Supporting Wireless Connected Cities by Empowering Edge Networks

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In future smart cities where all smart objects and people are constantly interacting, shifting context and locations, and interweaving in a global dance, wireless architectures and protocols will be come more important than ever before. Unfortunately, despite the abundance of network interfaces on a single mobile device that a person carries, including Bluetooth, NFC, WiFi, 4G, etc., users are still experiencing a great deal of inconvenience caused by the intermittent and disjointed coverage of readily available surrounding wireless networks. Current solutions for such inconvenience are sub-optimal, including the use of user interventions (e.g. having user explicitly select which network to use when, with constant pop-up prompts for selection, security authentication, warning, fine-print policy disclosure and agreement,etc.), making a financial sacrifice (e.g. constantly use their cellular network when walking down the street, discounting the presence and abundance of WiFi network along the way), or falling back to wire-based approach (e.g. one can't simply walk in any meeting room and use a projector wirelessly and instantly, but have to connect their device to the projector, in most case, with a cable). These limitations indicate the unpreparedness and inadequacy of current wireless services from the edge of the whole network. We propose to explore this last-mile wireless networks to better prepare for smart wireless cities to come. In particular, the following topics are proposed to be explored specifically in preparation of wireless networks for smart cities:

1. Wireless edge peering: Peering between autonomous domains is one of the most important capabilities of the Internet. ASes employ various types of peering agreements with different number of neighboring ASes and a recent report shows the presence of 75% more peering links than previously known. As a motivating example, consider the case of two small enterprise networks N1 and N2 which operate in geographically close locations (e.g. on different floors of a building) and have different Internet service providers ISP1 and ISP2. Due to the geographical proximity, some wireless routers in both networks can connect to each other, for example using the bridging-mode available in many enterprise WiFi APs, assuming a sufficient security solution is in place. This wireless peering link would keep the two networks connected even if both the service providers, I S P 1 and I S P 2 are undergoing failures, and can help one network to use the connectivity of the other network in case either one of ISPs has a link failure. We believe that wireless peering will be increasingly important for the future smart city, and requires more flexible and granular policy specifications than currently supported, especially for disaster-recovery (when wired connections to ISPs might fail) and congestion handling (to maintain partial edge-connectivity when the main links become too congested).

2. Software defined networking (SDN) for wireless edge: The flexibility provided by software-defined networking (SDN) could change the way wireless edge networks are designed, built and operated to allow the dynamics happening at the edge to be gracefully handled. To deliver agility for ad-hoc mobile networks, one could greatly benefit from SDN by tailoring the networks to fit their needs without any redundant functionality, to minimize the overhead and satisfy the strict resource constrains of mobile devices. We should first study how SDN could be used to enforce network management tasks such as device discovery, access control, and dynamic spectrum access for coexistence between heterogeneous radio systems. We will then pursue more general problems such as what kind of issues at the wireless edge can be better solved by SDN in other sub-domains, for example, in-city vehicular communication and disaster recovery communication.

3. Dynamic network formation and mobility. Another emerging mobility service scenario at city scale is that of dynamic network formation along with network mobility. For example, there are opportunities for a network to be formed between groups of enterprises sharing the same geographical location and these networks should be able to quickly peer and expand along the edge with different networks on demand. As another emerging use-case consider Googles Project Loon, which proposes to beam LTE access in developing countries from a network of aerial balloons. The exploring the similar concept has a potential for disaster reaction and recovery, in which the speed at which a network could be from is crucial.

We look forward to discussing above mentioned ideas at the Future Wireless Cities Workshop and, more importantly, to learning other potentially transformative research directions, and to aligning our interest to the development of the wireless networking research community. While it would be helpful to be reimbursed for the travel and local expenses, we could also fund for associated expenses from our departmental funding sources should the available funding from the workshop organizers are not sufficient to cover ours.