P2.4 CSU-CHILL OPERATION OVER THE INTERNET: VIRTUAL CSU-CHILL

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1. INTRODUCTION

The CSU-CHILL radar facility has embarked on an initiative to enable the real time operation of the radar over the Internet called VCHILL or Virtual CHILL. The concept of operation over the Internet can be implemented at several levels. The simplest one is to make the routine CHILL images available on the Internet as soon as the scans are completed. This type of data dissemination has been available with CSU-CHILL over 5 years. However such images are clearly not sufficient for aircraft coordination or actively conducting coordinated scans through a rapidly evolving thunderstorms. The VCHILL initiative has a more ambitious goal of providing the same Quality of Service (QOS) at remote location as at the radar site.

In addition, the goal of the VCHILL initiative is to provide the educational experience of polarimetric radar at a remote location, without compromising on features of an on-site radar console. This paper describes some progresses and plans of the VCHILL initiative.

2. RADAR CONSOLE OVER THE INTERNET: CONCEPTS AND CHALLENGES

Radar operation over the Internet can be at several levels starting from low bandwidth graphic image transfers, to intermediate bandwidth real time console display that shows the radar scanning via a ray-by-ray update to full set of signal samples transferred over the Internet. The first criterion for any of the above schemes to be implemented is the availability of network infrastructure with appropriate bandwidth.

Availability of communication links to support the required rate does not however guarantee the ability of the application to receive and handle the data at the same rate. Current communication subsystem mechanisms within workstation and PC class computers are limiting network communications throughput to a fraction of the present network data rates. Even though CPU and computer network speeds have increased dramatically (ex. Gigabit Ethernet is available for local area, and CPU clock rates exceed 1 GHz), the execution rates of computer functions and applications requiring network communication have not increased proportionally. This can be attributed to several factors including the layered implementation of protocols, linear increase in speed of memory over the years, and the memory intensive nature of network protocol processing.

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3. MEDIUM BANDWIDTH APPLICATION

"Real time" displays on graphic image basis have been available for CHILL radar for over 5 years and the real-time display and data broadcast of radar operation on a ray by ray basis has been operational at CSU-CHILL for over a year. The current implementation consists of a "client server model", where a server runs at the radar facility and the client display programs operate at remote locations. The client can display multiple radar fields such as reflectivity (dBz), differential reflectivity (Z_{dr}), differential propagation phase (ϕ_{dp}), radial velocity (n) correlation between horizontally and vertically polarized returns (ρ_{hv}), spectrum width and linear depolarization ratio (LDR), in real time. This display also indicates that these data are available in real time on a ray by ray basis (not after the sweep is completed). In addition the same set up can be used for display of archived data also. Fig. 1 shows the block diagram of the current implementation. The signal samples are processed by the DSP hardware at the radar site, and then the data are sent over the Internet for PPI and RHI displays. At WSR-88D scan rates, full suite of polarimetric radar parameters and Doppler measurements at the CHILL'S fine resolution mode (30 m resolution) can reach data rates in the excess of 7.5Mbps at 8bit resolution fields.

TCP (Transport Control Protocol) and UDP (User Datagram Protocol) versions of the real-time display were evaluated. Simultaneous access of the radar by multiple users introduces heavy bonding of the network resulting in deteriorated quality of service for real time data. The problem of loading due to multiple users is two fold, namely i) increased load on the server and ii) many copies of the same data being sent to different destinations producing very high bandwidth requirement at the exit point from the radar. This problem can be resolved by IP (Internet Protocol) multicasting. We have currently implemented IP multicasting in the lab. Fig. 2 shows the block diagram of the TCP, UDP and multicast servers providing real time radar data.

4. HIGH BANDWIDTH APPLICATIONS

In a multi user environment, different users may be interested in different sets of products. The number of products from a polarimetric radar are more than a few. One possible mode of operation providing full flexibility is to provide the full high bandwidth data (time series) over the Internet. CSU-CHILL generates digital numbers as output of four 40MHz A/D converters. While it may be impossible to transfer this whole set, it is possible to envision multiple processing of the same set of range time samples. Such an environment demands sustained bandwidth requirements of several hundred megabits per second per user, which pushes the limits of current day end-to-end sustained data transfers achievable. A pair of state of the art workstations with gigabit Ethernet interfaces cannot achieve this level of sustained throughput. A test bench version of full time sample data transfer using TCP server has been implemented, and is being currently tested.

5. MULTICASTING

The internet multicast backbone is essentially an interconnected set of sub-networks (also called islands) and routers that carry multicast traffic from one subnet to other subnet(s). The subnets have routers that are multicast-enabled. The subnets are connected usually using point-to-point links called "tunnels". The tunnels carry traffic through routers that do not forward multicast traffic. The multicast packets are sent over the tunnel after encapsulating them in another IP packet that is forwarded in a "unicast" fashion to the other end of the tunnel, where the multicast packet is de-encapsuled and forwarded by multicast enabled routers. Nodes can subscribe to this multicast traffic by informing their immediately neighboring router of their interest. The protocol through which hosts communicate this information to their local routers is called Internet Group Management Protocol (IGMP) by sending IGMP. Special mechanisms have been implemented for CSU-CHILL multicasting on a test basis.

6. SUMMARY AND CONCLUSIONS

CSU-CHILL has embarked on a major initiative to provide the radar operation experience over the Internet. This process can be divided into three categories, namely i) low bandwidth ii) medium bandwidth and iii) high bandwidth mode of operation. The low bandwidth application is primarily updating display images after the scan is done, and this mode has been available at CSU-CHILL for over five years. The medium bandwidth application involves observing the actual radar scan in real time and it is useful for time critical applications such as insitu aircraft coordination and fast scan updates following a rapidly developing thunderstorm. The high bandwidth mode enables unique signal processing at user end. Both medium bandwidth and high bandwidth applications are implemented with IP multicasting, to limit the load on the server and the bandwidth requirement. We expect this facility to be able to serve as an invaluable teaching and research tool, to provide the radar operation experience to a large pool of users over the Internet.

7. ACKNOWLEDGEMENTS

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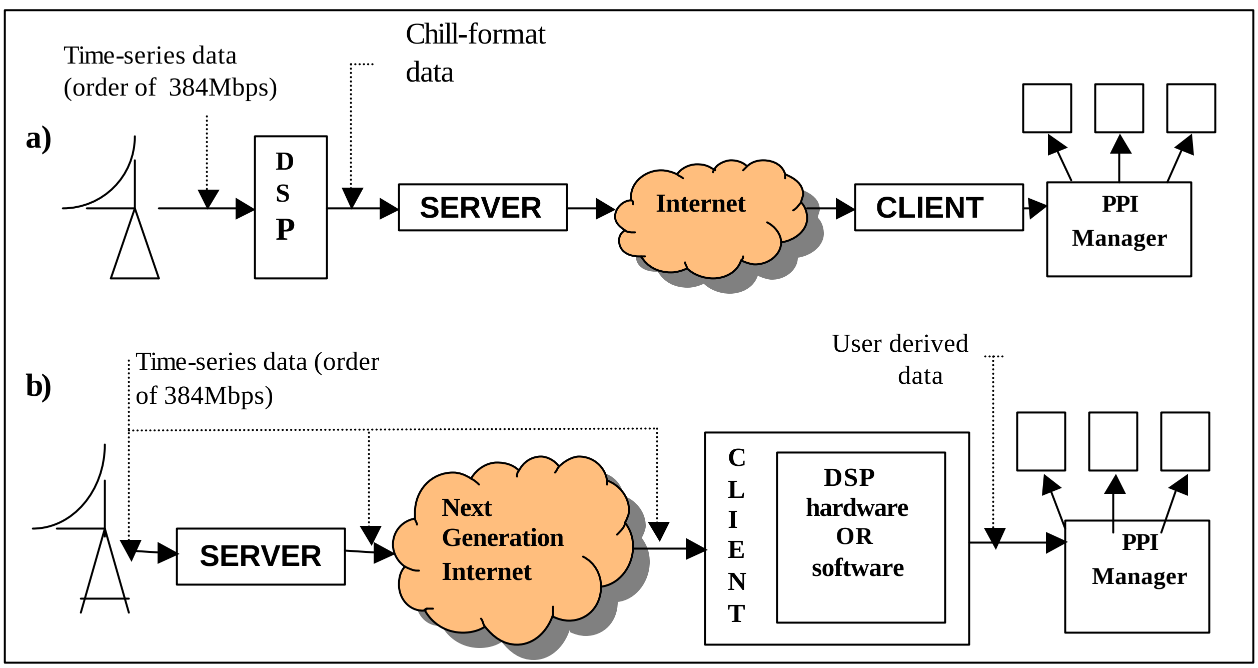

Figure 1 : Networking Chill data over Internet

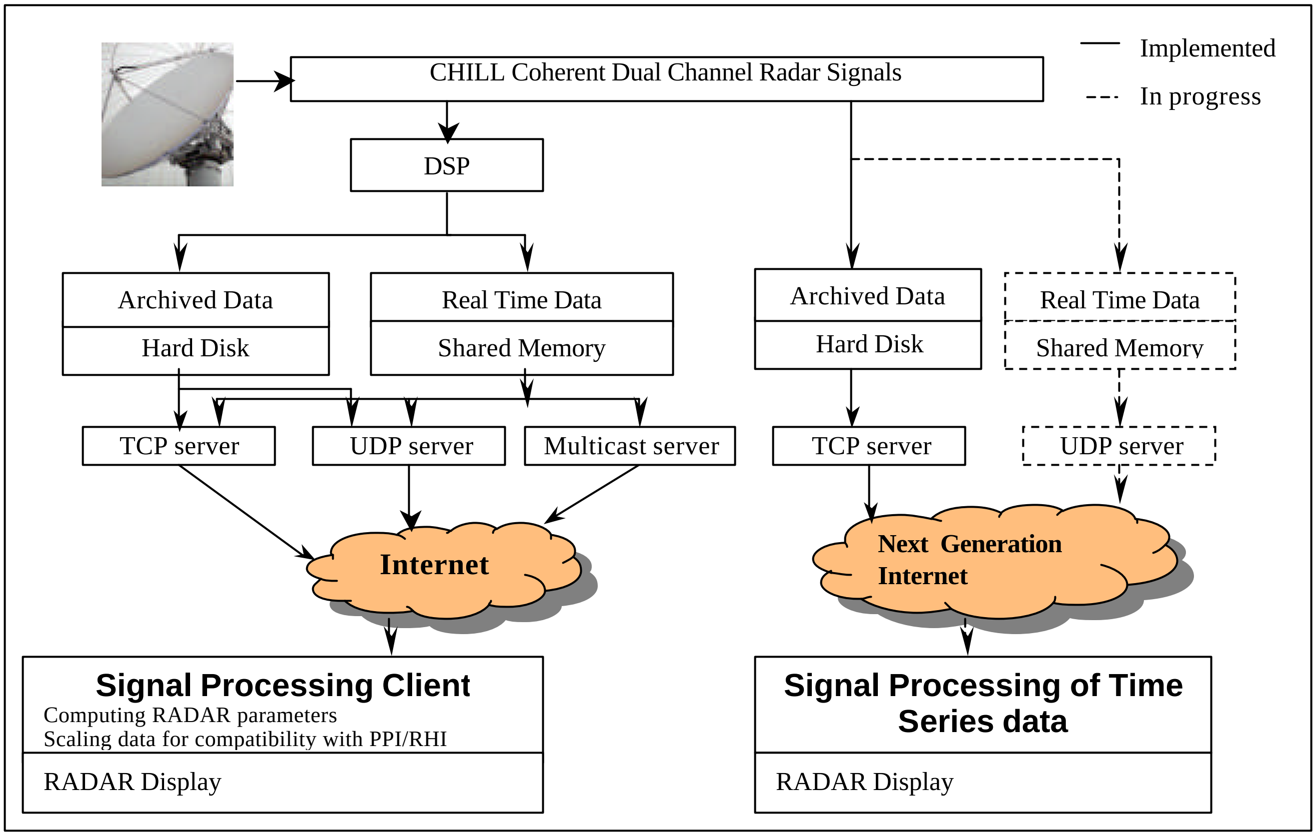

Figure 2: TCP, UDP and Multicast transfer of CHILL operation over the Internet.