Research Statement:

Kameswari Chebrolu, July 2004

Research Interests:

My research interests are in the areas of wireless, wired and sensor networks. In particular, I am interested in the design of protocols and architecture for network systems targeted towards deployment in the third-world. I am also interested in mainstream research in networks – Quality of Service provisioning, Mobility Management and 3G/4G architecture design.

Research Approach:

My research paradigm is one of system building and experimental evaluation. After initial analysis and preliminary simulation study if necessary, I believe that building a prototype helps validate system design. This is in line with my goal of focusing on technology development for use in the third world – prototypes are crucial in getting feedback from actual use, and also in quick deployment.

I also believe in collaborative research. Collaboration often brings in new perspectives and different skill sets that help address problems in new angles to produce high quality research.

Overview of Past Research:

Multi-Access Services in Heterogeneous Wireless Networks:

As part of my Ph.D thesis, I have looked into enabling new and interesting multi-access services brought about by the simultaneous use of multiple wireless interfaces. These services constitute Bandwidth Aggregation, Mobility/Reliability Support, Resource Sharing and Data-Control Plane Separation. As a first step towards realizing in practice the above mentioned services, I developed a network layer architecture that supports multiple communication paths. The architecture operates at the network layer and introduces minimal changes to the infrastructure and is totally transparent to the applications. I also identified and implemented on an experimental test bed, the various functional components that make up this architecture.

While the architecture can support many different services, I explored in depth one such service provided by the architecture: Bandwidth Aggregation (BAG) in the context of Video and TCP applications. Aggregating bandwidth across multiple interfaces can be used to improve the raw throughput of the client's applications. However, it introduces challenges in the form of packet reordering which can result in excess delay for video applications and congestion control invocation lowering throughputs for TCP applications.

An important aspect of the architecture when providing BAG services is the scheduling algorithm that partitions the traffic onto different wireless interfaces such that the application requirements are met. I proposed one such algorithm Earliest Delivery Path First (EDPF), for video applications. This algorithm ensures that packets meet their playback deadlines by scheduling packets based on the estimated delivery time of the packets. When enabling BAG services for TCP applications, a similar scheduling algorithm that minimizes reordering is needed, however it needs to operate under best-effort conditions. I proposed one such algorithm Packet Pair based Earliest-Delivery-Path-First Scheduling Algorithm for TCP applications (PET). The algorithm estimates the available bandwidth through *Packet Pair* technique and minimizes reordering by sending packet pairs on the path that introduces the least amount of delay. A buffer management policy (BMP) is also introduced at the client to hide any residual reordering from TCP. My evaluations show that the proposed scheduling algorithms achieve good bandwidth aggregation under a variety of network conditions.

Another aspect I have looked into in the context of video applications is selective frame discard to cope with cases when adequate bandwidth cannot be reserved on the interfaces. My proposed content adaptation algorithm, Min Cost Drop (MC-DROP) drops frames based on the impact the frame drop has on meeting future frame deadlines and hence on overall quality of the video. Trace driven simulations using my algorithm show that it outperforms by a good margin other considered approaches in terms of suitably defined metrics that capture overall video quality.

Seamless Handoff between Heterogeneous Networks:

During the course of my internship at 3Com Corp, I studied as part of a team, possible architectures to enable seamless handoff between heterogeneous networks. In this work, we implemented on a test bed, a mobile controlled handoff mechanism to achieve seamless handoff between a wireless local area network (802.11) and a wireless wide-

area network (Sprint PCS CDMA). Extensive field tests were conducted to capture handoff delay and packet loss statistics.

Energy Aware Sampling Schemes:

At the beginning of my graduate study, I looked into techniques to conserve energy of nodes in a sensor network. This work, done in collaboration with Pavan Nuggehalli and Vikram Srinivasan, used the statistical characteristics of the incoming traffic to devise appropriate sleep/wake patterns for the sensor nodes. Our evaluations using theory and simulations showed that significant gains can be accrued by intelligent wake-up schemes over a deterministic wake up strategy which current systems (back then) employed.

Future Research Plans:

I primarily intend to focus on the design of *appropriate technology* for use in the developing world in general, and in India in particular. Under this theme, one of the areas I plan to work on is on the design of wireless networks suited for operation in rural settings. Such network design varies significantly from conventional approaches in that the *cost of the system* is a significant factor, with system efficiency only a secondary concern.

A related aspect is that of availability of (reliable) *power*, and its efficient use. Both of these aspects are likely to affect not just the design of access networks to rural villages, but also the design of the wired backbone network, as well as end computer systems. Internet design has not thus far concerned itself with *power efficiency* – this is an important aspect in developing countries where power is scarce.

A specific application I plan to look at in the context of appropriate technology is *"telemedicine"*. Health-care infrastructure is often weak or non-existent in developing countries and telemedicine can play an important role in easing the situation. Supporting such applications over wireless access networks in rural areas brings its own set of challenging technical issues – bandwidth scarcity, latency, and loss.

Another area of interest to me is *sensor networks*. Although the broad area of sensor networks has received much attention in the recent past, I believe that design of such networks is highly application specific. I plan to explore specific applications by designing and building prototypes. Examples of possible applications include:

environment monitoring (e.g. river pollution), habitat monitoring (for endangered species), and structure health monitoring (of buildings and other constructions).

Apart from the above, I plan to work on mainstream areas of research related to next-generation (3G/4G) wireless networks. Since 4G networks are expected to be mainly driven by the services they offer, one critical aspect which requires attention is QoS provisioning. The design of scheduling algorithms and mechanisms for wireless cells, for optimal and fair allocation of resources, remains a challenge. A related aspect is that of mobility management. With 4G networks expected to have smaller cells (for higher capacity per cell), user mobility and related processing can be expected to be a significant overhead. I plan to look at the performance analysis and improvement of transport protocols and QoS aspects in this context.