A DUPLEX PACKET RADIO REPEATER APPROACH TO LAYER ONE EFFICIENCY

PART TWO

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BACKGROUND

Last year the authors presented the first part of this paper at the 6th conference by presenting related material NOT contained within the text of the published paper itself. The intent of the verbal presentation was to spur interest in reading the published paper itself. This presentation contained a simple mathematical examination of simplex versus duplex repeater approaches to local area network implementation. In contrast the paper contained the design goals and basic equipment approach we implemented in our duplex repeater environment here in Southern California.

THE PURPOSE

The purpose of our verbal presentation was to startle the audience into accepting duplex packet repeaters' INHERENT superior performance profile. We supported this position with 'hard numbers' presented in chart form. We then hoped this audience 'realization' would lead to examination of our written paper.

Many conference attendees asked us to consider publishing the verbal presentation material. We therefore are including these charts for publication this year. Some explanation is required to accompany these charts.

THE CHARTS

Chart number one is the visual representation of the network 'topography' associated with simplex store and forward repeating's "HIDDEN TERMINAL" effect. Of course it is a problem because it leads to channel capacity limitation due to collision potential. This is covered in depth as basic packet primer material in many papers and networking texts. (Does anyone in ham packet not know about this?) But it does serve a useful purpose in logically leading into the next chart.

Chart number two is a less well known (at least by name) simplex digital effect called **EXPOSED TERMINAL? While the newer versions of layer two and especially layer three, which have become prevalent within the last year, have a tendency to diminish the effects of this simplex related problem, they by no means eliminate it to the extent that duplex does.

Chart number three examines why in some visual detail. Topographic R.F. barriers are of no concern if a properly coordinated AND balanced duplex repeater is used. As long as a user can 'hear and copy' the duplex repeater's output these barriers and users' relational proximity to them can do no harm.

Chart number four explains how this lack of susceptibility to hidden terminal effects relates to improved performance for a duplex packet repeater. On the top left half of the page the transmission timing of the simplex LAN (local area network) is totaled and the percentage of this time which is exposed to possible collisions is determined. This assumes two simple constructs. First a packet length of three seconds, which the authors feel is a valid average that occurs, at least here in southern California, on LAN's. The second assumption is that all user transmissions and delay intervals are time periods in which collisions may take place. On the right half the same user's packet is examined on a duplex based LAN. But this time since there are no hidden terminals, the user's packet transmission interval is NOT available for possible collisions, and therefore only the delay intervals are added to achieve a percentage of time exposed to these collisions. Since a duplex repeater doesn't store and forward, there is just one packet transmission interval, and approximately one-half the total time slot of a simplex store and forward relay of the packet.

From here the chart makes a simple comparison of total time figures. With no collisions taking place the duplex channel has a 10% advantage of speed over a simplex channel, when adjusted for bandwidth. But perhaps no collisions is not a real world issue? Well then the chart does examine a heavy loaded channel. The equation for this % of duplex traffic handling improvement = 100 x (1 minus (((1 + E duplex) x T duplex) / ((1 + E simplex) x T simplex))), where E is exposure time to collisions and T is the total packet timing interval. This figure is a whopping 37% EVEN WHEN ADJUSTED FOR BANDWIDTH.

It should also be noted that this chart does not take into account any of the exposed terminal effects. Basically since an exposed terminal is outside of the topographical boundaries of a duplex repeater's LAN, it can be safely assumed to have only detrimental effects for a simplex network. Therefore the 37% figure above is probably conservative in most highly populated areas with the attendant scarcity of resource and therefore geographically 'reused' and heavily loaded channels.

Chart number five is self explanatory on the right side but requires some guidance on the left. Item number one assumes that the addition of exposed terminal effects can safely double the performance degradation of simplex repeaters and therefore the 68% figure. Items three through seven are explained or are logical extensions of the material covered in the authors' paper from last year. Item number eight assumes that like all good voice repeaters the duplex repeater will have a well balanced receive to transmit coverage, and unlike simplex repeaters isn't plaqued by poorly coordinated channel and user activity.

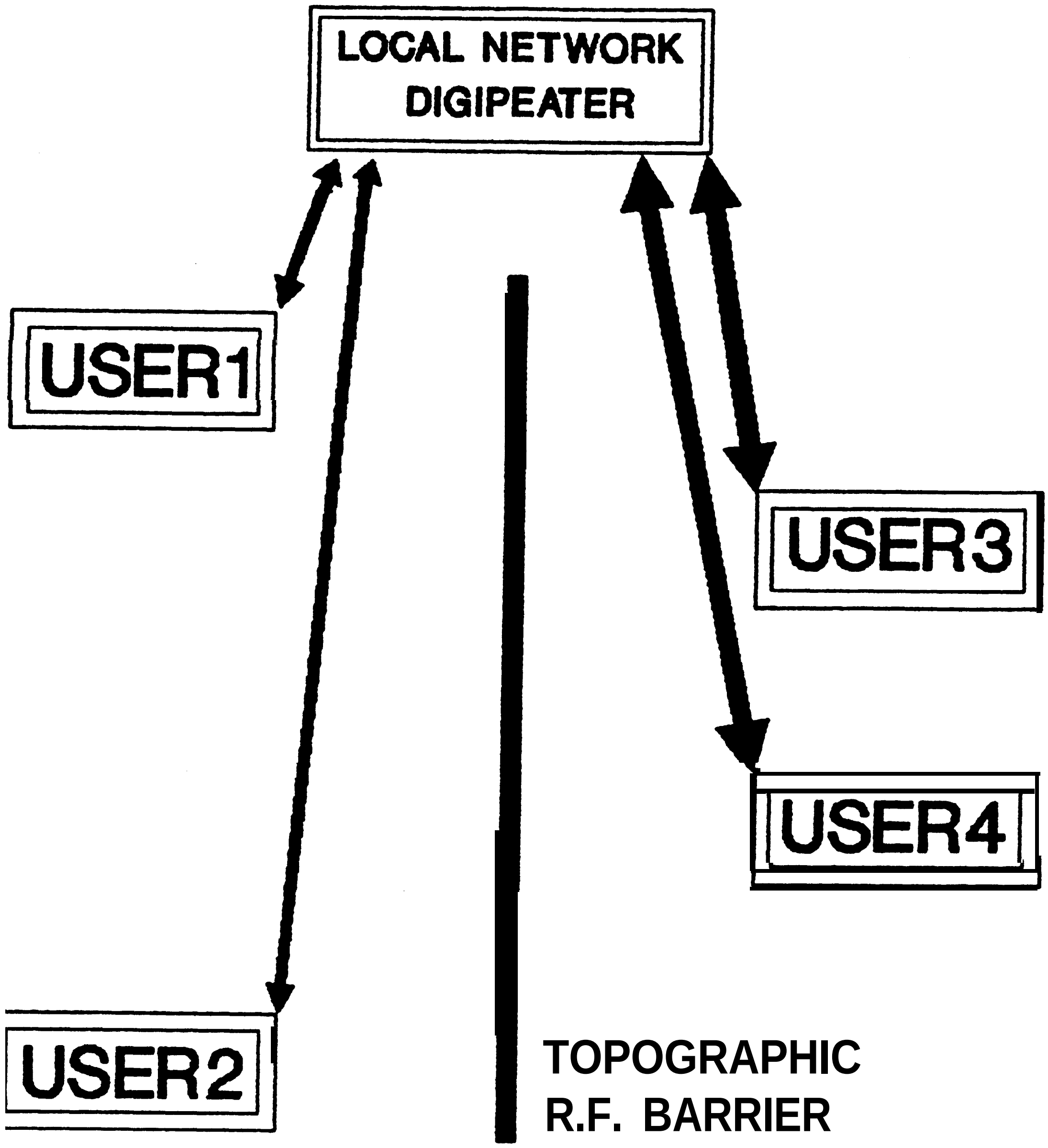
The final chart, number six, is for reference. It is explained in detail in last year's paper (part one). However when we wrote last year's paper we were using a directly connected rs-232 internetwork access port, Since that time the current four port interconnect has been relocateed to another site and the current repeater configuration is as drawn in this chart.

IN CONCLUSION

We hope that these charts will begin to open up thought with the further hope that other parts of the country will begin to have duplex packet LAN's. Since the publication of part one of this paper, the authors have heard of but a scant few duplex repeaters being opened up for packet use. We can think of no better ways, all other things being equal, to significantly improve layer one, than the addition of some cavities, a 202 modem, and some shielding. Failure to provide an efficient layer one network base, is like building a skyscraper upon a foundation of sand.

CHART 1

SIMPLEX PACKET NETWORK
'HIDDEN TERMINAL' EFFECT

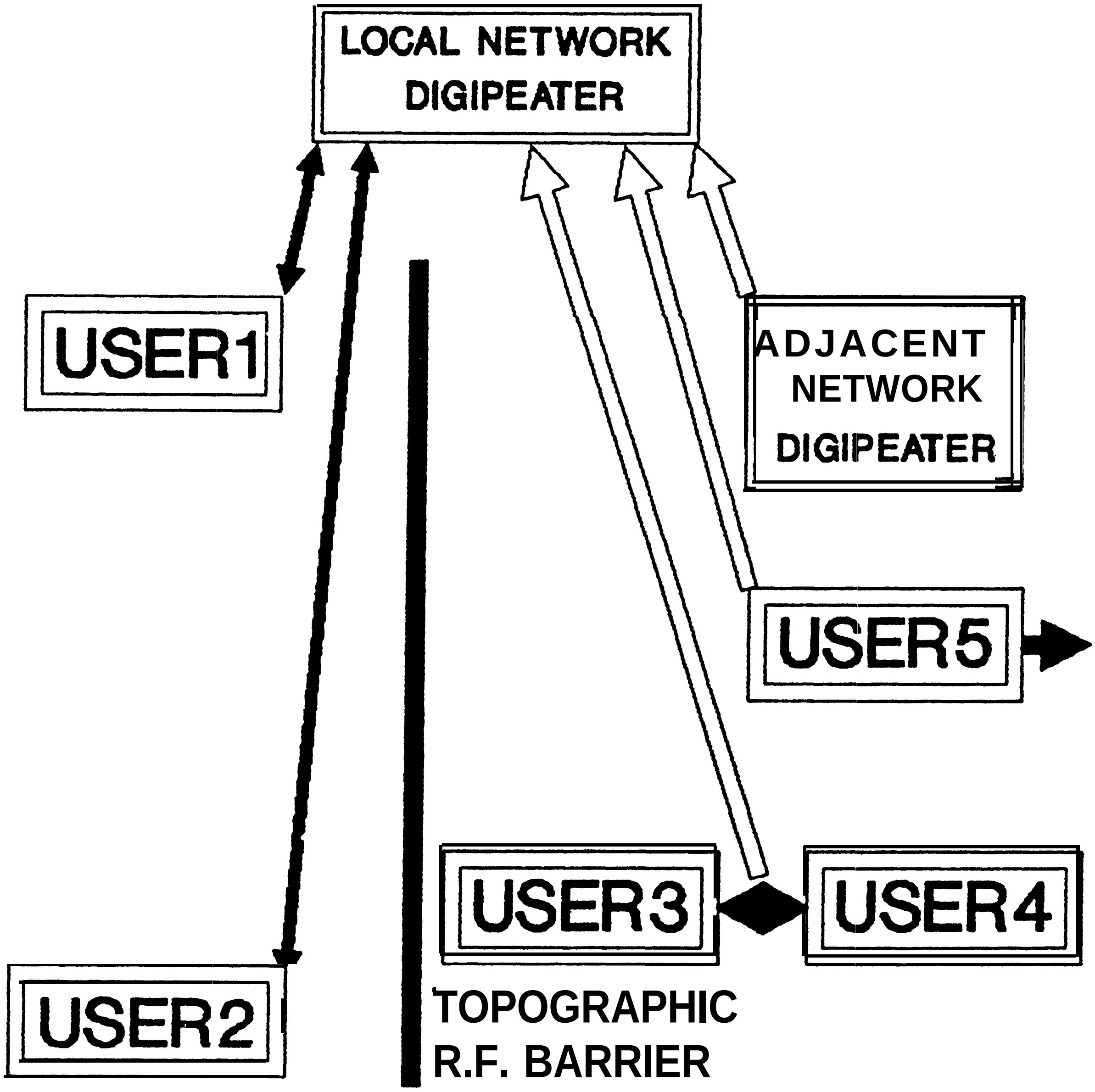


Users cannot copy those on the other side of the topographic barrier directly
User 1 will destroy packets from 3 and 4
users 3&4 will destroy packets from 2.

CHART 2

SIMPLEX PACKET NET'WORK

'EXPOSED TERMINAL' EFFECT

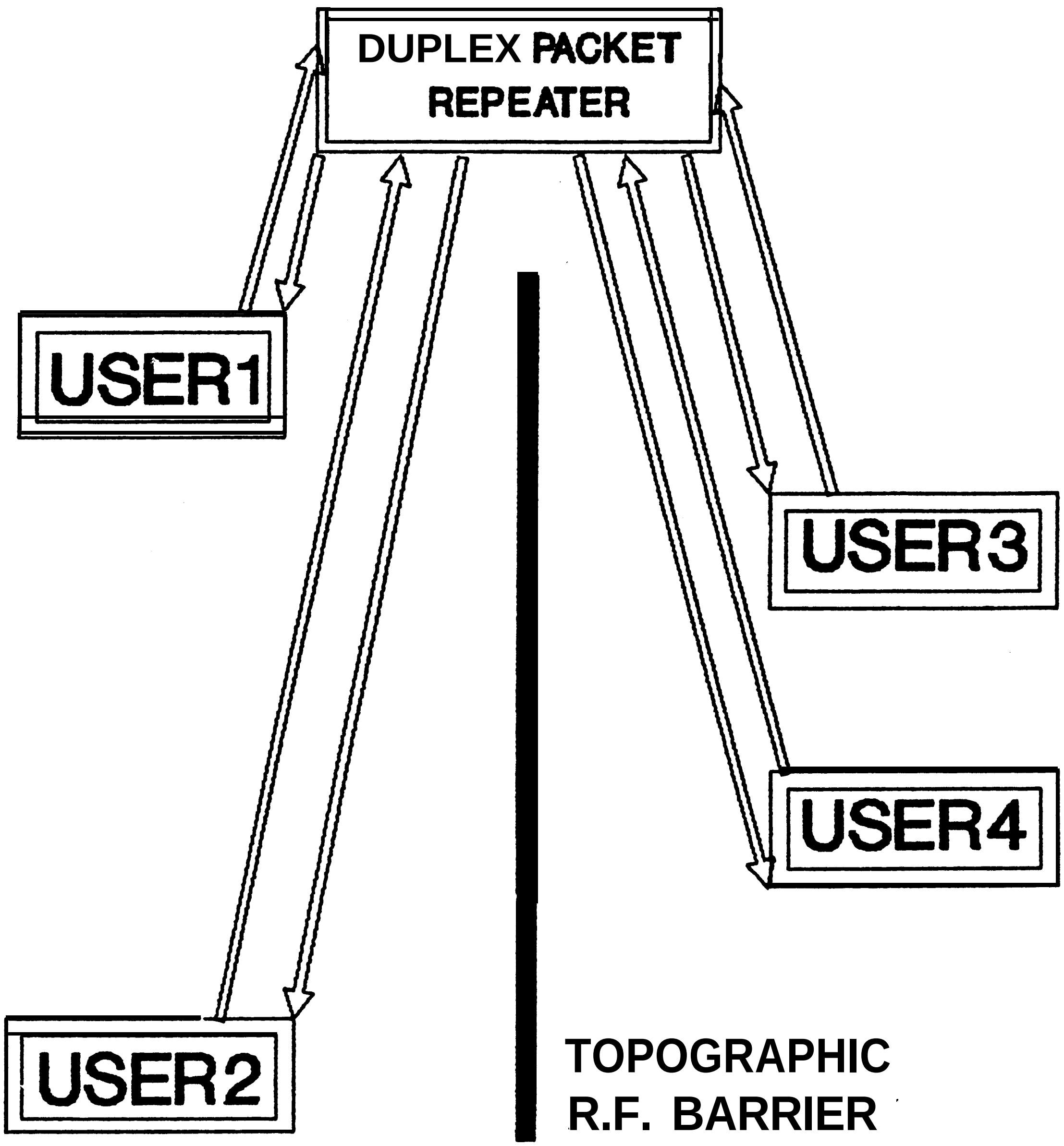


Distant signals from adjacent digipeater direct users 3 & 4, and DX'er 5, cause local digipeater to hold off all output transmissions until channel is clear.

CHART 3 --

DUPLEX PACKET NETWORK

COLLISION RESISTANT LAN



Each user can copy all others on the LAN regardless of physical location.

Users transmit on uplink channel and receive on output channel of repeater.

CHART 4

COMPARISON OF DATA TRANSMISSION TIMING AND PROBABILITY OF COLLISIONS OCCURING ON A SIMPLEX AND DUPLEX LAN

SIMPLEX LAN (ONE DIGIPEAT)	TIME (mSec)
User1 keyup dly	10
Digi DCD dly	10
User1 XMIT	3000
Digi keyup dly	10
User2 DCD dly	10
Digi XMIT	3000
User2 T2 timer	1000
User2 keyup dly	10
Digi DCD dly	10
User2 ACK	1000
User1 DCD dly	10
Digi ACK	1000
TOTAL TIME (mSec)	9070

Percentage of time exposed to collisions: 44.9 %

DUPLEX LAN (REPEATER)	TIME (mSec)
User1 keyup dly	10
Rptr DCD dly	20
Rptr keyup dly	0
User2 DCD dly	10
User1 XMIT	3000
User2 keyup dly	10
Rptr DCD dly	20
Rptr keyup dly	0
User1 DCD dly	10
User2 ACK	1000
TOTAL TIME (mSec)	4080

Percentage of time exposed to collisions: 2 %

Transmission speed advantage (apparent to the end user) of a duplex LAN over simplex, assuming that no collisions have occured during the transmission: 55 %

A duplex system requires TWO channels to operate, which would be equivalent to TWO simplex networks simultaneously.
Again, we assume no collisions have occured.
Advantage of Duplex adjusted for RF bandwidth used: 10 %

The real advantage of a duplex LAN comes out when the channel is heavily loaded. Here is an example using the arbitrary collision exposure figures shown above. For pedagogical reasons we assume that retries will occur at a rate approaching the percent exposure to collisions, and that the data will make it through *on* the first *retry.* All stations are assumed to be 'Hidden Terminals' in this model-

Advantage of duplex (apparent to the end user) in a heavily LAN, not adjusted for RF bandwidth used: 68.3 %

Advantage of duplex in a heavily loaded LAN, adjusted for RF bandwidth used: 36.7 %

CHART 5

COMPARISON OF FEATURES BETWEEN LAN TYPES

DUPLEX LAN (repeater)

* Up to 68% higher data throughput
* Superior collision resistance
* Can be used with various protocols simultaneously, making it a good test bed for advanced data transmission protocol experiments
* Can support 'Roundtable' nets
* Can be linked to a 'Backbone' net using Dualport or Net/Rom node
* Existing voice repeater can be shared or converted entirely to digital use
* Cash outlay to convert an existing repeater is fairly low (if no network access is desired)
* LAN boundaries are well defined, by repeater coverage area

SIMPLEX LAN (digipeater)

* Simpler and cheaper to construct
* Channel assignments more available
* Easier to network in low use areas
* Requires only half the RF bandwidth of a duplex LAN
* Can be linked to a 'Backbone' net with Dualport or Net/Rom software
* Supported better by manufacturers and software designers

CHART 6

Duplex Repeater Block Diagram