To ~~Multics Administrative Distribution~~ file

From: J. H. Saltzer
Subj: Busy signal rates: observed and predicted
~~As the number of~~

~~As~~ Whenever the load on Multics changes, a new flood of ~~busy signal~~ Telephone busy signal reports arrives. To aid in anticipating, rather than reacting to, this perennial problem, ~~I have worked out~~ evolved an some more precise prediction of the traffic handling capability of our step-by-step exchange. ~~These predictions are illustrated in figure 1, which~~ For the present switch configuration, which uses a single digit to access a trunk group, figure 1 ~~gives the~~ allows one to estimate the busy signal frequency for various ~~situations~~ levels of ~~trunk~~ trunk loading. For example, ~~[illegible] 25% of the~~ [illegible] one has a group of 64 trunks (as the present 2741 trunk group) then if the trunks are 75% loaded (~~48~~ that is, 48 are in are) a potential 44th caller will receive a busy signal with ~~probability~~ frequency ~~somewhere between~~ about .05 -- about 1 in 20 calls. Appendix 1 gives the detailed formula from which figures are were drawn. The formulas given there are derived using an ~~the very significant~~ not-well-founded assumption: that successive ~~all or more~~ calls ~~are~~ originate uniformly, at random throughout the network, ~~and that the "grading" pattern of the network is also randomly arranged.~~ with respect to the pattern of graded connection in the data switch. The present pattern of calls and grading pattern combine to give a measured busy signal probability much higher than that indicated in the diagram.

~~Hence~~ One question of some import is to settle on an acceptable probability of busy signal. The Telephone company normally considers that if 1 or 2 calls ~~in a~~ out of a hundred are blocked by the network during the busiest ~~one~~ hour, ~~that~~ service is just acceptable. This acceptability is based on a very important property of voice traffic, however: short telephone talking (holding) times. In a step-by-step exchange, if a busy signal is received, despite free trunks, it is because exactly ten other ~~conversa~~ conversations have conspired to block access to the free trunks. Thus, one must wait for at least one of the ~~one~~ ten conversations to be broken down before redialing will not just get another busy signal. Since voice conversations average about 2 minutes in length, one must wait an average of about 2/10 minute (12 seconds) before redialing ~~has a chance~~ gives a new opportunity. Since this is less than the time it takes to redial, a second dialing almost always finds a new pattern of ~~two~~ interconnection somewhat independent of the ~~blocked~~ one encountered when the busy signal was originally received. Thus, the chance that two successive tries, no matter how closely spaced, will both receive a busy signal is

about

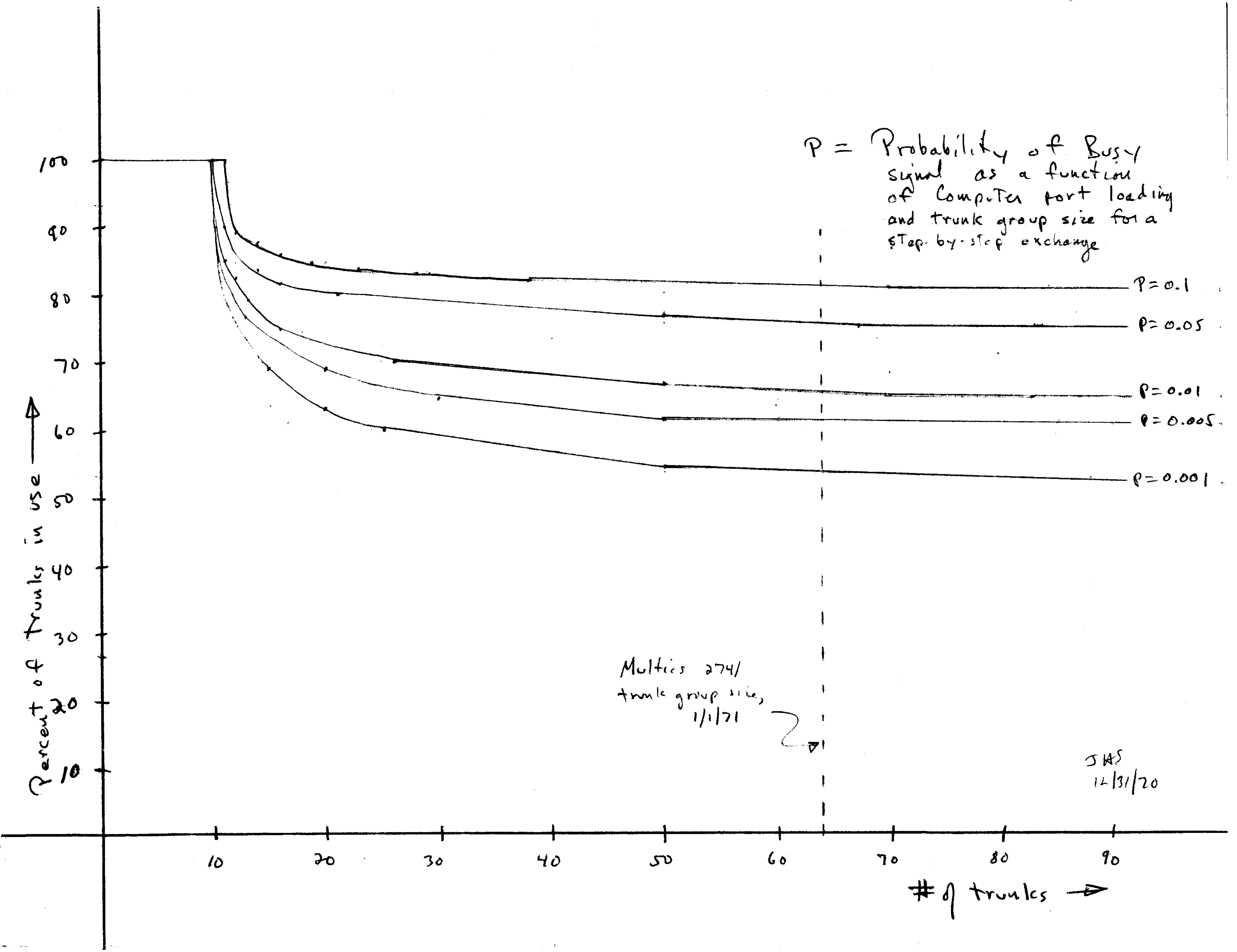
$$\frac{2}{100} \times \frac{2}{100} = \frac{4}{1000}$$

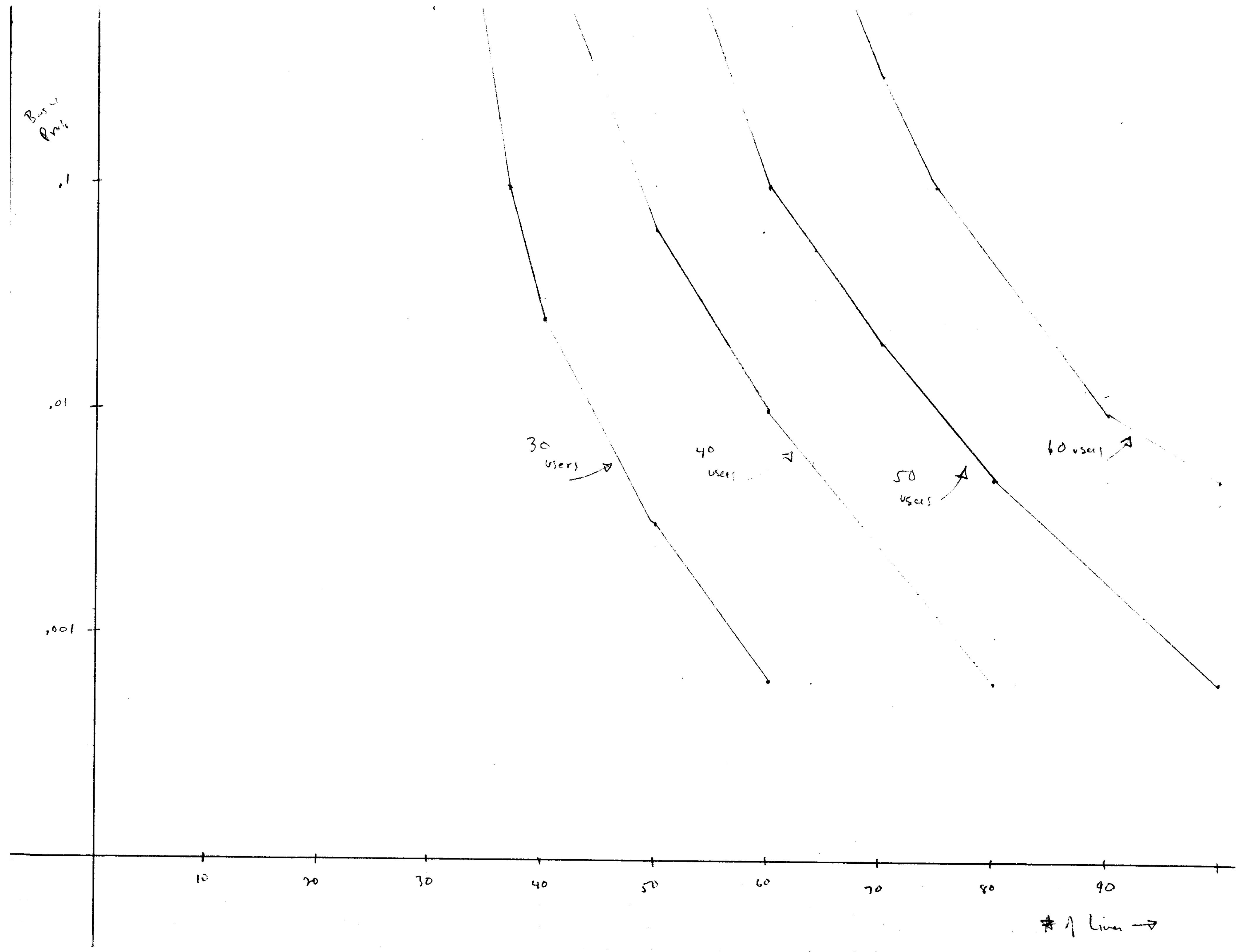
for voice telephone traffic; the average customer would thus notice such a condition once every four years, and not complain.

For data traffic, ~~the long holding~~ observed longer holding times make for a much different result. For example, in November, 1970, the average holding time for callers to Multics was 40 minutes. If one is waiting for the completion of ~~competing with~~ one of ten such callers ~~for access to a trunk group~~, one must wait an average about 4 minutes for access to the trunk group. ~~for one of these to complete~~. Thus, if one receive a busy signal ~~from the exchange~~, he can expect to receive the same busy signal over and over again for about 4 minutes. As a result, one may say that a busy signal frequency of one ~~in~~ 2 in 100 is made more annoying than with voice traffic, ~~in the data case~~, since

~~the call cannot be completed or one must get a new opportunity~~

that will be encountered more often, say once per month


P = Probability of Busy signal as a function of Computer port loading and trunk group size for a step-by-step exchange
Percent of trunks in use
100
90
80
70
60
50
40
30
20
10
P=0.1
P=0.05
P=0.01
P=0.005
P=0.001
Multics 274/ trunk group size, 1/1/71
10
20
30
40
50
60
70
80
90
# of trunks
JHS
12/31/70


Busy Prob
.1
.01
.001
10
20
30
40
50
60
70
80
90
30 users
40 users
50 users
60 users
# of Lines →