Break-out Session: Wireless, Mobile and Embedded Systems

Part of the NSF United-States/Middle-East Workshop On
Trustworthiness in Emerging Distributed Systems and Networks

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The breakout session on wireless, mobile and embedded systems convened over two days. The first day included intense exchange of ideas and starting discussion points that were combined into three main categories representing potential mutual interest and subsequently collaboration opportunities. The main categories are:

1. Data collection and management, participatory sensing, context-awareness,
2. Mobile and wireless architectures , and
3. Mobile applications (m-health, m-learning, transportation, emergency management)

In the second day, breakout sessions were conducted by sub-groups of interest. The group (with 16 researchers total) was divided into three sub-groups corresponding to the three categories identified in the first day. A summary of each of the sub-groups is provided below, along with notes on that sub-area from the first day's discussion. Some of the participants (mainly A. Helmy) circulated between the sub-groups in attempt to contribute to the overall discussions. Note that many more were interested in the applications area but did not have the opportunity to participate due to the limited time.

1. Contextual Data Collection and Management

Participants: A ElNahas, Ghobril, S Shaheen, M Mokbel, S Aly, D Turgut, K Sayed, A Helmy

The group members focused on what they considered as the main problems, challenges and approaches. One of the main problems identified is the lack of sufficient publicly available context mobility-related data for research purposes, including: I- Sensory data, such as location, accelerometer, gyroscope, signal strength, ambient temperature, camera, mic, etc., and II- Social data, such as social graph, interests, trust, relationships, etc.

Obtaining and making accessible large scale mobile data provides several challenges. Particularly, when the expectation is that users will voluntarily provide data, challenges include: privacy, battery depletion, communication bandwidth utilization, computational overhead. Data is needed at a much wider and diverse scale than currently available. At the same time there are no attractive incentives to allow people to volunteer data at a much wider scale.

Several possible approaches were discussed to overcome the challenges in addressing the mobile data collection problem. These approaches included ideas for: I- crowd sourcing, which could be very promising in the middle-east (as evidenced by recent mobile applications such as zabatak, bey2ollak and U-shahid). Trustworthiness of contributed data through participatory sensing is an issue of interest in this area, II- other existing channels for data collection, including FourSquare, Twitter, cell operator data, etc. to elicit more data than location, III- new platforms for data collection, which could be a subject of investigation through collaborative research using domain and region/culture specific information.

Certainly, using different approaches and channels comes with inherent trade-offs between data quality (also utility, security, or traceability) and privacy (or anonymity) of data sources or data. Studying these trade-offs in a systematic manner provides another avenue of potential collaboration.

In addition, issues were discussed relating to data management for data collection and its usage. As for data collection, several issues were discussed regarding available data, crawling data, and building systems (hardware and/or software) to collect data. As for user collected data, issues of general use and query were discussed. General use issues include building knowledge base and analysis, which can be either on-line or off-line. Of particular interest were challenges in real-time analysis, identification of trends in social networks, and the creation of web 2.0 search.

Interest was evident among most participants in linking the research on data collection and analysis with possible applications, particularly in the fields of health care (so called mHealth), education (and e-learning), transportation and urban planning (more on applications below). Also, at a more fundamental level, mobile data collection and analysis was deemed imperative to the realistic modeling for simulation, analysis, architecture and design of mobile and wireless systems.

Finally, during the general discussion issues of privacy, difference of policies across countries and the role of research in data collection were discussed. There was apparent awareness of the issues and agreement to conform with IRB approval guidelines from the researchers.

2. Overarching Architecture for Mobile and Wireless Networks

Participants: S Baydere, T ElBatt, K Harras, P Steenkiste, M Youssef

This sub-group discussed issues of mobile networking architecture, including challenged and opportunistic networking, sensor networks, various types of ad hoc networks (including vehicular and networking for the poor), in addition to integrating wired and wireless networks.

On challenged networks, the group discussed its characteristics of mobile, frequently disconnected nodes, mostly carried by mobile users. Such architecture can be used to establish delay tolerant networks, and multi-modal wireless sensor networks (serving diverse applications). Discussion also included vehicular networks as potential architectural direction. Issues of mobile devices with multiple interfaces were considered of mutual interest. Issues of connectivity for underserved communities provided major challenges.

Common characteristics that were identified in mobile architectures included unpredictable connectivity, but with lots of diversity, issues of security, energy-efficiency, incentives and poor integration with today's Internet. As for the mobile networking community lack and diversity of data, performance criteria, and benchmarking were discussed.

The discussion identified several opportunities: I- The need for an overarching networking architecture to: a. provide seamless transition between operating regimes, b. leverage Content-centric and in-network services, c. leverage infrastructure-less networking paradigms, e.g., multi-hop, DTNs, and d. leverage heterogeneous wireless access technologies, and II- Introducing an architecture that is adaptable to the context/scenario in response to: a. differing performance metrics, b. diverse resource constraints, c. varying security requirements, and d. different regimes (the architecture must be adaptable both within and across regimes, i.e., (re)negotiate with application on nature of service.

Research issues, leading to potential collaboration included: 1. appropriate evaluation metrics, mapping application metrics onto network metrics, 2. opportunistic communication; network service

driven preferred, 3. resource sharing and management, including incentive schemes for cooperation, 4. energy-efficient computing and networking, 5. Adaptive mobile networking architectures: adaptable to multiple context, adaptable to multiple application paradigms; e.g., in-network data aggregation, security, … etc. 6. Architectural and mechanistic reusability across network types, 7. security and privacy: trust, provable/quantifiable security, Impact on other metrics, e.g. throughput, energy. Note that not all applications may be appropriate in all context (e.g., lack of trust, e.g. in forwarding nodes).

3. Mobile Applications

Participants: M ElTaee, S Ergen, M Guirguis

This breakout session sub-group was focused on Mobile apps. The group discussed three potential applications for collaboration: (1) Health applications, (2) Vehicular Networks, and (3) Emergency application.

In the health app, the research exploring the use of humanoid robots to interact with patients as a mean of a virtual doctor/nurse was discussed. The robot captures data from several medical devices over wireless connections (e.g., Bluetooth) and sends them to a central location for analysis. Based on the analysis and the recommendations, the robot would engage the patient in different activities that would enhance his/her condition. The privacy and the security of the medical data was discussed and how to ensure that no manipulation can trigger an unwanted reactive behavior from the robot.

Other issues of mobile health applications discussed in the general discussion and other meetings included the use of mobile devices and smartphones for long-term multi-modal sensing of users' activities to identify early risks of disease or disorders (e.g., obesity, mobility, frailty) via differential behavioral analysis. In addition, the role of support groups (identified via similarity analysis of mobile networks) in self disease management and self-efficacy (e.g., diabetes, depression, elderly care) was of interest to some.

In the vehicular networks are, issues were discussed on how to study the communication security between different sensors on the car. In particular, there has been an effort to replace wires in the cars with wireless connections to reduce the cost and the weight on the car. Interference and noise may significantly impact important information that may trigger an unchecked behavior. For example, if we have 4 sensors that report their speed to an ABS Brakes system, delay or loss of measurement from one the sensor may cause an accident. So the question is how to ensure the security and the safety of the system.

The role of inter-vehicular networks and participatory mobile app in alleviating transportation problems and mitigating congestion in middle-eastern cities was also found to be of interest to several researchers through the general discussions. Moreover, collecting vehicular mobility data and characterization of vehicular mobility models in various scenarios and locations was of interest.

In the emergency application, our though was general on how to form an ad-hoc networks in the cases of a disasters and ensure their operation even under attacks.

Several researchers also indicated significant interest in the user of mobile applications and connectivity to improve education at various levels (K-12 and higher education). Time was limited and these interests were not discussed at length during the breakout session.

Below is a summary (mainly by A ElNahas) of the various items that were suggested in the first day, based on which the three categories of sub-groups (above) were determined. Note that not all of the suggested items were discussed at length in the sub-groups breakout sessions.

Breakout session 1

Proposed ideas:

- Directed ads A,B
- Context aware info dissemination A, B,C
- Mobile big data management A
- Sensing and web access data A
- Mobile operators data A
- Education, health and social nets B
- Vehicular net/transportation b,c
- Networking in challenging environment (emergency management)
- Crowd sourcing (participatory sensing/ crowd watch) a,b
- Poor communities as target c
- Future Infrastructure (less) issues. Uniqueness in middle east: norms and trends C
- Community detection across cultures, Trust (Adaptive incentive systems) B
- Connecting the disconnected C
- Selfishness – complexity of embedded systems C
- CPS for smart grid B,C
- Monitoring and measuring of mobile systems A
- Localization B,C
- Indoor vs outdoor C
- Elderly care and smart homes B
- Smarter access C
- Experiments and testbeds C

Major categories:

A. Data collection and management, participatory sensing, context-awareness
B. Mobile Apps (m-health, education, transportation, emergency management)
C. Mobile and wireless architectures