

Impact of Public Protests on Mobile Networks

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Abstract—We propose an analytical framework based on a simple metric and capable of analyzing mobile network data so as to identify changes in consumption patterns across antennas due to the occurrence of massive public protests. We collect data from an operational network in France and analyze how it was impacted by the 2023 French pension reform strikes. We are able to identify a number of antennas that were clearly affected by the strike, and to follow the corresponding events in the mobile traffic demand as it propagates in space and time along the designated route followed by the marchers. The proposed framework is a stepping stone for more robust classification models on the impacts of massive protests on mobile networks, paving the road to network-based solutions for a pervasive and cost-effective monitoring of such events.

I. INTRODUCTION

Thanks to the ever-increasing success of mobile communications, network operators can gather massive amounts of data generated by their user populations every day. Given today's pervasive diffusion of smartphones, such data can provide in-depth insights about human behavior, land usage and events occurrence. In recent years, this has spurred the development of solutions that leverage mobile network data to understand and monitor human behaviors and activities [1], [2].

This poster paper is an initial step in creating a framework to identify events in mobile traffic that can be linked to massive agglomerations of people, by studying the impacts of the French pension reform strikes of 2023 on the user demand. A total of 14 strikes happened between January and June 2023, and here we focus on the one that happened on May 1st in Paris, which coincided with the International Workers' Day and recorded one of the biggest participations, with estimates ranging from 112,000 to 550,000 attendees [3]. This strike in Paris started at 14:00 in Place de la République and ended at 19:00 around Place de la Nation.

We propose a simple metric that is only based on mobile traffic consumption and allows identifying when and where the protest occurred, by automatically flagging antennas with abnormal events in their traffic patterns. This metric will be the basis for more complex solutions that we aim at developing in order to determine the overall impact of such manifestations across the nationwide network.

II. DATA COLLECTION AND PREPARATION

This study builds on measurements at the production mobile network of Orange in the metropolitan territory of France, spanning from January 31st to May 31st of 2023. We collect data about the 4G and 5G traffic generated by users through passive measurement probes monitoring the interface connecting Gateway GPRS Support Nodes (GGSNs) and Packet

Data Network Gateway (PGWs) to external Public Data Networks (PDNs). All users' sessions were associated to antennas through signaling data of the 4G Mobility Management Entity (MME), which allows referencing the location where traffic was generated; monitoring the MME is sufficient as the target 5G deployment is non-standalone (NSA). User sessions are processed in the secure premises of the operator, and aggregated per antenna and into 5-minute bins to ensure the privacy of data subjects and comply with applicable regulations.

In order to identify events in traffic caused by the protests, we establish a baseline period where traffic consumption was deemed *normal*. Since the majority of pension reform strikes in France occurred during work days, we construct a *median baseline day* from weeks where no major strikes were registered. For each antenna, we calculated the median day across 6 work days from two base weeks, namely, February 28th, March 1st and 2nd, and April 25th, 26th and 27th.

III. IMPACT OF PUBLIC PROTESTS ON MOBILE TRAFFIC

A. Flagging antennas affected by the protest

In order to reduce the search space, we perform an initial triage by selecting antennas that are within 1 km to the route of the protests [4]. Considering only this set of nearby antennas, we want to single out those clearly affected by participants in the protest. For this, we compare the traffic recorded at each antenna during the day of the selected protest with the corresponding baseline median day, and look for changes in traffic volume and patterns of mobile traffic consumption.

To make comparisons fair, we first normalize the traffic. Here, we cannot perform a volume (*e.g.*, min-max) standardization because this puts emphasis solely on changes of volume that may lead to an incorrect flagging of an antenna: for instance, one antenna may yield a higher demand during the protest day than in the baseline, and yet have aligned peaks of usage, meaning that the observed behavior is semantically the same and most likely not affected by the protest (which is limited to a few specific hours). Instead, we opt for a z-score standardization that avoids volume bias and allows for a direct comparison of the traffic dynamics. In each 5-minute interval t , let us denote by $T_p(t)$ the traffic observed during the protest day and by $T_b(t)$ that computed for the baseline; let μ_p and σ_p be the mean and standard deviation of the protest day traffic values, and μ_b σ_b their equivalents for the baseline. The standardized traffic is then computed as $\bar{T}_p(t) = (T_p(t) - \mu_p) / \sigma_p$ and $\bar{T}_b(t) = (T_b(t) - \mu_b) / \sigma_b$, respectively. Finally, we calculate a metric $M(t) = (\bar{T}_p(t) - \sigma_p) - (\bar{T}_b(t) + \sigma_b)$, and associate values of $M(t) > 0$ to significant pattern deviations at time t due to protesters roaming within coverage of the antenna.

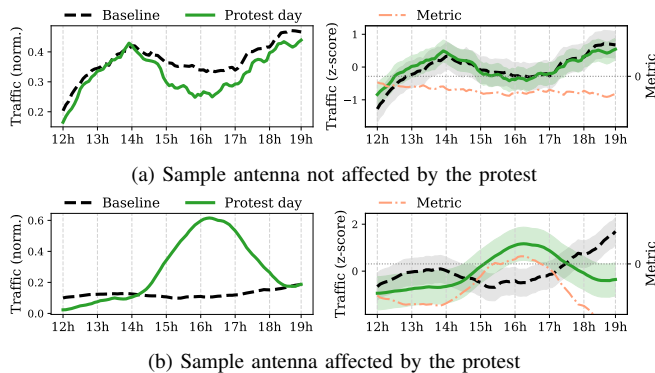


Fig. 1: Examples on antennas that are (a) not affected and (b) affected by the protest, as detected by our proposed metric.

For the sake of clarity, we provide two visual examples. Figure 1a represents the traffic of an antenna that is located nearby the protest route where T_p (green) and T_b (black) have similar min-max normalized volumes (left) and z-score standardized patterns \bar{T}_p and \bar{T}_b (right). This results in a metric $M(t)$ that is never greater than zero, which implies that the demand peaks (at around 14:00 and 18:00) are aligned for the baseline and the protest day, and that the antenna traffic is not affected by the march. On the opposite hand, Figure 1b shows a flagged antenna with clear changes in volume and behavior. We specifically note that this antenna experiences an uncommon surge of traffic volume (left) in the afternoon, whereas levels look normal until 14:00 and after 18:00, indicating that the demand is changed by the protest. The standardized \bar{T}_p and \bar{T}_b (right) provide a more accurate flagging of the exact period during which the antenna traffic is strongly affected by the presence of protest marchers, with $M(t) > 0$ between 15:30 and 17:00 approximately.

B. Spatiotemporal tracking of the protest

After flagging all antennas affected by the protest and the specific time intervals of incidence of the event at each such antenna, we can use such information to model how the march moved through the city. More precisely, we order the affected antennas based on the time at which their traffic is found to be impacted by the event, and then analyze the spatiotemporal evolution of the phenomenon. We select the flagged antennas on May 1st to visualize the progress of the protest over time through its impact on mobile traffic consumption, as highlighted on Figure 2a. There, antennas are ranked according to the mean time of the interval during which the standardized traffic demand is found to vary, *i.e.*, $M(t) > 0$: yellow highlights antennas affected first, while purple represents the ones affected last. The figure clearly highlights the traffic surge due to the substantial and anomalous demand generated by the mobile phones of the protesters, as well as its dynamic nature over space and time. The impact of the event on the cellular network can be noted starting at around 13:00, before the 14:00 official start time and possibly due to people gathering at the origin location of the protest; the effects of the march

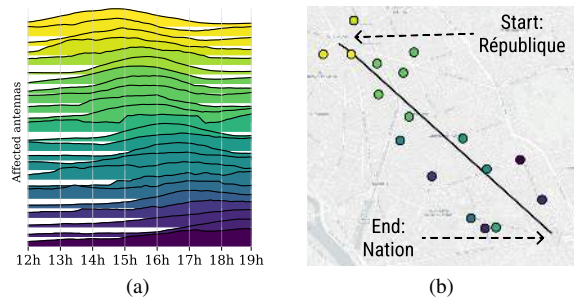


Fig. 2: Evolution of the May 1st protest. (a) Standardized traffic of the flagged antennas, ranked (from yellow to purple) by the average time when $M(t) > 0$. (b) Spatial distribution of the flagged antennas, color coded according to the time ranking.

propagate across antennas and are still visible well past the official end time of 19:00, as protesters took their time to finally disperse over Paris at the end of the manifestation.

It is worth noting that no single antenna displays surges throughout the whole day: as the march flows along the route, there is a natural handover of the digital communications generated by the protesters among antennas with different coverage along the route. We visualize this progression over space in Figure 2b. Here, the antennas that had their traffic surges first (in yellow) were at the initial point of the protest (Place de la République), while the antennas with later surges (in purple) were closer to the end point (Place de la Nation).

IV. CONCLUSIONS AND FUTURE DIRECTIONS

We present a suitable metric to detect anomalies in the mobile traffic demand that are generated by public protest marches happening in France in 2023. By applying this metric on data collected from an operational network, we show that these events can have a major impact on the mobile traffic. On the one end, this provides insights that can be useful for operators to respond to these special circumstances. On the other end, these result are preliminary to the development of a full-fledged framework to better track protests or similar public events while preserving the privacy of the participants.

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