

## Increasing Subscriber Capacity and Improving Wireless Network QOE

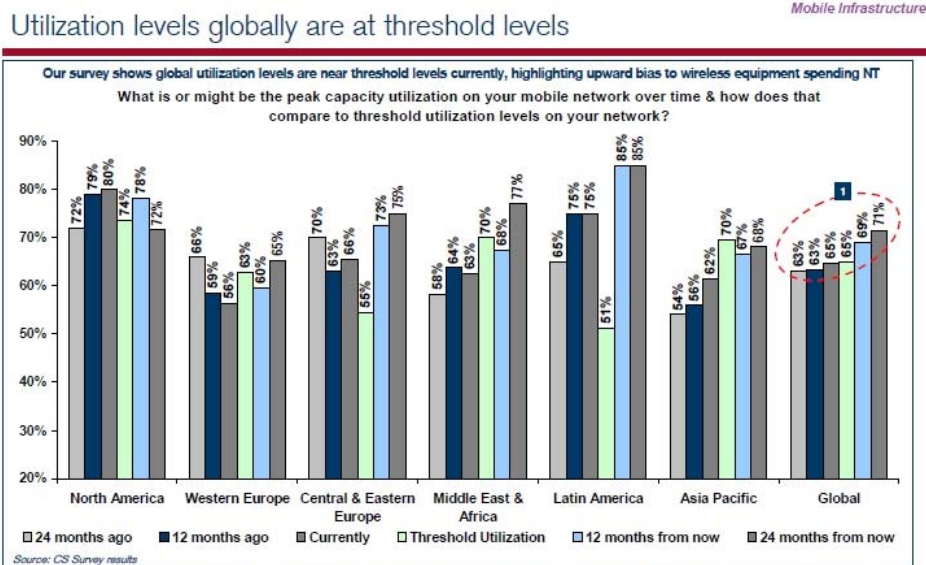
by Dr. Lawrence Roberts, PhD.

### The Wireless Network Challenge

Wireless networks (3G, 4G, and WiFi) face a serious challenge – how to increase subscriber capacity, improve QOE and increase ARPU given the rapid proliferation of smart phones and tablets and the associated increased of wireless bandwidth by data intensive applications.

In its latest market report, Gartner revealed that the worldwide mobile phone sales topped out at 427.8 million during the first three months of 2011. That represents an increase of 19% compared to the first quarter of 2010. Furthermore, International Data Corporation (IDC) predicts the worldwide **Smartphone** market to grow 49.2 percent in 2011.

The net result is a rapid increase in wireless bandwidth utilization. Credit Suisse has noted the wireless network utilization globally is at “threshold levels” where the network operators must add capacity to preserve and improve subscriber QOE.



1) Survey shows that mobile network utilisation rates have already reached threshold utilization levels of 65% globally. In every region, we are seeing average peak utilisation rates of over 50% level and at the global level, this currently is at 65%. In addition, respondents expect utilisation rates to reach around 70% within the next 12 months. However, more importantly, current utilization levels of 65% are at threshold levels at which our respondents believe it could trigger incremental capex spending.

Source: Credit Suisse, Mobile Infrastructure, June 2011

Given the bandwidth-intensive applications, limited capacity, and the variable number of active users, there will be poor response time, garbled voice over IP (VoIP), and slow file transfer, more often than not especially in high smart phone usage areas. This is due to:

1. Radio access network bandwidth generally being limited (currently 100-300 Mbps);
2. The proliferation of aggressive Internet applications that consume significant amounts of bandwidth, resulting in just a few number of subscribers easily filling the limited radio capacity;.
3. A highly variable number of users active at any one time on a fixed capacity radio.

The mismatch of the bandwidth between the fixed capacity radio channels and the backhaul links along with different performance characteristics needed by real time voice and video along with time insensitive data IP traffic requires intelligent “Offered Load Management” to significantly improve user quality of experience, improve web response, and eliminate poor VoIP performance and video stalls.

This paper examines the causes of these problems and then examines how Anagran’s management of the offered load provides acceptable user QOE while doubling the number active users.

## Anagran’s Offered Load Management Solution

Anagran’s Internet Traffic Manager, the FR-1000, represents a new class of network equipment designed to meet today’s Internet traffic management challenges. With its unique flow-based “Offered Load Management” capability, Anagran’s FR-1000 allows wireless service providers to effectively manage network overload while preserving throughput and reducing delay for all users. The FR-1000 continuously monitors and dynamically adjusts the rate of all TCP flows. Anagran’s Fast Flow Technology recognizes individual flows, dynamically associating a state with the flow and streaming all packets in the flow using this state information. Anagran’s Fast Flow Technology achieves granular control over each individual flow, and when coupled with additional Anagran technologies such as subscriber equalization, provides network operators the capability to effectively manage network overload and deliver network services with fair bandwidth allocation.

## Benefits of Offered Load Management

### Improved Web Page Response Time

Multi-packet discard causes flow stalls and added delay from queuing and must be avoided if one is to avoid the exponential degradation in response time particularly for web access where the slowest flow wins. Figure 1 shows web page response with Anagran’s Flow Rate Control (FRC) and with standard WRED Queuing.

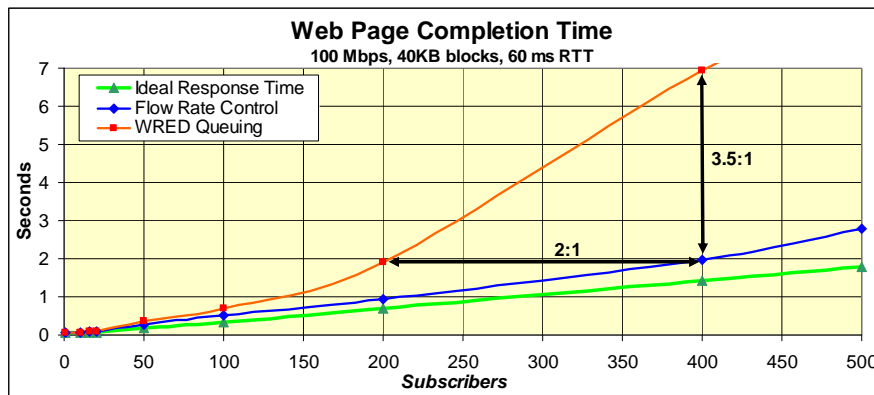


Figure 1: Web page response time as user load increases

Anagran's Flow Rate Control avoids multi-packet drops without adding delay. As a result, a 2 second web access can be achieved with twice the number of users or, at the same number of subscribers the web access is 3.5 times as fast. Since web access is the most important factor in user satisfaction, this is of major importance.

### Managing Abusive Users

One major problem all network services suffer from is that a small percentage of the users tend to consume the majority of the capacity. Typically, this results from their application using multiple flows. A P2P user may use 100 flows while map displays may use 6 to 16 flows. More and more application developers believe they can gain throughput by using multiple flows, but in doing so they cannibalize bandwidth from the other users who share the same limited network capacity.

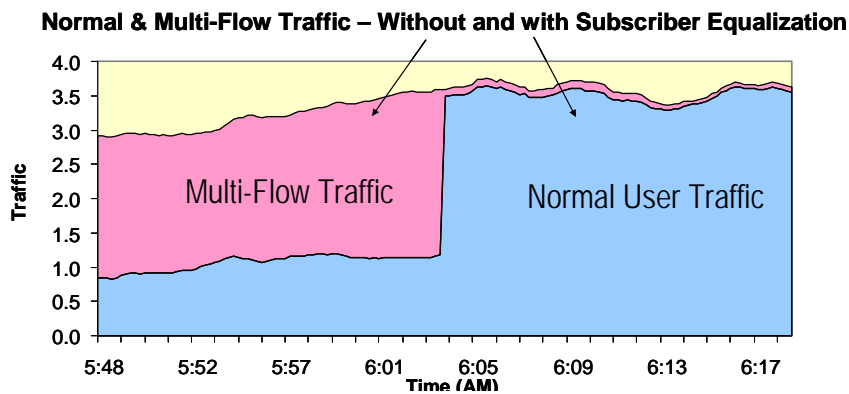
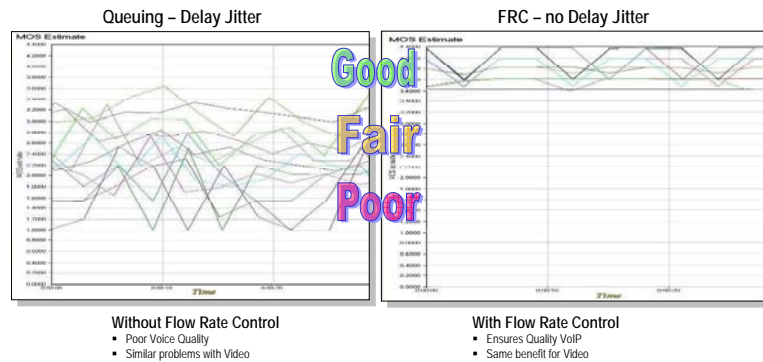


Figure 2: Subscriber Equalization

Anagran's Flow Rate Control feature equalizes the capacity each user receives within a shared space, like a cellular radio tower or WiFi radio access point. If users are using multiple flows, all flows are dynamically managed so that they receive the same total capacity as other active users. Figure 2 shows how this positively benefits the 95% of normal users where they now receive four times the capacity per user once subscriber equalization is enabled.

### Voice over IP Quality

Providing superior VoIP quality over wireless networks can be a challenge due to excessive delay jitter. Lost packets are replaced with noise and cause little problem, but delay jitter is greatly amplified over wireless networks. The delay jitter added by queuing in any of the systems in the radio access network and/or the routers is often close to the 200 ms limit for VoIP. However, added to this is the problem is the delay when the wireless device has to send a packet. If it encounters a collision with another device sending, it uses an exponential backoff which adds sufficient additional delay jitter to ruin VoIP. Figure 3 shows how this affects WiFi voice. Without Anagran's FRC the quality is Fair to Poor whereas FRC always maintains quality in the Good range. As more and more VoIP moves to wireless, FRC becomes a necessity.



**Figure 3: Voice over IP Quality – Greatly Improved with Flow Rate Control**

### Eliminating Network Performance Collapse on Cell Networks

3G and 4G wireless are also subject to massive flash overloads when a crowd of people collect within one cell or an event happens that all users access concurrently. With Anagran’s FRC the response time slows linearly but remains functional. Video throughput is reduced gracefully allowing video sources to decrease resolution as the flow is slowed. Anagran avoids slowing short flows so gaming and web response continues to work well. All traffic, including large file transfers, slow linearly but by avoiding exponential increases in response time a good quality of experience is maintained even with major increases in the number of subscribers. Referring back to Figure 1, the number of users sharing a wireless cell can be doubled before any reduction in response time is incurred.

### Conclusion

Ultimately, what customers care about is network availability and Quality of Experience (QoE) — consistent and timely web page downloads, application response time, smooth loading of their favorite streaming video. Yet, because of the inefficient manner in which packet networks respond to high loads, as well as the unfair manner in which networks allocate bandwidth, actual subscriber throughput and response time is often inconsistent and less than what available network bandwidth could provide.

Anagran’s FR-1000’s Offered Load Management capability eliminates TCP stalls while managing throughput and reducing delay for all customers. In addition to creating a more efficient and deterministic use of wireless bandwidth, the FR-1000 can be used to mitigate the bandwidth consumed by aggressive bandwidth-hungry applications, thereby minimizing their impact on other users. Anagran’s FR-1000 can also be used to ensure “quality sensitive” applications such as streaming video, on-line gaming and Voice over IP (VoIP) receive sufficient bandwidth to deliver the quality that broadband subscribers expect.

Four critical benefits are realized when deploying Anagran FR-1000 systems:

1. **Equalizing subscribers and in the process recovering capacity hogged by abusive users, often increases speed for the other subscribers by 4:1**
2. **Elimination of queuing delay improves both the rate of each flow and the response time.**
3. **Significant improvement in the customer’s quality of their wireless service experience**
4. **Ability to double the number of users on a cell while maintaining fast web access, quality video and good VoIP service.**