (used for selection).

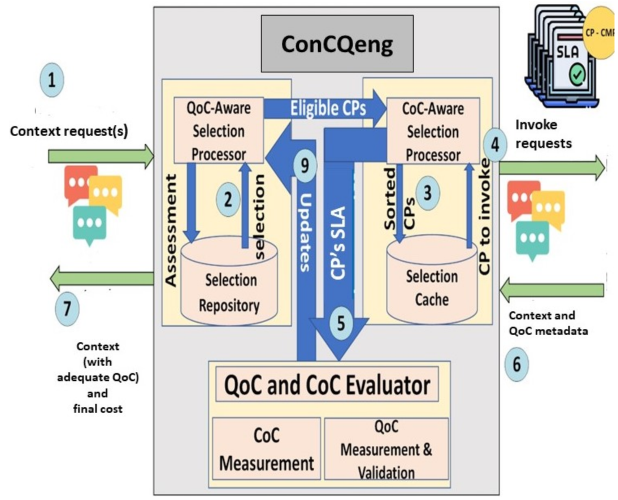

Fig. 2. ConCQeng's architecture and its internal and external data flow.

Finally, using these metrics, cost and quality violation penalties, conCQeng assesses the context's final CoC and delivers them to the CMP in step 7.

V. Demo Setup, Implementation and Outcomes

Fig. 3 depicts our demo setup and the data flow involved. The setup consists of context providers, instances of conCQeng and CoaaS [2] (a CMP) running on the Google Cloud Platform, and a web application (UI).

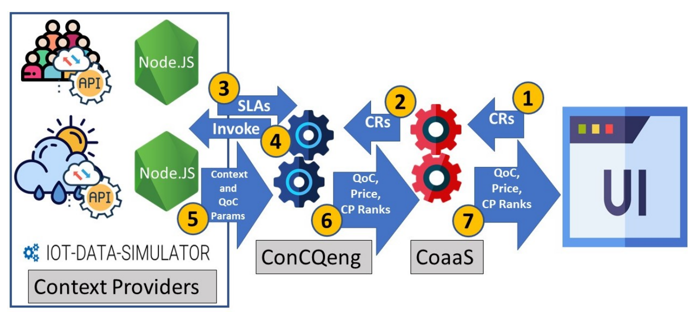

Fig. 3. The implementation setup: the components used and the process order between them.

In Steps 1 and 2, the context requests (CRs) with individual QoC requirements are submitted through the web application (UI) to the CoaaS, which forwards them to the conCQeng via a rest API. The context providers (data servers) provide context related to crowd density [11] and weather [12] – obtained from live APIs; detected emergencies – extracted from image processing from the surveillance images in surf life saving. Fig. 4 provides the capabilities of the current surveillance infrastructure, where objects such as lifejackets are detected. Similarly, the context related to emergencies such as shark attacks is detected. Furthermore, an IoT data simulator [13] presents other location information: related to emergency responders and crowd density. All context providers mentioned above are predefined in conCQeng by their SLAS (containing context, QoC and QoC guarantees) (as Step 3).

Fig. 4. ML algorithm extracting the context - implying that objects are wearing a life-jacket.

The conCQeng invokes potential provider(s) in step 4. It then captures the QoC parameters (e.g., time-stamp, delta) upon receiving the context in step 5 and uses this information to measure the QoC metrics. This demonstration focuses on three QoC metrics: timeliness, completeness, and representation. They describe the context's compliance for time, acquisition of requested attributes, data type and format. ConCQeng then measures the CoC and delivers them to CoaaS in step 6. Finally, this Context, QoC and CoC measures and IDs of the top-4 performers are displayed on the web application (as depicted in Fig. 5) in step 7.

The outcomes demonstrate that the ConCQeng effectively ensures QoC adequacy and cost-efficiency: upon obtaining non-compiling QoC, conCQeng adapts to re-select alternative providers to maintain optimal QoC and CoC. Fig. 5 depicts the dashboard provided to users to analyse ConCQeng's performance. It contains the obtained QoC metrics, context Price (CoC) (both initial and the final prices with penalties), percentage of applied penalties for each metric and other top-performing providers. Using the menu on the left-hand side, users can change the QoC in incoming streams – to test the conCQeng's performance. We further plan to deploy this as a general Web application to enable developers to test their applications in the conCQeng. The increment will allow users to create profiles, alternate views and access their historical context requests, providers and outcomes.

VI. Conclusion

We presented a demonstration report on conCQeng - a system obtaining QoC and CoC-effective context to the CMPs. Although we described the significance of this system in surf life saving, it possesses generic applicability across various domains. Our demonstration and outcome visualisation occurs on a web application, acting as a proof-of-concept to use conCQeng for an effective context acquisition.

Acknowledgment

We thank *Dr. Jeffrey Tweedale* from *Defence Science and Technology Group, Australia* for their valuable contributions to this paper.

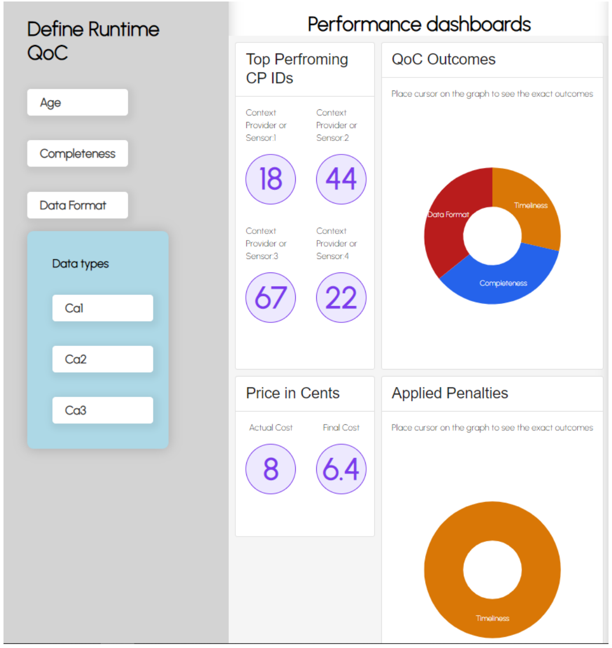

Fig. 5. A screenshot of the Web application; a few performance indicators and menu to modify the QoC outcomes in a context responses.

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