Moving towards Dynamic Groups and Hybrid Distributed Paradigms

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Participant's Background and Experience: I and my group have been researching pervasive computing and communication systems, especially Quality of Service and resource management techniques and later on applications and user behaviors for diverse group of static and mobile, DTN (Delay Tolerant Networks), ad hoc and infrastructure-based, single hop and multihop, wireless systems and networks. We have investigated *resource management* in wireless LANs and ad hoc networks [1,2, 3], *integrated QoS and security* considerations [4], and integrated *co-scheduling* for critical infrastructures [8]. We have been studying applications such as (a) *first responders* within mobile ad hoc and infrastructure-based wireless networks, considering their mobility patterns [6], relay placement [10], context [9], (b) pedestrian mobility patterns[7,11], (c) publish-subscribe applications [5], and (d) mobile learning communities [12]. Furthermore, I have been actively involved in the organization of the IEEE Pervasive Computing and Communication conference (Percom), being the TPC member since 2003, vice-chair for the network and communication track in 2004, technical program chair in 2005, steering community member 2006 and general chair in 2009. In 2010, I have participated in the exploratory workshop between NSF and EU funding agencies on impact of social networks on pervasive computing and communication.

Participant's Vision: As mobile phones become ubiquitous, the content distribution and usage of phones, for example, in and out of classrooms for educational purposes will change. The current traditional way of downloading content from a central server will be at first supplemented and later replaced by **inter-changeable hybrid distributed paradigms including client/server, publish-subscribe and peer-to-peer content distribution** protocols among people (e.g., students, professors and staff). The corresponding **hybrid protocol stack** will deal with dynamic situations with respect to central servers and the underlying infrastructure that exhibit major congestion as group sizes, content amount and access pattern change.

To enable hybrid protocol stack, my vision is that phones will become even smarter and utilize all sensors on the phone to allow *community sensing* and help us better understand group dynamics. We will need to better *understand social and socio-economic models* and their impact on group dynamics. As we already know from existing socio-economic models such as Schelling behavior [7], the group sizes change as people move towards points of interest or leave the points of interests.

The phones will need to sense *group-related dynamics such as group size changes, content dynamics and access dynamics* around them and ***know*** or ***predict*** *changing points in community behavior* to switch between protocols and paradigms. For this goal, we need community sensing to *identify the size of the group*, *movement dynamic* of a group of people, *localization of a group*, *duration of stay* for a group, and predict *changes in size of* groups by understanding socio-economic models, as well as utilizing *historical traces* and *user/community activities*. If we understand the dynamics of mobile groups and community, not only routing tables within a paradigm and its single content distribution protocol could be adjusted, but also paradigms/protocols can be changed to operate more efficiently under the particular group size (as we know, one single protocol does not fit all sizes of scale).

Evidence: We have conducted several *interviews* and *sensing experiments* with different groups of users such as first responders [6] and students of the Department of Computer Science at University of Illinois at Urbana-Champaign [12], and studied their different mobility patterns [11]. We have also studied *protocols* under different socio-economic models including Schelling behavior [7] and Regular behavior [11]. Through the prior research we are recognizing that there is a major need for community sensing, understanding group dynamics and hybrid distributed paradigms/protocols.

For example, through our and others research it was clearly shown [7,11] that increased sensing of neighbors, increased collection of context such as contact location, duration, proximity to others in a group, leads to more efficient content delivery. Through our Spring 2010 experiments, we have identified serious limitations of WiFi infrastructure when using large scale phones in a classroom [12] at the same time for quizzes.

Summary: Community sensing is a necessary condition towards dynamic groups and hybrid distributed paradigms. We need to have a clear understanding of group dynamics, content dynamics and access dynamics to content to understand breaking points at which protocols and even distribution paradigms need to change to yield efficient content distribution over changing group situations. The characterization of dynamic community behavior via mobile phones will also assist in validating old and developing new *social and socio-economic models*, as well as assist in predictions of group movement and prevention of disasters as we have seen in Germany during the Love Parade 2010.

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