A Summary of QoS Support in SWAN

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Abstract: *The SWAN wireless network uses ATM technology to provide integrated services to mobile terminals in an indoor setting. Variability caused by wireless access and mobility make this a very different environment for ATM, specifically for supporting QoS. This short paper provides a summary of QoS support in SWAN, including a scheme for renegotiating QoS in response to changes in available bandwidth. Experimental results are presented to demonstrate its operation and effectiveness.*

I. Introduction

Wireless LANs provide a convenient mechanism for access to data services while retaining the freedom of user mobility. Generically these systems consist of mobile hosts such as PCs or PDAs which use a wireless network interface to communicate with an access point device attached to the wireline infrastructure. Each access point provides network coverage for a small geographical area known as a cell, and mobile hosts are "handed-over" between adjacent cells as the user roams. Typical wireless LANs provide up to 2 Mb/s of raw bandwidth, shared between mobile hosts in a cell using a contention-based medium access control (MAC) protocol. This type of network is good for conventional traffic like email and file transfer, but the unpredictable nature of contention-based access makes it much less suitable for continuous media traffic, like voice and music. The desire to build an integrated services wireless LAN has led to the development of several research testbeds which provide a scheduled MAC between mobiles and the access points, typically to support ATM style operation [1, 2, 3]. However, the characteristics of the wireless medium and the impact of user mobility make this a very different environment than wireline ATM. Wireless communications are inherently unreliable and various forms of interference result in changing bandwidth availability and low effective bandwidths due to high error rates. These are exacerbated by user mobility.

This short paper summarizes work that addresses these problems in the context of SWAN (Seamless Wireless ATM Network) [1]. The contribution is a protocol which builds on SWAN's scheduled air access to provide a native ATM API with support for QoS. Variability is handled in the protocol by explicitly supporting a mechanism to alert applications of significant bandwidth changes and allow them to renegotiate QoS. This work is encouraged by work showing how continuous media applications can adapt to some degree based on available resources or network conditions [4, 5]. Section 2 briefly describes QoS support in the SWAN system, including QoS renegotiation. Section 3 describes an experiment to demonstrate QoS management in SWAN, while Section 4 concludes. More complete details of the QoS protocol and results are available in [6], while [7] explains its application in reacting to various wireless communication failures.

II. System design

Protocol processing in SWAN is performed by a set of modules as shown in Fig. 1. More details of the system are available in the papers cited above, but the key functions are as follows:

1. **MAC protocol:** The SWAN MAC protocol uses a simple token passing scheme to control access to radio frequency (RF) channels. A set of channels are assigned statically to each base station which acts as the central arbiter between mobile hosts requesting access tokens. In the current implementation, a mobile host has exclusive access to a channel once it gets the appropriate token. The current SWAN radio provides a time division duplex (TDD) scheme where the two ends of a channel get to transmit a fixed number of data cells (10 ms duration) alternately.

2. **Virtual circuit (VC) management:** VC setup and maintenance during hand off is done by the application-level "Etherware" module. It handles the

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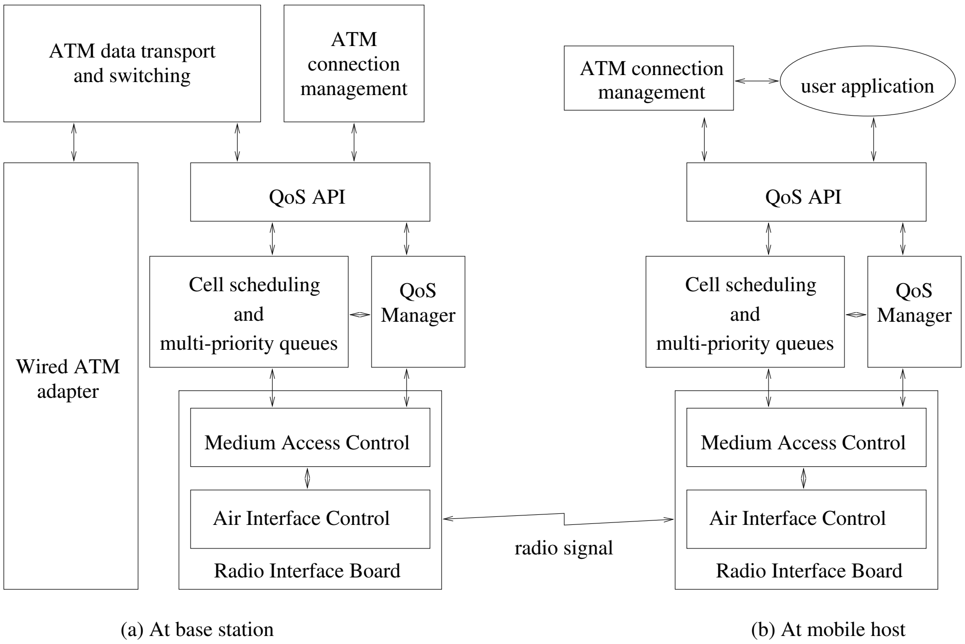

Fig. 1. Protocol modules in SWAN

signalling required for connection setup and resource reservation.

3. **API:** Standard `open()`, `close()`, `read()` and `write()` calls are provided for VC creation and access. QoS control is achieved using `ioctl()`. Currently the following QoS parameters are accepted: service type (available, constant or unspecified bitrate), preferred bandwidth, minimum bandwidth, and maximum delay.

4. **Cell scheduling:** A QoS manager examines QoS parameters passed through the API, translating them into system parameters for the cell scheduler. The scheduler employs a multi-priority queue with weighted round-robin service. The weights of these queues are stored in a service table maintained by the QoS manager.

5. **QoS renegotiation:** An important feature of SWAN is QoS renegotiation, invoked when there is an observed change in the available RF link bandwidth. When conditions change, the QoS manager first attempts to reallocate the available bandwidth to higher priority traffic, degrading lower priority traffic. Further, if this does not free up sufficient capacity, the QoS manager can explicitly request that particular applications renegotiate for reduced bandwidth. This mechanism is also used when conditions become more stable and available bandwidth increases.

III. Demonstration

To demonstrate these QoS mechanisms, the results of an experiment using the SWAN testbed are presented. This was based on applications that were modified to use the QoS API and perform adaptation. The aim is to demonstrate management of a limited bandwidth channel based on a QoS mechanism.

Three connections are used: two for real time video transmission that require constant bit rates of 75 Kb/s and 150 Kb/s, respectively; one for datagram transmission that requires only best effort service. The application uses the QoS API to indicate that the two videos require constant bitrate connections, and that the datagrams are of an unspecified bitrate (the default). Fig. 2 shows the bandwidth usage of the three streams. Both video connections acquired the bandwidth they requested, while the datagram traffic can use all the residual bandwidth. For comparison, we perform the same experiments with QoS disabled. Fig. 3 shows this result, where the different traffic streams are competing with each other. The result, as expected is that none of them get their desired bandwidth. Fig. 4 shows the results for interarrival jitter for video frames in the QoS and non-QoS cases. Clearly the ability to reserve bandwidth provides an effective control over jitter.

IV. Summary

This short paper provided a summary of QoS support in SWAN. SWAN is in indoor wireless ATM network which

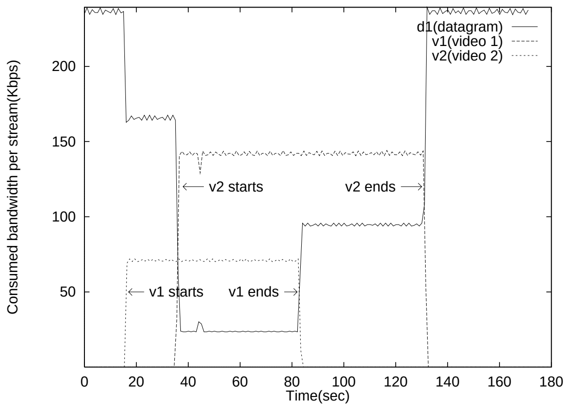

Fig. 2. Channel bandwidth usage, with QoS support

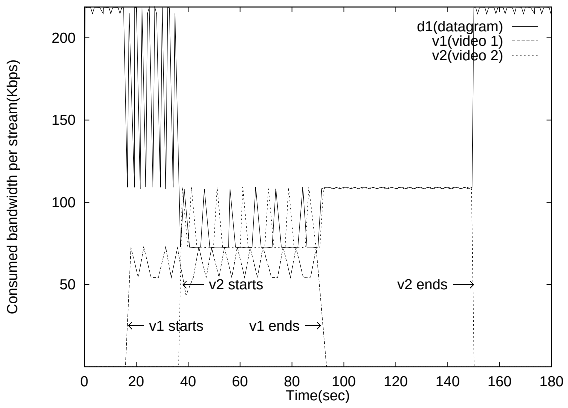

Fig. 3. Channel bandwidth usage, with QoS support disabled

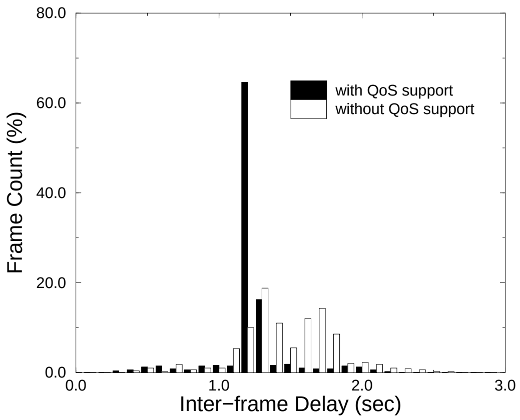

Fig. 4. Distribution of inter-frame delay for video

currently uses TDD RF channels. Channel access by mobile hosts in a cell is controlled centrally using a token passing mechanism. The protocol modules were described, including a mechanism for QoS renegotiation which is invoked in response to changes in available channel bandwidth. Results of an experiment demonstrating the use of QoS on the SWAN testbed were presented.

References

[1] P. Agrawal, E. Hyden, P. Krzyzanowski, P. P. Mishra, M. B. Srivastava, and J. A. Trotter, "SWAN: A Mobile Multimedia Wireless Network," in *IEEE Personal Communications*, Apr. 1996. pp. 18-33.

[2] D. Raychaudhuri, "Wireless ATM networks: architecture, system design and prototyping," in *IEEE Personal Communications*, Aug. 1996, pp. 42-49.

[3] J. Porter and A. Hopper, "An overview of the ORL Wireless ATM System," in *Proc. of IEEE ATM Workshop*, Washington, DC, Sept. 1995.

[4] C. J. Sreenan and P. P. Mishra, "Equus: A QoS Manager for Distributed Applications," in *Distributed Platforms*, Editors A. Schill et al. Publishers Chapman & Hall,1996, pp. 496-509.

[5] D. Sisalem, "End-to-end quality of service control using adaptive applications," in *Proc. of IFIP International Workshop on Quality of Service*, May 1997, pp. 381-92.

[6] T.-W. Chen, P. Krzyzanowski, M. R. Lyu, C. J. Sreenan and J. A. Trotter, "A VC-based API for Renegotiable QoS in Wireless ATM Networks," in *Proc. of The 6th IEEE ICUPC*, Oct. 1997.

[7] T.-W. Chen, P. Krzyzanowski, M. R. Lyu, C. J. Sreenan and J. A. Trotter, "Renegotiable Quality of Service – A New Scheme for Fault Tolerance in Wireless Networks," in *The 27th Annual International Symposium on Fault-Tolerant Computing*, Jun. 1997, pp. 21-30.