Resource Optimization Using PV Proprietary Approach

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The use of diversity factor is always a wise choice in any system design where there is a large population of users with finite number of resources.

However in most cases, this factor is usually established based on experience or using a similar installation as reference. This assumed factor does not reflect the actual condition and will not provide the user or client the actual picture of its associated risks.

Using the well established Erlang Formula with all the experience and data gained from our past installations, PV is able to compute and generate a detail report on the applied diversity factor with its corresponding risks.

System Usage Queues

Example:

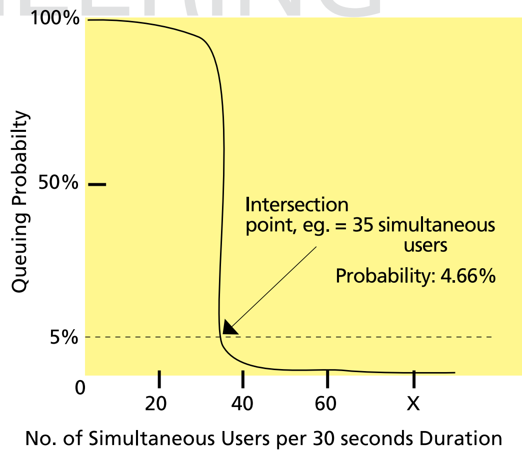
Average Simultaneous Users During Busiest Time :	X per 30 seconds
Average Time for Usage per Vacuum Point :	10 seconds

Let us plot the queuing probability.
See chart below :

Number of simultaneous users VS Queuing probability

Plot Queuing Probability for 1 to X simultaneous users. Using Erlang Delay Formula. Assume we want a probability of less than 5%.

Design Sys: 1 to x Users per 30sec Capacity



Using our report, user or client will now be able to make an informed decision on whether they should adopt the suggested diversity factor according to their own risk assessment criteria for the process or production.

In this example, designing the Centralised Vacuum System to support 68 simultaneous point of use will allow the owner's Risk Tolerance of less than 5% to be achieved.

Examples to be followed in the next pages.

ENGINEERING COMPUTATION SHEET

Project Name: XXXXX

Project No: NA Date: XX-X-XXXX

Subject: Probability Of Waiting To Use System

CENTRAL VACUUM SYSTEM

System Usage Queues

Assume that during the busiest time, an average of 163 users demand per 30 Seconds, and the average usage time (use per vacuum point) is 10 seconds.

Average Users' demand rate during the busiest time:	$\lambda := \frac{163}{30sec}$
Average time for Usage At Each Vacuum Point:	$x := 10 \cdot sec$

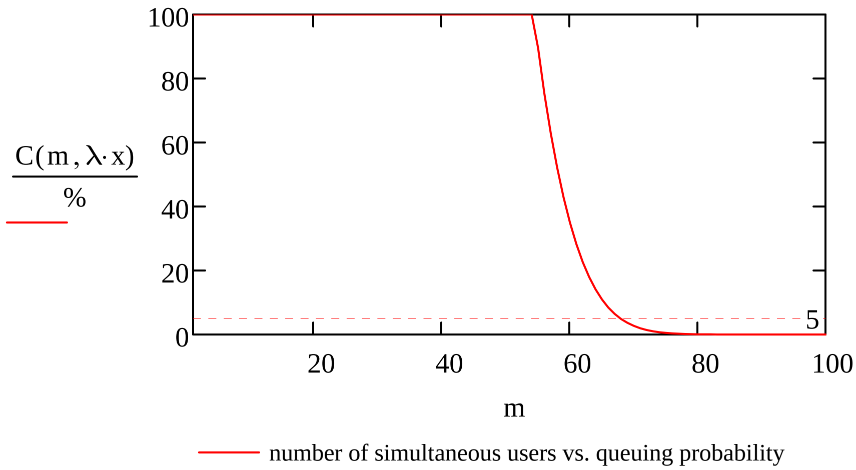
We will use queuing theory (the discipline which concerns itself with waiting-in-line systems) to calculate the probability of waiting for use of the system, given the numbers above. We know from queuing theory that, for this type of queuing system, the probability of waiting is given by the Erlang 's delay formula:

$$C(m,a) := \text{if}\left[\frac{a}{m} < 1, \frac{\frac{a^m}{m!}}{\left(1-\frac{a}{m}\right)\cdot\sum_{i=0}^{m-1}\frac{a^i}{i!}+\frac{a^m}{m!}}, 1\right]$$

Here, m is the number of Allow Simultaneous Users In The System, and a = λx. This formula reflects the fact that, for some ratios of Demand to number of Simultaneous Users, there will always be a wait; specifically, if λx / m >1, your changes of waiting for use are 100%.

Let's plot the queuing probability for 1 to 100 Simultaneous Users. Since we want this probability to be less than 5%, this threshold is shown on the graph.

number of simultaneous users $m := 1..100$



It looks like the 5% line crosses the probability curve at around **68**, given this rate of demands. The exact percentage probability of waiting with **68** simultaneous users system is calculated at right.

$$C(68, \lambda \cdot x) = 4.86\%$$

The graph also shows how the probability of having to wait decreases as we add simultaneous users. The trend of the curve is predictable: the more simultaneous users added, the less likely that users will have to wait. Notice also that the relationship is not linear. If only **65** simultaneous users are available instead of **68**, the probability of waiting jumps from 4.86% to over 10.968%: a Two fold increase.

$$\frac{68 - 65}{68} = 4.412\%$$ percent decrease in number of simultaneous users

$$C(65, \lambda \cdot x) = 10.968\%$$ new probability of having to wait

$$\frac{C(65, \lambda \cdot x)}{C(68, \lambda \cdot x)} = 2.257$$ increase in probability

Now, consider what happens if the number of simultaneous users remains the same, but the average demand rate increases. As traffic increases, it's reasonable to expect that the probability of waiting does so as well.

number of simultaneous users $m := 68$

average users' demand rate during the busiest time $\lambda := \frac{1}{30sec}, \frac{2}{30sec} .. \frac{163}{30sec}$