CS211 Project Proposal

Zengwen Yuan, Kainan Wang, Jie Wang

1 Introduction

Mobile Internet access has become an essential part of our daily life with our smartphones. From the user's perspective, (s)he demands for high-quality, anytime, and anywhere network access. From the infrastructure's standpoint, carriers are migrating towards faster technologies (*e.g.*, from 3G to 4G LTE), while boosting network capacity through dense deployment and efficient spectrum utilization. Despite such continuous efforts, no single carrier can ensure complete coverage or highest access quality at any place and anytime.

In additional to infrastructure upgrade from carriers, a promising alternative is to leverage multiple carrier networks at the end device. In practice, most regions are covered by more than one carrier (say, Verizon, T-Mobile, Sprint, *etc.* in the US). With multi-carrier access, the device may intelligently select among carrier networks and improve its access quality. To this end, industrial efforts have recently emerged to provide 3G/4G multi-carrier access via universal SIM card, including Google Project Fi [**?**], Apple SIM [**?**], and Samsung e-SIM [**?**]. The ongoing 5G standardization also seeks to integrate heterogenous network technologies [**?**].

However, study shows that the full benefits of multiple carrier access can be limited by today's cellular design.

It turns out that, these problems are rooted in the conflicts between legacy 3G/4G roaming design and user's multi-carrier access requests. With the single-carrier scenario in mind, the 3G/4G design places the controllability of carrier access to the network side. Roaming to other carriers is not preferred unless the home carrier is unavailable. As a result, today's carrier selection mechanism (i.e., PLMN selection) passively monitors other carriers after losing home carrier service, and selects the carrier based on pre-defined roaming preference given by the serving carrier network [**?**, **?**]. Although viable in the single carrier case, this design limits user's ability to explore multiple carriers. The user could miss the high-quality carrier network, delay the switch with redundant carrier scanning, and get stuck in the low-quality carrier.

While this problem may be solved in future architecture design (*e.g.* 5G), it takes years to accompolish. Instead, we seek to devise a solution that works in today's 3G/4G network, in line with ongoing industrial efforts, *e.g.* Google *Project-Fi*, Apple SIM and Samsung e-SIM. Specifically, we address the following problem: *can we overcome the design limitations of legacy 3G/4G roaming, without modifying phone hardware and 3G/4G network infrastructure?*

We propose *iCellular*, a phone-side service to let users define their own cellular network access. Different from the traditional network-controlled roaming, *iCellular* enhances the user's role in multi-carrier access. It offers users high-level APIs to customize the access strategy. *iCellular* is built on top of current 3G/4G mechanisms at the device, but applies cross-layer adaptations to ensure responsive multi-carrier access with minimal disruption. To help users make proper decisions, *iCellular* exploits online learning to predict heterogenous carrier's performance. It further safeguards access decisions with fault prevention techniques. We tries to implement *iCellular* on commodity phone models and assess its performance with *Project-Fi* based on previous work.

2 Survey

The network side efforts include sharing the radio resource [**?**, **?**] and infrastructure [**?**, **?**, **?**, **?**] between carriers, which helps reduce deployment cost. On the device side, both clean-slate design with dual SIM cards [**?**, **?**] and single universal SIM card [**?**, **?**, **?**] are explored for multi-carrier access. Our work complements the single-SIM approach for incremental deployment, but differs from recent efforts by moving beyond the network-controlled roaming, and offering user-defined selection in a responsive and non-disruptive way.

iCellular explores the rich cellular connectivities on mobile device. Similar efforts explore the multiple physical interfaces from WiFi and cellular network, including WiFi offloading [**?**, **?**, **?**] and multipath-TCP [**?**, **?**]. *iCellular* differs from them since it uses single cellular interface. In the WiFi context, recent works [**?**, **?**, **?**] propose aggregate multiple APs for higher capacity. As discussed in §**??**, similar techniques are unavailable for 3G/4G. Instead, *iCellular* chooses to let users customize the selection strategies between carriers.

3 Timeline

For now, we already got an interface that can collect runtime data through built-in analyzers. What we need to do first is to handle these data inside the mobile application. The premilary work is to build a reasonable metric to measure the performance of different services based on the information we get, which need to transplant the original code to android.

Then, we need to show our result in various format like chart or table.

Finally, we should enable the phone to switch automatically and ensure the performance not affected. Through the whole project, we still need to pay attention to possible alternative solutions and optimizations.

4 Roadmap

- Get Information From Low Level Interface
  typically in one week
- Transplant Analyze Code To Phone
  in 7-8 days
- Show Result In Different Format
  in one week
- Enable Auto Switch
- Performance Analysis And Optimization
  based on the performance requirement 5-8 days