Exploring Transitions in Mobile Network Monitoring in Highly Dynamic Environments

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***Abstract*—In recent years, the point of view in network research has changed. Instead of providing so called *one-fits-all* solutions which by design have limited applicability when conditions are changing, research is pursuing the concept of adaptations and transitions. In doing so, solutions that perform best-in-class under specific conditions are used exactly when those conditions occur, leading to superior performance. The benefit of transitions has been evaluated for use cases such as video streaming, mobile social gaming, and monitoring. However, to really understand the potential of transitions, this paper introduces an interactive, simulation-based demonstration highlighting the use of transitions on the example of a state-of-the-art monitoring system. Users can interact with the demonstration to understand (i) the use of transitions and (ii) how a system can use transitions to provide for wide applicability with better performance under various conditions.**

I. Introduction

With fluctuating environment and network conditions, the use of *transitions* to adapt on all kind of conditions gains in importance. While specialized solutions are limited in their applicability [1], transition-enabled systems can provide better performance when conditions change and require the adaptation to the changing conditions. In recent years, transitions found application in multiple use cases, ranging from video streaming [2], mobile social gaming [3], and network monitoring [4], [5]. Network monitoring should be, due to its role as a low-overhead background service, mostly unnoticed by network users. However, if monitoring systems fail to guarantee for an accurate network and environmental state any decision to execute transitions may be based on imperfect information leading to quality and performance degradations in the network. Especially for adaptation to changing conditions, thus for the planning and execution of transitions, accurate network and environmental state information is critical.

In this paper, we present a simulation-based demonstration that highlights the potential of the transition-enabled monitoring system CRATER [4] for highly dynamic mobile networks in an urban area. Depending on the current network and environment conditions, CRATER executes transitions between different monitoring data-collection mechanisms. This includes the active communication means and local interaction of mobile users to enable offloading of data in case of situations in which the network infrastructure becomes or may be or already is overloaded. Thereby, CRATER is able to provide for constant high performance irrespective of the conditions in the network.

The demonstration allows users to interact with the system by changing environmental conditions and enabling or disabling the potential of CRATER to execute transitions. That allows attendees to understand the concept and the usage of transitions in services such as network monitoring. Especially by changing the environment – live by interaction with the demo – users are able to force the system into extreme conditions and explore the potential of transitions under changing network conditions.

The paper is structured as follows. An overview of the transition-enabled monitoring system CRATER is provided in Section II. Section III describes the scenario and the setup of the demonstration, including the user scenario. It also includes an explanation of the possible ways attendees can interact with the demonstration. Section IV concludes this paper.

II. Transitions in Mobile Network Monitoring

Current monitoring mechanisms [1], [6], [7] for mobile networks do perform well under certain conditions. However, with the observed high dynamics in mobile networks [8], the applicability of those mechanisms is strictly limited. In recent years, the idea of adaptivity has emerged, whereas the concept of transitions between mechanisms has proven to significantly enhance both flexibility and performance under fluctuating conditions in various application domains [2], [3]. By executing transitions between mechanisms depending on the current network conditions systems can experience significant performance gains.

The applicability of transitions to bypass the limitations of individual mechanism in network monitoring is showcased in this demonstration on the example of the transition-enabled monitoring system CRATER [4], [5]. The demonstration is relying on the SIMONSTRATOR platform [9].

CRATER embodies a first of its kind transition-enabled monitoring system for mobile environments. The system is able to collect information on the current state of the network and is designed as a self-contained service to be robust against failure of other mechanisms. CRATER provides accurate estimates of the overall state by adapting to environmental changes. By executing transition between different collection schemes

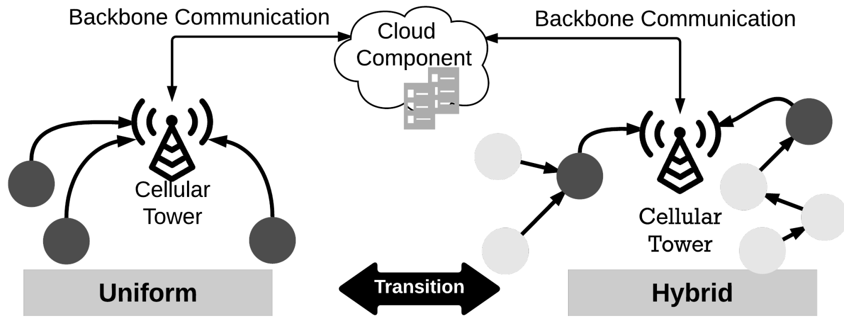

Fig. 1: Collection schemes of the transition-enabled monitoring system CRATER.

CRATER can handle a wide range of environmental conditions. The network state is collected at a central cloud component. It receives the measures from local nodes according to the individual sets of required monitoring attributes.

Depending on the environmental conditions, mobile nodes are assigned two distinct roles by a centralized role allocation mechanism: the *sink* and the *leaf* role [5]. Sinks directly upload monitoring information using the cellular connection to the cloud component. Leaves do not use their own cellular communication interface to upload information. Instead, they affiliate to adjacent sinks using local ad hoc connectivity, e.g., Bluetooth or Wi-Fi Direct. In overload situations, e.g. due to a high number of cellular connections, CRATER executes a transition from a *uniform* to a *hybrid* collection scheme and vice-versa once the conditions relax (cf. Figure 1).

In the uniform collection scheme, all nodes directly upload their monitoring information, operating as sinks. In the hybrid collection scheme a fraction of the nodes is assigned with the sink role, while all other nodes remain leaves (cf. Figure 1). Sinks still use their cellular link to the cloud component, while leaves drop their cellular connection to free additional capacities in the cellular network. Consequently, each leaf chooses a sink in their proximity that relays their monitoring data to the cloud component. If necessary, leaves also forward the data from other leaves to the respective sink. To do so CRATER consists of mechanisms for (i) hybrid topology maintenance and (ii) routing and forwarding information between leaves and sinks. The maintenance is split into the No-Sink Advertising and the Sink Advertising. The routing and forwarding of monitoring data is based on bio-inspired routing that is combined with overhead and collision reducing techniques such as the usage of hesitation times and aggregation. For space reasons, we encourage the interested reader to take a look into [4], [5].

III. DEMONSTRATION SCENARIO AND SETUP

a) Demonstration Scenario: This demonstration allows users to explore the benefit of transitions in today's networks on the example of mobile network monitoring. Especially under fluctuating environmental conditions the concept of transitions shows its advantage over state-of-the-art approaches. The demonstration scenario models the downtown area of Darmstadt based on OpenStreetMap data[1]. Such areas are typically subject to high dynamics regarding the user movement and density as well as the observed cellular connectivity. The dynamics concerning the density is represented by users joining and leaving at different points in time by, e.g., switching either their mobile phones on or off or the respective communication interfaces or by leaving the area. People walk along paths and streets, obstacles like houses are taken into account. Mobile users are equipped with communication devices, such as mobile phones or tablets, having communication interfaces for ad-hoc communication via Wi-Fi and for cellular communication. Part of the scenario are public places, such as restaurants or parks. These public places emit a certain degree of attraction to the mobile users. Depending on the intensity of the attraction the public places are more or less crowded.

The demonstration is shown in the explained scenario. Users interact with the demonstration by changing environmental parameters such as the node density and the capacity of the cellular network. The demonstration allows attendees to enable or disable the ability of CRATER to execute transitions. When changing the environmental conditions, CRATER shows that by using transitions the system is able to allow for constantly high performance, where traditional monitoring systems experience performance degradations, which can be seen when the ability to perform transitions is disabled. Performance is measured using the completeness metric of the monitoring system [4]. Furthermore, system-related information such as the communication range of nodes or the respective chosen sink to relay monitoring data from leaves to understand the system in more detail can be visualized.

b) Demonstration Setup: The user interface of the demonstration consists of three main panels, as visible in Figure 2: (i) the world panel, (ii) the statistics panel and (ii) the interaction panel. The world and statistics panel show (i) the underlying map integrated in the simulation including the mobile users, (ii) any enabled additional information about CRATER, and (iii) the statistics of the environment and the monitoring system CRATER. Users can continuously interact with the demonstration using the touch-based interaction panel, as visible on the right side of Figure 2. By (i) changing the node density (churn peak and join time) and (ii) the

[1] http://www.openstreetmap.org/

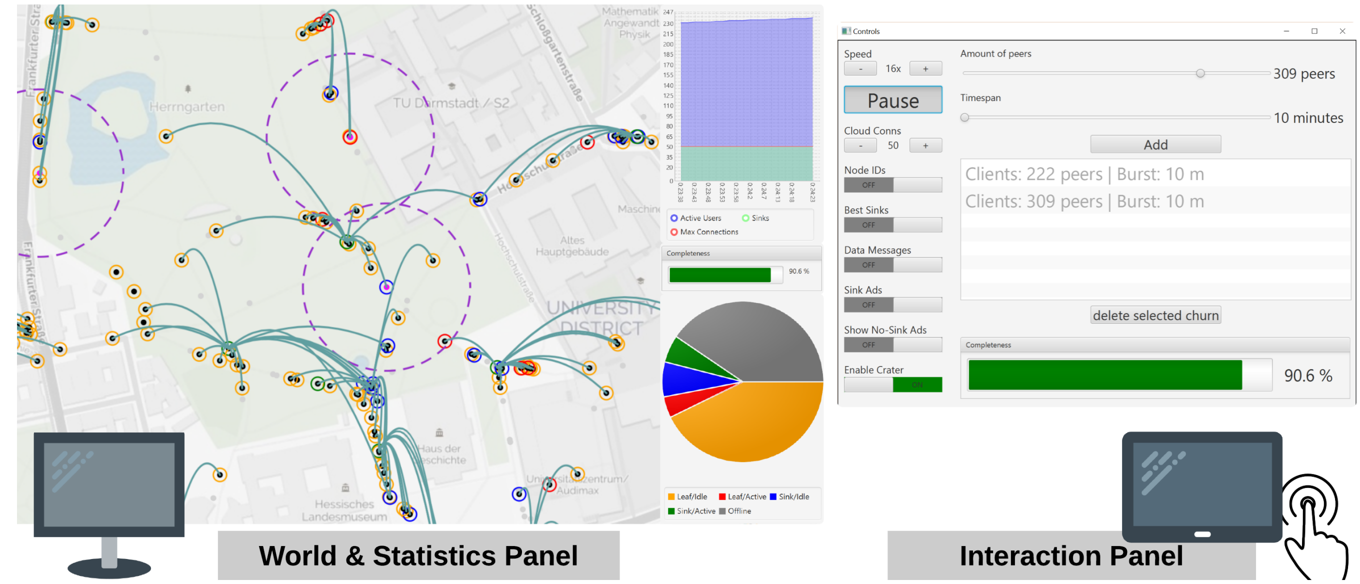

Fig. 2: Setup of the demonstration: World and statistics panel for detailed examination of the system and the transitions made. The interaction panel allowing attendees to actively interact with the demonstration by for example changing the node density.

capacity of the cellular network, the environmental conditions are varied. Furthermore, as explained before, the attendee is able to show or hide different system-related information such as the respective sinks chosen by leaves to relay their monitoring data to or the different messages used within CRATER for topology maintenance or the routing of information. The ability of CRATER to execute transitions between the different data collection mechanisms can also be disabled, resulting in a monitoring system that is limited regarding its adaptivity to changes of environmental conditions. While interacting with the demonstration, attendees are encouraged to use the interaction panel to explore the impact of environment and network changes on both transition-enabled and traditional, non-adaptive systems. Attendees are able to explore the factors and situations that require transitions in the presented system.

Requirements for the Demonstration

The equipment used in the demonstration comprises one laptop and a computer monitor. The laptop runs the simulation used in the demonstration and shows the interaction panel with which attendees can interact with the demonstration. The additional computer monitor shows the world and statistics panel providing the user great detail to explore the potential of transitions in the herein presented monitoring system CRATER. We would kindly ask the conference organizers to provide us a computer monitor (e.g. 22-24") and two power outlets for the demonstration. Demonstration set up will need 15 minutes.

IV. CONCLUSIONS

Most mechanisms in (mobile) networks pursue a specific goal, which is their strength on the one hand, however the applicability of those mechanisms is mostly reduced to a limited scenario on the other hand. The concept of transitions understands the specific strength of a mechanism not as a restriction. Instead, it exploits the superior performance of those mechanisms as a chance to use specific mechanisms in the respective scenarios and change between mechanisms if the conditions require it. The demonstration, presented in this paper allows users to interactively explore the potential of transitions within the use case of an adaptive monitoring system, called CRATER [4]. By changing network and system conditions, users experience the usability of transitions and factors requiring the former live during the demonstration.

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