Alpha-test report of PRUG96 High speed radio link

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Abstract
The PRUG96 system is designed to create a reliable high-speed ham radio based computer network. This report describes a PRUG96 system using IP network protocol. We have an alpha-test structure to make it clear the weakness point of the system. The difference in the daily data throughput in various environments and error rate trend were measured.

1. Introduction

The Prug98 system is designed to create a reliable high-speed ham radio based computer network.

This report describes a PRUG96 system using IP network protocol. Use of other network protocols are expected to make the system match the radio link characteristics.

We have an alpha-test structure to identify the weak points of the system.

Expected cause of weakness.

IP network protocol is used. The network protocol isn't designed to match the radio link character and results in an unreliable link caused by radio phasing, multi-pass, hidden terminal and other problems.

High-speed radio is used. High-speed radio is always expected. High speed is a magic word, but high speed and reliability do not exist at the same time.
A newly designed Spread Spectrum 808kbps radio on 2.4GHz ham band was used.

Data measured. The difference in the daily data throughput in various environments and error rate trend were measured.

2. Structure of the Alpha Test

The test structure consists of five (you've got six stations listed) radio stations in southern Tokyo. Their antenna highs are listed for reference.

JG8OOM	30m	Rooftop of a ten-story building
JL1ZCF	6m	Rooftop of a two-story house
7K4KES	5m	
7K4JBX	9m	Rooftop of a three-story house
JM1ZNW	8 m	Rooftop of a two-story house

This test environment is similar to practical use. Not all the stations are line of sight.
Hidden terminals do exist. The distance between stations are from 200m to 2000m. Error rate is not always of a level necessary to maintain a lasting link.
Our PRUG96 system provides automatic routing system. The routing table changes dynamically.

3. Throughput

FTP Throughput. Throughput numbers described here are measured by the FTP application. Note that the real throughput of radio porting is much better. The radio handles data and large overhead for better error correction.

Best throughput

Tables 1 through 4 show the best results. They show approximately 10kbps per second throughput. Which is better than ISDN (64kbps) or High-speed modem (56kbps) links. It must be noted that the same test in a room resulted in up to 15kbyte per second.

File Size	File Transfer Time	File Transfer speed
920504 byte	**84.45** sec	10.64 Kbyte/sec
920504 byte	122.96 sec	**7.3** 1 Kbyte/sec
920504 byte	89.41 sec	10.05 Kbyte/sec
384124 byte	**28.63** sec	13.10 Kbyte/sec
384124 byte	?	12.86 Kbyte/sec

Table 1: 7K4JBX -> JG8OOM

File Size	File Transfer Time	File Transfer speed
920504 byte	157.12 sec	5.72 Kbyte/sec
384124 byte	50.97 sec	7.36 Kbyte/sec

384124 byte	38.49 sec	9.75 Kbyte/sec
3 84 124 byte	44.70 sec	7.55 Kbyte/sec

Table 2: 7K4JBX <- JGSOOM

File Size	File Transfer Time	File Transfer speed
128640 byte	10.83 sec	11.60 Kbyte/sec
384124 byte	36.74 sec	10.21 Kbyte/sec
384124 byte	52.52 sec	7.14 Kbyte/sec
384124 byte	35.65 sec	10.52 Kbyte/sec

Table 3: 7K4JBX -> 7K4KES

File Size	File Transfer Time	File Transfer speed
384124 byte	56.68 sec	6.62 Kbyte/sec
384124 byte	35.26 sec	10.64 Kbyte/sec
384124 byte	29.68 sec	12.64 Kbyte/sec

Table 4: 7K4JBX <- 7K4KES

Under Interference

Tables 5 through 7 show the influence of concurrent access to one FTP server. The Difference between two equal application users is expected to be caused by radio interference between these two users. JG8OOM is located on the top of high building vice 7K4KES, who is in a residential area. This result may be explained by 7K4KES's receiver blocking caused by JG8OOM's transmission. JGSOOM and 7K4KES are often thought of as hidden terminal in relation to each other.

File Size	File Transfer Time	File Transfer speed
384124 byte	a) 29.75 sec b) 68.07 sec	12.61 Kbyte/sec 5.51 Kbyte/sec
384124 byte	a) 33.32 sec b) 33.32 sec	11.26 Kbyte/sec 5.79 Kbyte/sec
384124 byte	a) 26.61 sec b) 54.62 sec	14.10 Kbyte/sec 6.87 Kbyte/sec

Table 5: a) 7K4JBX -> JGSOOM, b) 7K4JBX -> 7K4KES

File Size	File Transfer Time	File Transfer speed
384124 byte	a) 45.25 sec b) 88.49 sec	7.60 Kbyte/sec 4.29 Kbyte/sec
384124 byte	a) 29.44 sec b) 66.88 sec	12.74 Kbyte/sec 5.61 Kbyte/sec
384124 byte	a) 27.43 sec b) 64.90 sec	13.68 Kbyte/sec 5.78 Kbyte/sec

Table 6: a) 7K4JBX -> JGSOOM, b) 7K4JBX <- 7K4KES

File Size	File Transfer Time	File Transfer speed
384124 byte	a) 73.23 sec b) 81.49 sec	5.12 Kbyte/sec 4.60 Kbyte/sec
384124 byte	a) 85.49 sec b) 72.74 sec	4.39 Kbyte/sec 5.16 Kbyte/sec
384124 byte	a) 68.84 sec b) 46.06 sec	5.45 Kbyte/sec 8.14 Kbyte/sec

Table 7: a) 7K4JBX <- JGSOOM, b) 7K4JBX -> 7K4KES

Tables 8 through 9 show two pairs of server/client FTP transfer throughput. It means that there was almost equal resources distributed to each pair.

File Size	File Transfer speed
384124 byte	a) 7.79 Kbyte/sec b) 4.60 Kbyte/sec
384124 byte	a) 3.67 Kbyte/sec b) 5.45 Kbyte/sec
384124 byte	a) 3.49 Kbyte/sec b) 6.26 Kbyte/sec

Table 8: a) 7K4KES -> 7K4JBX, b) JGSOOM -> JL1ZCF

File Size	File Transfer speed
384124 byte	a) 5.04 Kbyte/sec b) 4.44 Kbyte/sec
384124 byte	a) 8.50 Kbyte/sec b) 4.75 Kbyte/sec
384124 byte	a) 5.25 Kbyte/sec b) 4.51 Kbyte/sec

Table 9: a) 7K4JBX -> 7K4KES, b) JGSOOM -> JL1ZCF

4. Fluctuation of error rate

Figure 1 shows error rate fluctuation on a specific day. Error rates change periodically. The rate falling in morning exists daily. Another dip often arises early in the evening, especially between 16:00 and 18:O0. The cause is not clear, but it is possibly as stated below:

a. Microwave oven. Many ovens are active during mealtimes. This particular phenomenon may by explained by effect caused by the microwave oven's radiation.

b. Traffic. Good rates were achieved at midnight. Vehicle activity may responsible to the radio link failure.

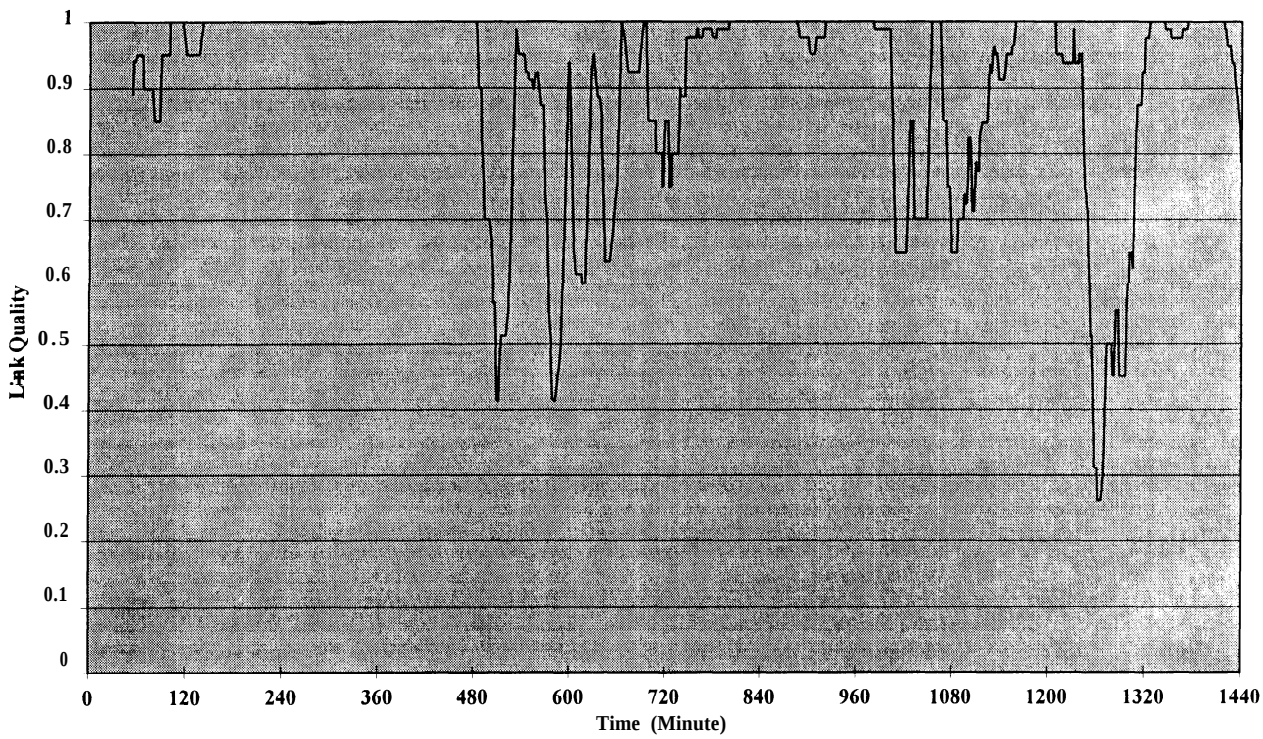

Figure 1: Fluctuation of error rate

5. Conclusion

Practicality assessment

(1) Application throughput was found to be competitive with commercial high-speed data communication services on wire.

The field test showed that up to 14kbyte per second throughput on FTP transfer rates were achieved.

(2) Automatic routing function

Automatic routing is a principal characteristic of the PRUG96 system. The distributed routing function will make this system practical on dynamic changing data pass in ham radio networks.

(3) Radio link fluctuates even on relatively short distance.

This weakness is expected to be solved using an additional power amplifier. A 20-25 dBm output amplifier has been designed and is currently under testing.

(4) Hidden terminal problem.

The alpha test was based on mixed protocol layers with the newly designed routing function and existing functions (i.e. CSMA).

Mismatching between existing protocol layers and radio physical layers will be solved with the implementation of a newly designed media access layer, network layer, and transport layer. PRUG is now designing plural original media access layers and is researching higher layers.

In the future. Error rate trends over long periods will be measured.
We are interested in studying the relationship between data error rate and weather conditions and the day of the week.