The An Binh Nguyen, Christian Meurisch, Stefan Niemczyk, Christian Klos, Doreen Bohnstedt, Ralf Steinmetz. *Facilitating Volunteer Computing Resources for In-Network Processing through Message Template*. In Proc. International Conference on Networked Systems (NetSyS), p.1 - 2, IEEE 2017. ISBN 978-1-5090-4394-1

Facilitating Volunteer Computing Resources for In-Network Processing through Message Template

The An Binh Nguyen*, Christian Meurisch†, Stefan Niemczyk‡, Christian Klos*, Doreen Böhnstedt*, Ralf Steinmetz*
*Multimedia Communications Lab, TU Darmstadt, Rundeturmstr. 10, 64283 Darmstadt, Germany
Email: {the.an.binh.nguyen,doreen.boehnstedt,ralf.steinmetz}@kom.tu-darmstadt.de, christianklos@gmx.net
†Telecooperation Lab, TU Darmstadt, Hochschulstr. 10, 64289 Darmstadt, Germany
Email: meurisch@tk.tu-darmstadt.de
‡Distributed Systems, University of Kassel, Wilhelmshöher Allee 73, 34121 Kassel, Germany
Email: sni@vs.uni-kassel.de

***Abstract*—Crowd sensing is an emerging paradigm that utilizes the power of the smart devices within the crowd to collect information. In general, the collected information is aggregated in a cloud server for further analysis. Such centralized analysis model can be at disadvantage in several cases. For instance, in emergency response, where the communication infrastructure is unstable while the results of data analyses are critical for timely relief operations. To cope with this situation, the volunteered processing capabilities of the devices within the crowd can be exploited for data analysis directly in the network. However, exploiting volunteered mobile resources in a decentralized unstable network without coordinated entities is still challenging. For this purpose, we propose an encapsulated message template designed to support in-network data analysis for decentralized ad-hoc network. The demonstration shown in this work showcases the exploitation of volunteered crowd resources to carry out data analysis using our proposed message template.**

I. Introduction

Nowadays, mobile devices possess many capabilities like networking through various interfaces (e.g., WiFi, Bluetooth), sensing through many built-in sensors (e.g., sound, camera), and computation through modern hardware. With the proliferation of the mobile devices, these capabilities can be volunteered and shared within a crowd, which can be exploited for many scenarios. For instance, in emergency response: the mobile devices can be used to form an ad-hoc communication platform to replace the collapsed communication infrastructure, the sensors available in the devices can be exploited to collect situation information (termed *crowd sensing*), and their idle resources provide a powerful distributed computing platform to process the collected information [1]. Altogether, communication, sensing and computation capabilities of mobile devices can be combined to realize a complete data analysis workflow directly in the network.

To enable this cooperation of devices, coordination mechanisms and a common message format are required. However, existing crowd coordination approaches like [2] and data formats such as SOAP, BPEL and WSFL, which can support such service workflow in the context of web services [3], partly rely on a cloud server and, thus, are not suitable for the above mentioned decentralized ad-hoc scenario.

II. Task oriented Message Template

In [4], we have developed an adaptive task-oriented message template (ATMT) to overcome existing cooperation issues in decentralized ad-hoc networks and facilitate the utilization of heterogeneous resources and capabilities hidden within the crowd for in-network data analysis. The message template is designed specifically to enhance autonomous decision of the devices, which is to cope with the instability caused by decentralized mobile ad hoc network and the lack of centralized coordination entity such as in emergency response scenario. Due to this reason, the message is designed to be self-encapsulated, which contains both metadata required to describe the analysis task as well as the belonging payload.

Figure 1 illustrates the structure of our message template. The self-encapsulation and hierarchical structure properties of this message template bring several benefits. Each node in the network, that receives the message, is able to decide what to do based on the information available in the analysis metadata header. Therefore, no coordination entity or control synchronization mechanism is required. The analysis metadata contains a tree of operations that represent the order in which the operations need to be executed to accomplish the goal of the analysis task. The data required for each operation and the resulting analyzed data are separately compressed and stored in the payload part. Separating the analysis metadata and the analysis payload is useful to check for the status of the ongoing analysis. A device reading the metadata analysis can learn which operations it can execute and how many operations have been already processed, all without having to extract the real content of the analysis data. Additionally, the message template library developed according to our design also allows the message to be modified on the fly. As a result, after executing an operation, a device can replace the raw data in the payload by the analysis results - but only if no other operation requires this raw data - in order to reduce network traffic.

All in all, the novelty of our proposed adaptive task-oriented message template is the self-encapsulated, hierarchical structure, that is designed to facilitate cooperation of the devices in an autonomous decentralized ad-hoc network.

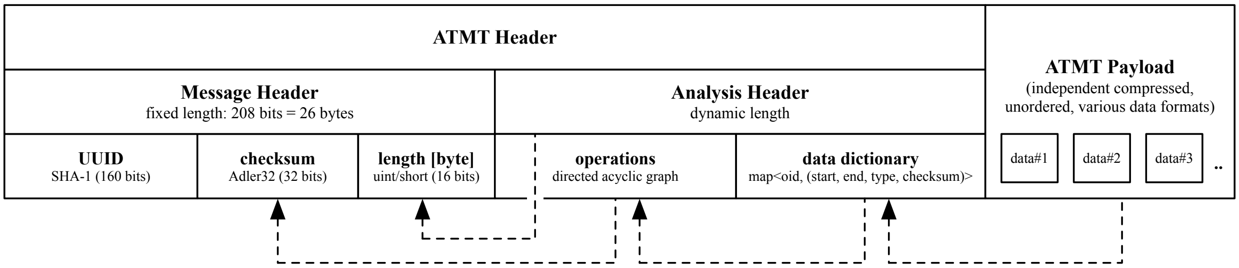

Fig. 1: Structure of the adaptive task-oriented message template (ATMT) for in-network data analysis [4]

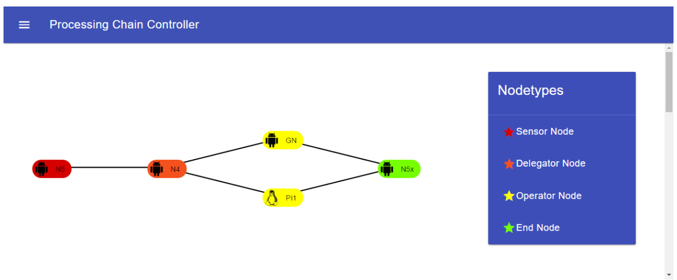

Fig. 2: Network topology controller for modifying the scenario

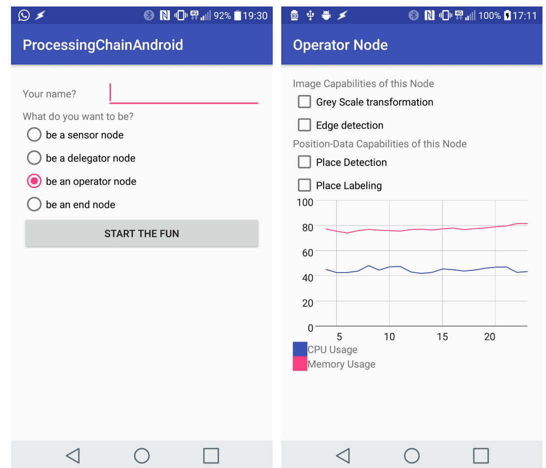

Fig. 3: Opt-in operations on an Android mobile device

III. Demonstration Description

In the demonstration, we will show a fictive in-network data analysis chain implemented using our developed message template. The demonstration comprises several Android based devices and a laptop to configure the topology of the network. A predefined data analysis processing chain containing multiple operations will be distributed into the network through a gateway device. In emergency response scenario, such device can belong to the authorities, who want to exploit the crowd to assess the current situation; thus, the authorities are aware of the operations required for the analysis and can describe them in the task message template. Without central coordination entity, the devices will cooperate based on the current information available in the metadata header of the message to execute the processing chain. The following interactions will be expected by the participants:

- With the user interface provided by the laptop as the topology controller (shown in Figure 2), the users can configure the network topology of the devices.
- The user interface on the Android devices allow the user to opt-in the processing operations that the users want to offer as a service. In the particular setup, two operations for image processing and two operations for location data processing are pre-installed on all the demo devices (shown in Figure 3). According to the configured topology and opt-in operations on the devices, the processing chain will be executed differently.
- The current status of the executed operations will be shown on the respective running devices.

The demonstration setup as described above is able to show the benefit of our designed message template. First, the heterogeneous and idle resources of the devices are utilized; this is demonstrated through the fact that a task will be divided in several operations as a processing chain, which will be collaboratively executed by the devices in the network. Second, the autonomous behavior of the devices without centralized coordination entity is demonstrated by letting the participants configure the topology of the network and the opt-in operations on the devices; the operations are executed by the devices solely based on the available information from analysis metadata header and the provided opt-in operations.

Acknowledgment

This work has been co-funded by the LOEWE initiative (Hessen, Germany) within the NICER project and by the German Federal Ministry of Education and Research (BMBF) Software Campus project ”OppEPM” [01IS12054].

References

[1] C. Tapparello, C. F. B. Karaoglu, H. Ba, S. Hijazi, J. Shi, A. Aquino, and W. Heinzelman, “Volunteer Computing on Mobile Devices: State of the Art and Future,” *Enabling Real-Time Mobile Cloud Computing through Emerging Technologies*, pp. 153–181, 2015.

[2] M.-R. Ra, B. Liu, T. F. La Porta, and R. Govindan, “Medusa: A Programming Framework for Crowd-Sensing Applications,” in *MobiSys'12*. ACM, 2012, pp. 337–350.

[3] Q. Z. Sheng, X. Qiao, A. V. Vasilakos, C. Szabo, S. Bourne, and X. Xu, “Web Services Composition: A Decade's Overview,” *Information Sciences*, vol. 280, pp. 218–238, 2014.

[4] T. A. B. Nguyen, C. Meurisch, S. Niemczyk, D. Böhnstedt, K. Geihs, M. Mühlhäuser, and R. Steinmetz, “Adaptive Task-oriented Message Template for In-Network Processing,” in *NetSys'17*. IEEE, 2017.