A Link Management Architecture for IP over Long Distance and High Speed Fixed Wireless Access

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Abstract This paper presents a backup architecture to manage an IP link over a 20-30km distance fixed wireless access (FWA), which was originally designed for several km range of services, to access a point of presence (POP) provided by ISP's. The results of the experiment of 26.1km distance using 21GHz band FWA show the adaptability of FWA to router architectures and the ability to provide an access link of commercial quality under a suitable policy backup control.

1 Introduction

KDD (Kokusai Denshin Denwa Co. Ltd.) has been providing an FWA service as an LDR (Local Distribution Radio) system with the service distance of 8km since 1988. The most attractive advantage of LDR is that it is quite easy to set up a high speed link (originally up to 2Mbit/s, currently 6.3Mbit/s) between a Hub station and a desired location if there is an appropriate installation space and you can look straight that location from the Hub station.

Fixed Wireless Access or FWA, which was formerly defined as WLL (Wireless Local Loop), was developed as a 26GHz band digital wireless subscriber system by NTT in 1985 [26SS-D1], [26SS-PP]. Since that time, several types of systems have been developed for 21GHz, 22GHz and 38GHz bands of FWA [21G-LDR], [LDR]. Despite these development efforts, FWA has not been widely deployed right now. The reasons are (1) the high cost of installation since the FWA equipment is usually put on a roof of building, (2) the low availability of such installation spaces in the enterprise market, and (3) the unreliability of wireless links. The unreliability of FWA comes from the rain attenuation problem of Ka-band propagation [KaBand]. That is, the link will down under a heavy rain fall condition. The reliability depends on the distance between the Hub station and the subscriber's station. The longer, the less reliable.

This paper intends to solve the third deficiency of this technology when used in the Internet or intranet environments, presents a backup architecture to make FWA used with routers, and shows FWA has possibility to provide reasonable quality of Internet access links to enterprise users with a reasonable price. In Section 2, the experimental results using 21GHz FWA link are shown, and FWA is shown to be a suitable link used with routers. Section 3 describes the FWA backup architecture, and defines the domain of problems. Section 4 and Section 5 give the discussions based on these results and conclusions.

2 Experiments Using 21GHz Long Distance FWA

To investigate the practicality of FWA for LAN (Local Area Network) environments, authors set up a 26.1km distance 21GHz FWA link between KDD R.&D. Labs. (Kamifukuoka-shi, Saitama) and KDD Bldg. (Shinjuku, Tokyo), and collected the link status data from 20:25 on May 29, 1995 to 07:08 on July 10, 1996, where the data collection was not done from 14:07:53 on December 28, 1995 to 15:43:02 on January 8, 1996. The system configurations of this experiment are shown in Fig.1, where the protocols used were IP and AppleTalk, and we used KDD's LDR service whose environments were shown in Table 1. In this experiment two LAN segments 26.1 km apart from each other are connected with two types of links, 21GHz FWA (1.5Mbit/s) and 64kbit/s ISDN dialup link, which are connected to a CISCO 2500 router at their edge.

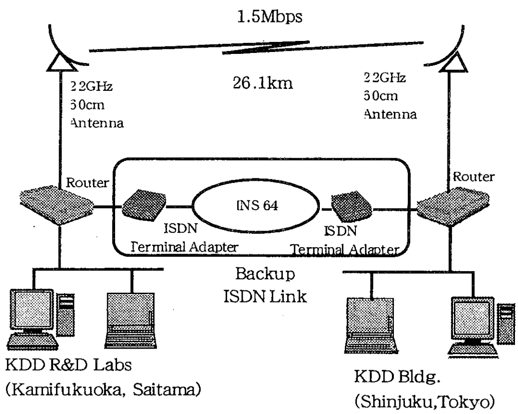

Figure 1: System Configuration of FWA Experiment

Table 1: Link Budget

	KDD R.&D.	KDD Bldg.
Transmit Frequency (GHz)	21.2075	21.8575
Receive Frequency (GHz)	21.2875	21.2075
Transmit Power	0.1W (20dBm)	0.1W (20dBm)
Transmission Rate	1.536Mbit/s	1.536Mbit/s
Antenna	60cm (39.8dB)	60cm (39.8dB)
Rain Attenuation Margin	35dB	35dB

During this time period of 34,247,214 seconds (about 13 months), the status data of routers were captured as UNIX SYSLOG messages. These UNIX SYSLOG messages are gathered by a SPARCstation 20 in each LAN segment.

2.1 Time between Failures

Fig.2 shows the distribution of time between failures. The maximum time between failures was 448, 9144 seconds (about 52 days), and the MTBF (Mean

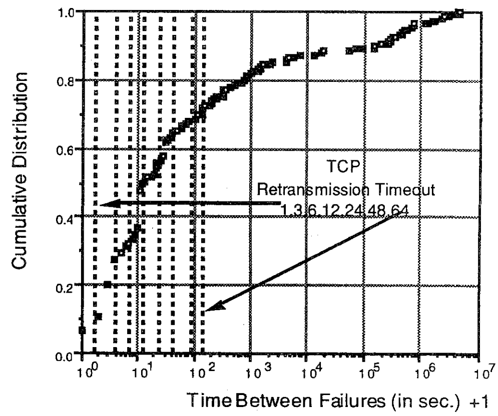

Figure 2: Time between Failures

Time Between Failures) was 130,074 seconds (about 36 hours).

This LDR link was down for 33,129 seconds (LINK-3-DOWN), and for 37,699 seconds (LINEPROTO-5-DOWN), which correspond to 0.097% and 0.110% of the total operation period respectively. Thus the working ratio was 99.89%, which means this link will be down for 9.6 hours per year. This working ratio is about the same value that the analytical method gives with 35dB Rain Margin.

About 70% of the time periods between failures are relatively short and the duration periods are less than the TCP retransmission timeout period.

2.2 Failure Duration

Fig.3 shows the distribution of failure duration time. The maximum failure duration was 3,080 seconds (about 51 minutes). About 80% of the failures have short duration periods, which are less than the TCP retransmission timeout period. This means that, unlike PBX's connected to FWA, TCP/IP based applications do not suffer from 80% of FWA link failures.

"Cumulative Time" in Fig.3 shows the sum of culated from the theoretical analysis. The reason is 26km is too long for rain to fall uniformly.

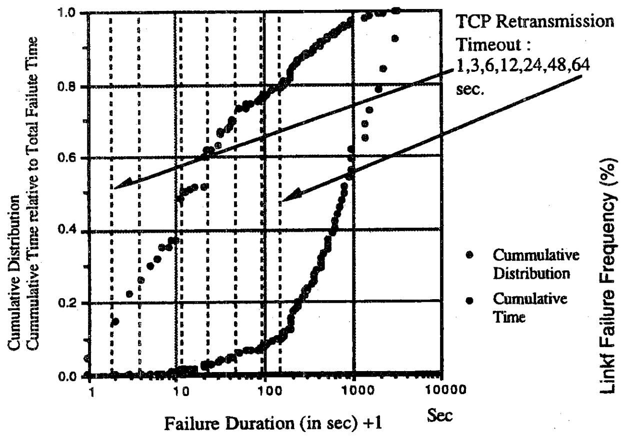

Figure 3: Failure Duration

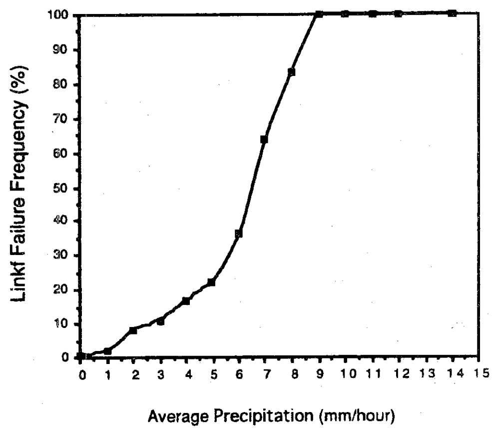

Figure 4: Relation between Failures and Rainfall-rate

the failure duration times less than a specific time period, relative to the total failure duration time. This means TCP saves 11% of FWA link failure time (about 69 minutes), which increases the working rate of TCP link to 99.90%.

AMeDAS is an automatic weather data-collection developed by Japan's Meteorological Agency for monitoring anomalous weather events. Since the robot observatories are spaced about 17km, we picked 4 points nearby Kamifukuoka-shi and Shinjuku such as Urawa, Tokorozawa, Nerima and Tokyo, we approximated the one-hour rainfall-rate data between Kamifukuoka-shi and Shinjuku with the average of those observed at these four points. Let us define link failures for each AMeDAS rainfall-rate as follows: if at least one failure occurs during each AMeDAS observation hour, then this link is considered to failure at the corresponding AMeDAS rainfall-rate.

The link failure frequency for each AMeDAS rainfall-rate is shown in Fig. 4. It is observed that the FWA link failed at probability of 20%, 50%, and 100% for 5mm, 7mm, and 9mm of one-hour rainfall-rate, respectively. This gives a better result than that cal-

3 Backup Architecture

Fig. 1 shows a basic principle to backup an FWA link with routers. Many short FWA link failures occur during a heavy rain period, where each failure period is accompanied by two short link up periods. This reflects that most of link failures and times between failures are short and less than the TCP retransmission timeout period in Fig. 2 and Fig. 3.

Hence the backup procedure must be designed as follows. Firstly the optimum backup must minimize the cost function of two variables, where one of the variables is a backup link usage duration which corresponds a communication cost, and the other is the CPU overhead during the backup process. If we choose to the minimum backup cost, the system must use an FWA link with many consecutive short link failures, which may increase the CPU overhead of the router resulting the increase of packet loss ratio between these routers.

Secondly the backup link needs not be a dialup link. It may Frame Relay, ATM, or other types of leased line circuits. This means the link speed of the backup link varies to a large extent, for examples, from 64kbit/s to 6.3Mbit/s. This may introduce a sophisticated link management policy, especially for relatively low speed backup link such as a dialup ISDN link. During a backup period, applications transferred through an alternative low speed link must be ordered according to their importance in the business. Unimportant messages with high volumes must be reduced to use this low speed link effectively. Mails or SMTP messages may be the most important, and hence with the highest priority in many of the business environments. Since they are queued to transmit, the high priority to them will not give a serious effect to the link usage. The secondly common application will be WWW in the business environments. It is very difficult for a Web user to distinguish a congestion at a link from a congestion of WWW servers, the priority of HTTP messages can be low.

This kind of policy control is very difficult to define a priori, and must be defined according to the importance of each application and the actual daily traffic through the link, which can be gathered by a workstation in each of the segments. The lower backup link speed, the more sophisticated packet prioritization will be needed.

4 Discussion

The following features of FWA show that FWA is extremely suitable to be used with routers. Firstly, according to Section 2, TCP/IP architecture does not suffer from most of the FWA link failures because of TCP Retransmission Control. Secondly, many routers such as CISCO routers have a function to back up a fault link, in this case an FWA link, with the alternative one such as ISDN, FR, etc., by a fixed failure detection time. This gives us a reliable access system with FWA. Finally, the link operator can set up the optimum back up procedure based on the failure detection time calculated from the observations described in Section 2. This kind of static operation may lead to the ISDN back up for FWA failure time (0.110% of the total running time), which means about 8.6 hours per year of ISDN back up ensures the 100% working ratio from the stand point of TCP connections. The combination with this kind of dial-up link may dramatically reduce a operation cost of high speed link, which means FWA has possibility to provide us the least inexpensive systems for high speed Internet access services.

Since the operational environments are different from user to user, these parameters are not fixed values, and need to be optimized according to the environments. An complex policy to back up an FWA link will be required based on the geological location as well as users' application environments. The rainfall attenuation is related to one-minute rainfall rate, the distribution of which varies year by year. The percentage of time rain rate exceeds the ordinate was shown by Y. Karasawa et al. [KaBand]. So the working ratio must be calculated based on this statistical fluctuations.

Applications used by users will also be different from user to user. The priority of each application must be given according to the importance and the statistical usages of this application. In the above sense, an adaptive control system based on the link failure logs and the application usage logs will be needed to reduce the operational cost to keep the optimum backup procedure.

5 Conclusion

This paper presents a backup architecture of FWA to be used for IP links. The experimental results are also presented for 21GHz FWA(1.5Mbit/s).

From this autumn, the market of FWA is put into a new age, an open market. The transmission speed of FWA will increased from the current 6.3 Mbit/s (22 GHz) to 45 Mbit/s (38 GHz) and 155 Mbit/s (22 GHz). This may make FWA more attractive to consumers. Many of the applications using these new wireless links will be IP-based. Some of them will be used by end users, and the others by ISP's. Since it is very difficult to get a high speed link more than 6.3Mbit/s in most of the locations in Japan, especially rural areas, FWA is considered to be an important access media right now. The line speeds and the application environments for these new FWA systems are different from ours in this paper, the backup procedures for these FWA's must be optimized according to their environments.

Authors are still investigating the task of parameter tuning for a new experimental 22GHz band links (6.3Mbit/s) between KDD R&D Labs (Kamifukuoka-shi, Saitama) and Univ. of Tsukuba (Tsukuba-shi, Ibaraki) with a plan to extend this experimental test bed to the wider areas using higher speed FWA links.

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