the Availability Digest

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# Avoiding Capacity Exhaustion

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VocaLink

## Introduction by Bill Highleyman

Is your business growing at a rapid rate? Are your IT systems getting close to their capacity limits? Is there enough of a capacity margin to get you through the peaks of the coming year? What will a CPU failure mean in terms of overloading your systems during peak traffic times?

At the recent BITUG (British Isles Tandem User Group) meeting in London in December, 2011, Damian Ward, NonStop Solutions Architect at VocaLink, presented an in-depth analysis of the capacity planning used by VocaLink, the provider of the Faster Payments Service (FPS) and LINK Scheme (LS) service to UK banks. Damian has been immersed in the IT industry for over twenty years and was Vice Chairman of BITUG at the time of his presentation. He is now Chairman.

The technique he describes is based on past statistics and future projections of system traffic. It results in an amazingly simple graphic showing daily “hot spots” predicted for the coming year and predicts the probability that a CPU failure during a particular hot spot will cause an overload condition. Damian shows how this analysis was recently used to select an LS service upgrade strategy from several options.

## LINK is the UK's cash machine network.

Virtually every cash machine in the UK is connected to LINK, and LINK provides the only route through which debit card and ATM card issuers can offer their customers reliable nationwide access to cash. All of the UK's significant debit and ATM card issuers are LINK members.

Cash machine operators who want to deploy ATMs in the UK must join the LINK scheme in order to be able to offer cash to the 100 million LINK-enabled cards in circulation.

LINK cash withdrawals can exceed £10 billion per month in value and at its busiest; LINK processes over 1 million transactions an hour and experiences transaction arrival rates of up to 482 transactions per second.

The number of cash machines in the UK has grown from 36,000 in 2001 to around 64,500 today. The number of free-to-use ATMs is at an all-time high of over 42,000. Almost 97% of all ATM cash withdrawals by UK cardholders in the UK are made free of charge.

## Transaction Volume Forecasting

The process begins by forecasting the daily volume over the next 24 months, a remarkable task in itself. This is done via a combination of past daily statistics and future monthly projections. Specifically these are not IT led forecasts but come from the business, although we can help with the modelling.

### *Monthly volume Forecasting*

The high level data used for transaction forecasting must come from the business. This approach not only ensures that any new business initiatives are taken into account but also serves to protect IT from the dangers of reliance on past data only.

The business provides monthly transaction volume forecast data covering a rolling 24 month period.

### *Past Daily Projections*

VocaLink uses historical transaction data to determine various peak ratios:

- Year to Peak Month
- Peak Month to Peak Day
- Peak Day to Peak Hour
- Peak Hour to Peak Minute
- Peak Minute to Peak Second

As an example, this analysis might lead to the following tables. Given a monthly transaction volume, Table 1 shows the ratios to determine the peak day, the peak hour, the peak minute, and the peak second of the month. VocaLink's data shows that the peak day of the month is always the last Friday of the month[1]. Table 2 allows the calculation of the peak traffic on the other Fridays relative to the peak Friday. For months with five Fridays, a fifth Friday ratio is included). Table 3 then allows these projections to be extended to the other days of the week for each week in the month.

| Period | Ratio |
|---|---|
| Monthly volume | given |
| Peak Day | 0.05 |
| Peak Hour | 0.09 |
| Peak Minute | 0.02 |
| Peak Second | 0.02 |

**Period Ratios**
**Table 1**

| Friday | Ratio |
|---|---|
| 1st | 0.92 |
| 2nd | 0.92 |
| 3rd | 0.93 |
| 4th | 1.00 |

**Friday Ratios**
**Table 2**

| Weekday | Ratio |
|---|---|
| Monday | 0.69 |
| Tuesday | 0.72 |
| Wednesday | 0.74 |
| Thursday | 0.80 |
| Friday | 1.00 |
| Saturday | 0.89 |
| Sunday | 0.57 |

**Weekday Ratios**
**Table 3**

For instance, if the monthly volume is 250,000,000 transactions, the last Friday in that month would process 12,500,000 transactions, the peak hour 1,125,000 transactions, the peak minute 22,500 transactions, and the peak second 450 transactions. The peak transaction rate for the third Friday of that month would be 418 transactions/sec. (.93 x 450), and the peak transaction rate for the Tuesday of that week would be 301 transactions/sec. (418 x .72).

This start of this process is illustrated below:

[1] With the exception of Christmas and other holiday periods which are modelled manually.

| | | | | |
|---|---|---|---|---|
| June 2012 | WEEK 23 | Mon | 28-May | 0 |
| | | Tue | 29-May | 0 |
| | | Wed | 30-May | 0 |
| | | Thu | 31-May | 0 |
| | | Fri | 01-Jun | 0 |
| | | Sat | 02-Jun | 0 |
| | | Sun | 03-Jun | 0 |
| | WEEK 24 | Mon | 04-Jun | 0 |
| | | Tue | 05-Jun | 0 |
| | | Wed | 06-Jun | 0 |
| | | Thu | 07-Jun | 0 |
| | | Fri | 08-Jun | 0 |
| | | Sat | 09-Jun | 0 |
| | | Sun | 10-Jun | 0 |
| | WEEK 25 | Mon | 11-Jun | 0 |
| | | Tue | 12-Jun | 0 |
| | | Wed | 13-Jun | 0 |
| | | Thu | 14-Jun | 0 |
| | | Fri | 15-Jun | 0 |
| | | Sat | 16-Jun | 0 |
| | | Sun | 17-Jun | 0 |
| | WEEK 26 | Mon | 18-Jun | 0 |
| | | Tue | 19-Jun | 0 |
| | | Wed | 20-Jun | 0 |
| | | Thu | 21-Jun | 0 |
| | | Fri | 22-Jun | 14,474,142 |
| | | Sat | 23-Jun | 0 |
| | | Sun | 24-Jun | 0 |
| | WEEK 27 | Mon | 25-Jun | 0 |
| | | Tue | 26-Jun | 0 |
| | | Wed | 27-Jun | 0 |
| | | Thu | 28-Jun | 0 |
| | | Fri | 29-Jun | 0 |
| | | Sat | 30-Jun | 0 |
| | | Sun | 01-Jul | 0 |

**Stage 1**
**insert 4th Friday volume**

| | | | | |
|---|---|---|---|---|
| June 2012 | WEEK 23 | Mon | 28-May | 0 |
| | | Tue | 29-May | 0 |
| | | Wed | 30-May | 0 |
| | | Thu | 31-May | 0 |
| | | Fri | 01-Jun | 11,103,754 |
| | | Sat | 02-Jun | 0 |
| | | Sun | 03-Jun | 0 |
| | WEEK 24 | Mon | 04-Jun | 0 |
| | | Tue | 05-Jun | 0 |
| | | Wed | 06-Jun | 0 |
| | | Thu | 07-Jun | 0 |
| | | Fri | 08-Jun | 11,838,953 |
| | | Sat | 09-Jun | 0 |
| | | Sun | 10-Jun | 0 |
| | WEEK 25 | Mon | 11-Jun | 0 |
| | | Tue | 12-Jun | 0 |
| | | Wed | 13-Jun | 0 |
| | | Thu | 14-Jun | 0 |
| | | Fri | 15-Jun | 13,106,336 |
| | | Sat | 16-Jun | 0 |
| | | Sun | 17-Jun | 0 |
| | WEEK 26 | Mon | 18-Jun | 0 |
| | | Tue | 19-Jun | 0 |
| | | Wed | 20-Jun | 0 |
| | | Thu | 21-Jun | 0 |
| | | Fri | 22-Jun | 14,474,142 |
| | | Sat | 23-Jun | 0 |
| | | Sun | 24-Jun | 0 |
| | WEEK 27 | Mon | 25-Jun | 0 |
| | | Tue | 26-Jun | 0 |
| | | Wed | 27-Jun | 0 |
| | | Thu | 28-Jun | 0 |
| | | Fri | 29-Jun | 12,810,478 |
| | | Sat | 30-Jun | 0 |
| | | Sun | 01-Jul | 0 |

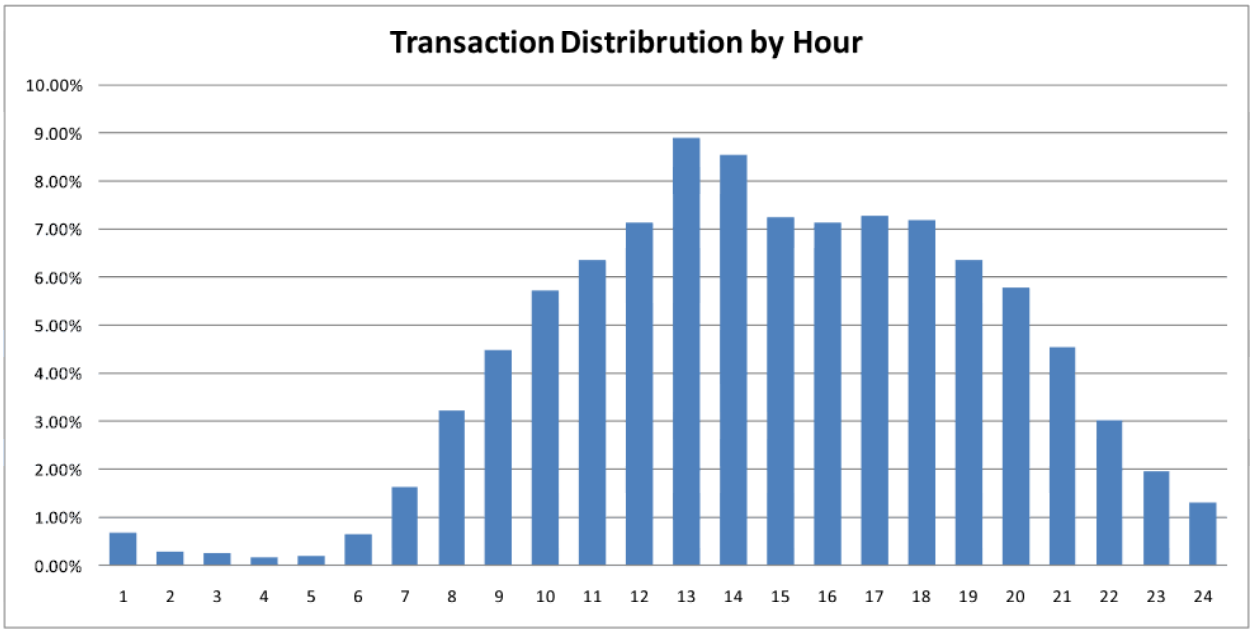
**Stage 2**
**Populate remaining Fridays**

| | | | | |
|---|---|---|---|---|
| June 2012 | WEEK 23 | Mon | 28-May | 7,623,837 |
| | | Tue | 29-May | 8,041,339 |
| | | Wed | 30-May | 8,173,473 |
| | | Thu | 31-May | 8,930,749 |
| | | Fri | 01-Jun | 11,103,754 |
| | | Sat | 02-Jun | 9,849,030 |
| | | Sun | 03-Jun | 6,296,939 |
| | WEEK 24 | Mon | 04-Jun | 8,128,625 |
| | | Tue | 05-Jun | 8,573,770 |
| | | Wed | 06-Jun | 8,714,653 |
| | | Thu | 07-Jun | 9,522,070 |
| | | Fri | 08-Jun | 11,838,953 |
| | | Sat | 09-Jun | 10,501,151 |
| | | Sun | 10-Jun | 6,713,870 |
| | WEEK 25 | Mon | 11-Jun | 8,998,810 |
| | | Tue | 12-Jun | 9,491,608 |
| | | Wed | 13-Jun | 9,647,574 |
| | | Thu | 14-Jun | 10,541,426 |
| | | Fri | 15-Jun | 13,106,336 |
| | | Sat | 16-Jun | 11,625,320 |
| | | Sun | 17-Jun | 7,432,603 |
| | WEEK 26 | Mon | 18-Jun | 9,937,946 |
| | | Tue | 19-Jun | 10,482,174 |
| | | Wed | 20-Jun | 10,654,416 |
| | | Thu | 21-Jun | 11,641,552 |
| | | Fri | 22-Jun | 14,474,142 |
| | | Sat | 23-Jun | 12,838,564 |
| | | Sun | 24-Jun | 8,208,286 |
| | WEEK 27 | Mon | 25-Jun | 8,795,674 |
| | | Tue | 26-Jun | 9,277,348 |
| | | Wed | 27-Jun | 9,429,793 |
| | | Thu | 28-Jun | 10,303,468 |
| | | Fri | 29-Jun | 12,810,478 |
| | | Sat | 30-Jun | 11,362,894 |
| | | Sun | 01-Jul | 7,264,822 |

**Stage 3**
**Populate remaining week days**

***Daily Profiling***

In order to get a more detailed view of the transaction day we analyzed historical data to determine hourly transaction volumes for a peak Friday. This gives us the transaction profile for the peak day as illustrated below.



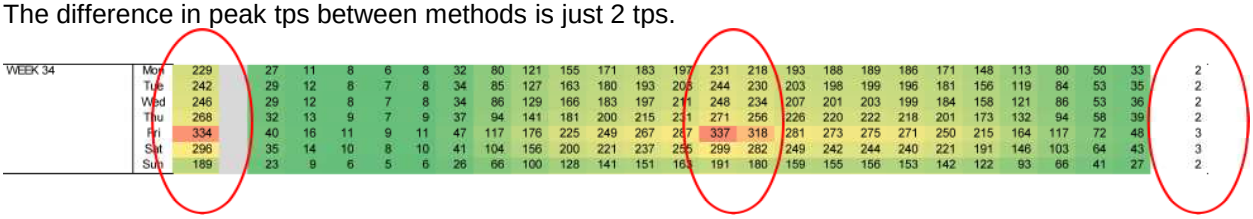

This profile is for a peak Friday but matches other weekdays pretty well which all share the typical 'lunch time' peak followed by another busy period following the end of the working day. With a little more effort the distribution for weekends and holidays could also be created. Typically weekends and holidays exhibit a smoother, less peaky profile. That said, capacity planning is all about the peaks and this is where we focus our effort.

After using the profile to predict hourly volumes from the daily volumes already calculated, the hour to minute and minute to second ratio's are used to predict the peak second for each hour in the day.

By comparing the results of both approaches we can see the peak hour and hence minute and second values are very close, the use of these 2 different approaches helps to validate the model.

In the extract below, on the left we have the peak second value derived purely from the ratio's. In the centre we show the peak second derived using the hourly profile and then ratio's and on the right we show the difference between the two.

The difference in peak tps between methods is just 2 tps.



| WEEK 34 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mon | 229 | 27 | 11 | 8 | 6 | 8 | 32 | 80 | 121 | 155 | 171 | 183 | 197 | 231 | 218 | 193 | 188 | 189 | 186 | 171 | 148 | 113 | 80 | 50 | 33 | 2 |
| | Tue | 242 | 29 | 12 | 8 | 7 | 8 | 34 | 85 | 127 | 163 | 180 | 193 | 208 | 244 | 230 | 203 | 198 | 199 | 196 | 181 | 156 | 119 | 84 | 53 | 35 | 2 |
| | Wed | 246 | 29 | 12 | 8 | 7 | 8 | 34 | 86 | 129 | 166 | 183 | 197 | 211 | 248 | 234 | 207 | 201 | 203 | 199 | 184 | 158 | 121 | 86 | 53 | 36 | 2 |
| | Thu | 268 | 32 | 13 | 9 | 7 | 9 | 37 | 94 | 141 | 181 | 200 | 215 | 231 | 271 | 256 | 226 | 220 | 222 | 218 | 201 | 173 | 132 | 94 | 58 | 39 | 2 |
| | Fri | 334 | 40 | 16 | 11 | 9 | 11 | 47 | 117 | 176 | 225 | 249 | 267 | 287 | 337 | 318 | 281 | 273 | 275 | 271 | 250 | 215 | 164 | 117 | 72 | 48 | 3 |
| | Sat | 296 | 35 | 14 | 10 | 8 | 10 | 41 | 104 | 156 | 200 | 221 | 237 | 255 | 299 | 282 | 249 | 242 | 244 | 240 | 221 | 191 | 146 | 103 | 64 | 43 | 3 |
| | Sun | 189 | 23 | 9 | 6 | 5 | 6 | 26 | 66 | 100 | 128 | 141 | 151 | 163 | 191 | 180 | 159 | 155 | 156 | 153 | 142 | 122 | 93 | 66 | 41 | 27 | 2 |

The forward looking transactional model is now complete; this will be used to determine system capacity requirements going forward. And to answer "what if" scenario questions from the Business.

However our work is not yet done with this model, this like any transactional model must be continually refined over time and must also adapt to changing business conditions. To this end the model is tuned through comparison with actual transactional data and is reviewed and adjusted annually.

We work in conjunction with the Business to refine not only their transaction forecasts but also the mapping from a given monthly transaction volume to the peak second volumes illustrated above.

## Determining Server Workload

The transaction workload imposed on a server can be determined by looking at Measure data gathered from production and / or volume test environments. This Measure data allows the per-CPU transaction cost to be calculated. A maximum workload can be determined based on the application. In the case of the LINK scheme, basic service time to switch a transaction from an transaction acquirer to a card issuer feed is about 0.1 seconds. Knowing the allowable server loading and the CPU cost per transaction, the maximum transaction rate that can be safely handled is easily determined.

### *Representing Critical Days Graphically*

The profile of relative transaction volumes for each of the hourly periods in a day can be used to extend the transaction-rate results across all the hours of the day. VocaLink plots the peak per-second transaction rates for each hour in an Excel table with colour coding using Excel's conditional formatting capability. The result is a table that appears below.

Peak transaction rates near or in excess of the maximum allowable transaction rates are colour coded in deepening shades of red. In this chart, 345 tps was specified as the critical transaction rate. The periods of concern are obvious.

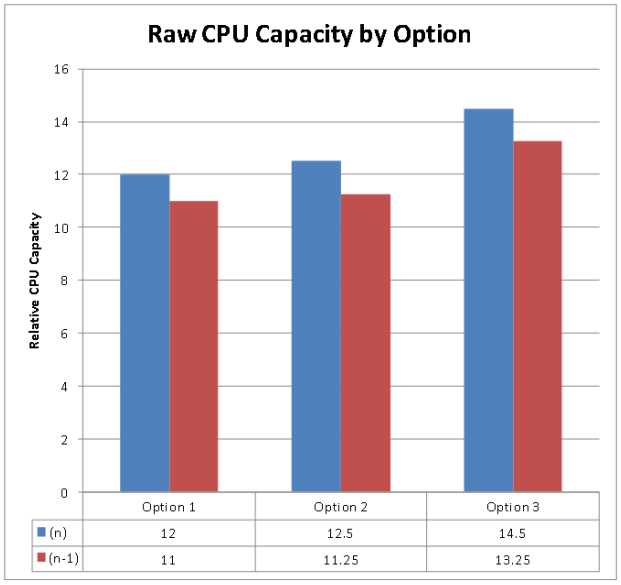
| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WEEK 37 | Mon | 216 | 25 | 10 | 7 | 6 | 7 | 29 | 73 | 110 | 140 | 155 | 166 | 179 | 210 | 198 | 175 | 170 | 172 | 169 | 156 | 134 | 102 | 73 | 45 | 30 |
| | Tue | 227 | 26 | 11 | 8 | 6 | 7 | 31 | 77 | 116 | 148 | 163 | 175 | 189 | 221 | 209 | 184 | 180 | 181 | 178 | 164 | 141 | 108 | 77 | 48 | 32 |
| | Wed | 231 | 27 | 11 | 8 | 6 | 7 | 31 | 78 | 117 | 150 | 166 | 178 | 192 | 225 | 212 | 187 | 183 | 184 | 181 | 167 | 144 | 110 | 78 | 48 | 32 |
| | Thu | 252 | 29 | 12 | 8 | 7 | 8 | 34 | 85 | 128 | 164 | 181 | 195 | 210 | 246 | 232 | 205 | 199 | 201 | 198 | 182 | 157 | 120 | 85 | 53 | 35 |
| | Fri | 314 | 36 | 15 | 10 | 8 | 10 | 42 | 106 | 160 | 204 | 226 | 242 | 260 | 306 | 288 | 255 | 248 | 250 | 246 | 227 | 195 | 149 | 106 | 66 | 44 |
| | Sat | 278 | 32 | 13 | 9 | 7 | 9 | 37 | 94 | 142 | 181 | 200 | 215 | 231 | 271 | 256 | 226 | 220 | 222 | 218 | 201 | 173 | 132 | 94 | 58 | 39 |
| | Sun | 178 | 20 | 8 | 6 | 5 | 6 | 24 | 60 | 90 | 116 | 128 | 137 | 148 | 173 | 163 | 144 | 141 | 142 | 139 | 128 | 111 | 85 | 60 | 37 | 25 |
| WEEK 38 | Mon | 216 | 25 | 10 | 7 | 6 | 7 | 29 | 73 | 110 | 141 | 155 | 167 | 179 | 210 | 198 | 175 | 171 | 172 | 169 | 156 | 134 | 103 | 73 | 45 | 30 |
| | Tue | 228 | 26 | 11 | 8 | 6 | 7 | 31 | 77 | 116 | 148 | 164 | 176 | 189 | 222 | 209 | 185 | 180 | 181 | 178 | 164 | 142 | 108 | 77 | 48 | 32 |
| | Wed | 232 | 27 | 11 | 8 | 6 | 7 | 31 | 78 | 118 | 151 | 166 | 179 | 192 | 225 | 213 | 188 | 183 | 184 | 181 | 167 | 144 | 110 | 78 | 49 | 32 |
| | Thu | 253 | 29 | 12 | 8 | 7 | 8 | 34 | 86 | 129 | 165 | 182 | 195 | 210 | 246 | 232 | 205 | 200 | 202 | 198 | 183 | 158 | 120 | 85 | 53 | 35 |
| | Fri | 315 | 36 | 15 | 10 | 8 | 10 | 42 | 106 | 160 | 205 | 226 | 243 | 261 | 306 | 289 | 255 | 249 | 251 | 246 | 227 | 196 | 149 | 106 | 66 | 44 |
| | Sat | 279 | 32 | 13 | 9 | 7 | 9 | 38 | 94 | 142 | 182 | 201 | 215 | 232 | 272 | 256 | 226 | 220 | 222 | 218 | 201 | 174 | 132 | 94 | 58 | 39 |
| | Sun | 178 | 20 | 8 | 6 | 5 | 6 | 24 | 60 | 91 | 116 | 128 | 138 | 148 | 174 | 164 | 145 | 141 | 142 | 140 | 129 | 111 | 85 | 60 | 37 | 25 |
| WEEK 39 | Mon | 223 | 26 | 10 | 7 | 6 | 7 | 30 | 75 | 114 | 145 | 160 | 172 | 185 | 217 | 205 | 181 | 176 | 178 | 175 | 161 | 139 | 106 | 75 | 47 | 31 |
| | Tue | 236 | 27 | 11 | 8 | 6 | 8 | 32 | 80 | 120 | 153 | 169 | 182 | 195 | 229 | 216 | 191 | 186 | 188 | 184 | 170 | 147 | 112 | 79 | 49 | 33 |
| | Wed | 239 | 27 | 11 | 8 | 6 | 8 | 32 | 81 | 122 | 156 | 172 | 185 | 199 | 233 | 220 | 194 | 189 | 191 | 187 | 173 | 149 | 114 | 81 | 50 | 33 |
| | Thu | 262 | 30 | 12 | 9 | 7 | 8 | 35 | 88 | 133 | 170 | 188 | 202 | 217 | 255 | 240 | 212 | 207 | 208 | 205 | 189 | 163 | 124 | 88 | 55 | 37 |
| | Fri | 325 | 37 | 15 | 11 | 9 | 10 | 44 | 110 | 165 | 212 | 234 | 251 | 270 | 317 | 299 | 264 | 257 | 259 | 254 | 235 | 202 | 154 | 110 | 68 | 45 |
| | Sat | 288 | 33 | 13 | 10 | 8 | 9 | 39 | 98 | 147 | 188 | 207 | 223 | 239 | 281 | 265 | 234 | 228 | 230 | 226 | 208 | 180 | 137 | 97 | 60 | 40 |
| | Sun | 184 | 21 | 9 | 6 | 5 | 6 | 25 | 62 | 94 | 120 | 133 | 142 | 153 | 180 | 169 | 150 | 146 | 147 | 144 | 133 | 115 | 88 | 62 | 39 | 26 |
| WEEK 40 | Mon | 239 | 27 | 11 | 8 | 6 | 8 | 32 | 81 | 121 | 155 | 171 | 184 | 198 | 232 | 219 | 194 | 188 | 190 | 187 | 172 | 149 | 113 | 80 | 50 | 33 |
| | Tue | 252 | 29 | 12 | 8 | 7 | 8 | 34 | 85 | 128 | 164 | 181 | 194 | 209 | 245 | 231 | 204 | 199 | 200 | 197 | 182 | 157 | 119 | 85 | 53 | 35 |
| | Wed | 256 | 29 | 12 | 8 | 7 | 8 | 34 | 86 | 130 | 166 | 184 | 197 | 212 | 249 | 235 | 207 | 202 | 204 | 200 | 185 | 159 | 121 | 86 | 54 | 36 |
| | Thu | 279 | 32 | 13 | 9 | 7 | 9 | 38 | 94 | 142 | 182 | 201 | 216 | 232 | 272 | 257 | 227 | 221 | 223 | 219 | 202 | 174 | 133 | 94 | 59 | 39 |
| | Fri | 347 | 40 | 16 | 11 | 9 | 11 | 47 | 117 | 177 | 226 | 250 | 268 | 288 | 338 | 319 | 282 | 274 | 277 | 272 | 251 | 216 | 165 | 117 | 73 | 49 |
| | Sat | 308 | 35 | 14 | 10 | 8 | 10 | 41 | 104 | 157 | 201 | 222 | 238 | 256 | 300 | 283 | 250 | 243 | 245 | 241 | 222 | 192 | 146 | 104 | 65 | 43 |
| | Sun | 197 | 23 | 9 | 7 | 5 | 6 | 27 | 67 | 100 | 128 | 142 | 152 | 164 | 192 | 181 | 160 | 156 | 157 | 154 | 142 | 123 | 94 | 66 | 41 | 28 |
| WEEK 41 | Mon | 201 | 23 | 9 | 7 | 5 | 6 | 27 | 68 | 102 | 131 | 145 | 155 | 167 | 196 | 185 | 163 | 159 | 160 | 157 | 145 | 125 | 96 | 68 | 42 | 28 |
| | Tue | 212 | 24 | 10 | 7 | 6 | 7 | 29 | 72 | 108 | 138 | 153 | 164 | 176 | 207 | 195 | 172 | 168 | 169 | 166 | 153 | 132 | 101 | 72 | 44 | 30 |
| | Wed | 216 | 25 | 10 | 7 | 6 | 7 | 29 | 73 | 110 | 140 | 155 | 166 | 179 | 210 | 198 | 175 | 170 | 172 | 169 | 156 | 134 | 102 | 73 | 45 | 30 |
| | Thu | 236 | 27 | 11 | 8 | 6 | 8 | 32 | 80 | 120 | 153 | 169 | 182 | 196 | 229 | 216 | 191 | 186 | 188 | 184 | 170 | 147 | 112 | 79 | 49 | 33 |
| | Fri | 293 | 34 | 14 | 10 | 8 | 9 | 39 | 99 | 149 | 191 | 211 | 226 | 243 | 285 | 269 | 238 | 231 | 233 | 229 | 212 | 182 | 139 | 99 | 61 | 41 |
| | Sat | 260 | 30 | 12 | 9 | 7 | 8 | 35 | 88 | 132 | 169 | 187 | 201 | 216 | 253 | 239 | 211 | 205 | 207 | 203 | 188 | 162 | 123 | 88 | 54 | 36 |
| | Sun | 166 | 19 | 8 | 5 | 4 | 5 | 22 | 56 | 84 | 108 | 119 | 128 | 138 | 162 | 153 | 135 | 131 | 132 | 130 | 120 | 103 | 79 | 56 | 35 | 23 |
| WEEK 42 | Mon | 215 | 25 | 10 | 7 | 6 | 7 | 29 | 73 | 109 | 140 | 154 | 166 | 178 | 209 | 197 | 174 | 169 | 171 | 168 | 155 | 134 | 102 | 72 | 45 | 30 |
| | Tue | 226 | 26 | 11 | 7 | 6 | 7 | 30 | 76 | 115 | 147 | 163 | 175 | 188 | 220 | 208 | 184 | 179 | 180 | 177 | 163 | 141 | 107 | 76 | 47 | 32 |
| | Wed | 230 | 26 | 11 | 8 | 6 | 7 | 31 | 78 | 117 | 150 | 165 | 178 | 191 | 224 | 211 | 187 | 182 | 183 | 180 | 166 | 143 | 109 | 78 | 48 | 32 |
| | Thu | 251 | 29 | 12 | 8 | 7 | 8 | 34 | 85 | 128 | 163 | 181 | 194 | 209 | 245 | 231 | 204 | 199 | 200 | 197 | 181 | 156 | 119 | 85 | 53 | 35 |
| | Fri | 312 | 36 | 15 | 10 | 8 | 10 | 42 | 106 | 159 | 203 | 225 | 241 | 259 | 304 | 287 | 253 | 247 | 249 | 244 | 226 | 195 | 148 | 105 | 65 | 44 |
| | Sat | 277 | 32 | 13 | 9 | 7 | 9 | 37 | 94 | 141 | 180 | 199 | 214 | 230 | 270 | 255 | 225 | 219 | 221 | 217 | 200 | 173 | 132 | 93 | 58 | 39 |
| | Sun | 177 | 20 | 8 | 6 | 5 | 6 | 24 | 60 | 90 | 115 | 127 | 137 | 147 | 172 | 163 | 144 | 140 | 141 | 139 | 128 | 110 | 84 | 60 | 37 | 25 |

Using this method the model can be rolled forward as far as there are valid projections from the Business, VocaLink projects transaction volumes over a rolling 24 month period.

## Example Case Study - A thought exercise

The analysis discussed so far can be used to illustrate the compound probability of a CPU failure impacting service. And to help the business select from a number of expansion options. VocaLink had already planned a migration from S series to an NB series blade system. However prior to the scheduled migration a software upgrade significantly raised the resource requirements of a core application jeopardizing out ability to comfortable process peak volumes with a CPU down.

At quiet time a CPU failure would not impact the service, however at a busy time it could, here we attempt illustrate and quantify this for each potential upgrade path.



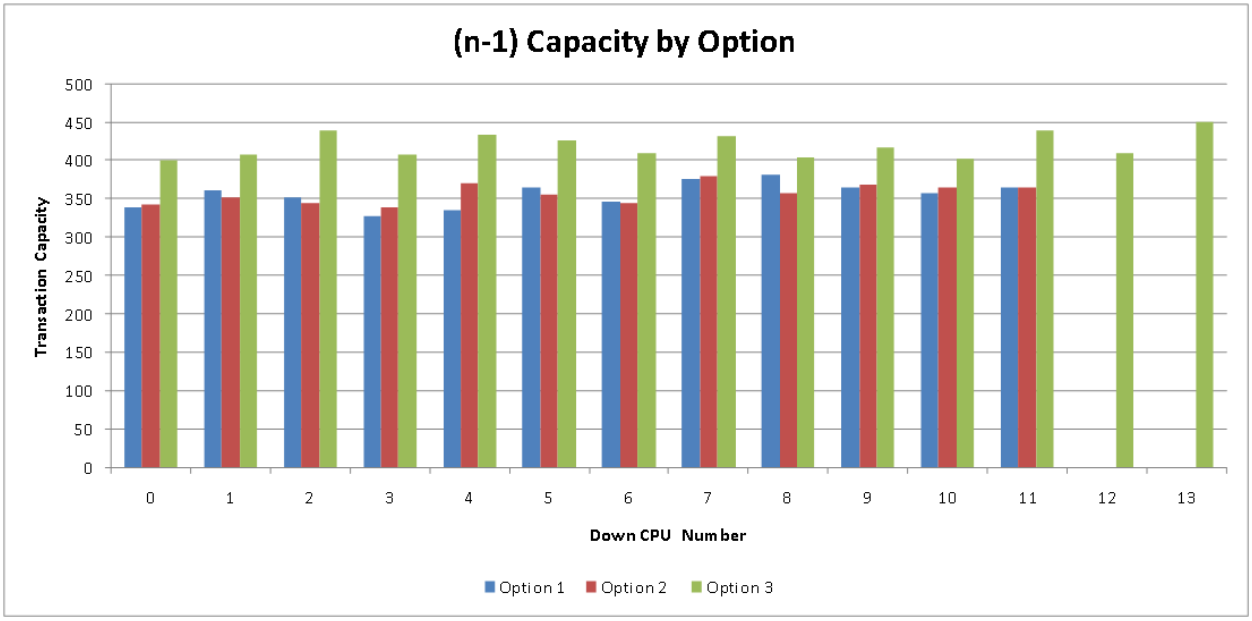

Three options were considered to expand the capacity of the NonStop S-Series servers.

- **Option 1**, rebalance + shut down non essential processes.
- **Option 2**, upgrade two of the twelve CPUs to a newer version CPU (increase the capacity of two CPUs by 25%).
- **Option 3,** add two new CPUs to the current twelve-CPU configuration (each has 25% more capacity than the current CPUs).

The relative CPU capacity of each option is illustrated above.

Taking this relative capacity and applying to the CPU failure model we can build up various “what-if” scenarios.

The system capacity (tps) following a specific CPU failure for each option is illustrated below:



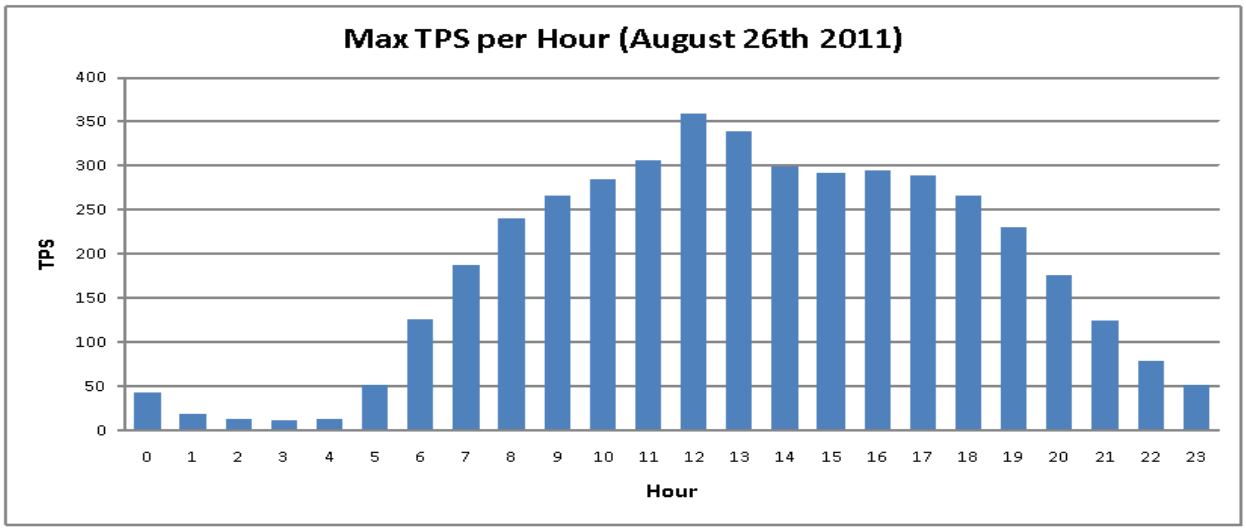

The model illustrated so far takes many factors into account to determine maximum system capacity. For a Production / DR configuration the maximum capacity is that of the system with a single CPU down (n-1) and with none of the remaining CPUs running in excess of 80% utilized.

This is a relatively conservative approach, these services are designed to be highly available and down time or degraded service caused by inadequate capacity is the same as downtime caused by component failure. The customer / cardholder does not care why a service is unavailable, they only know that it is.

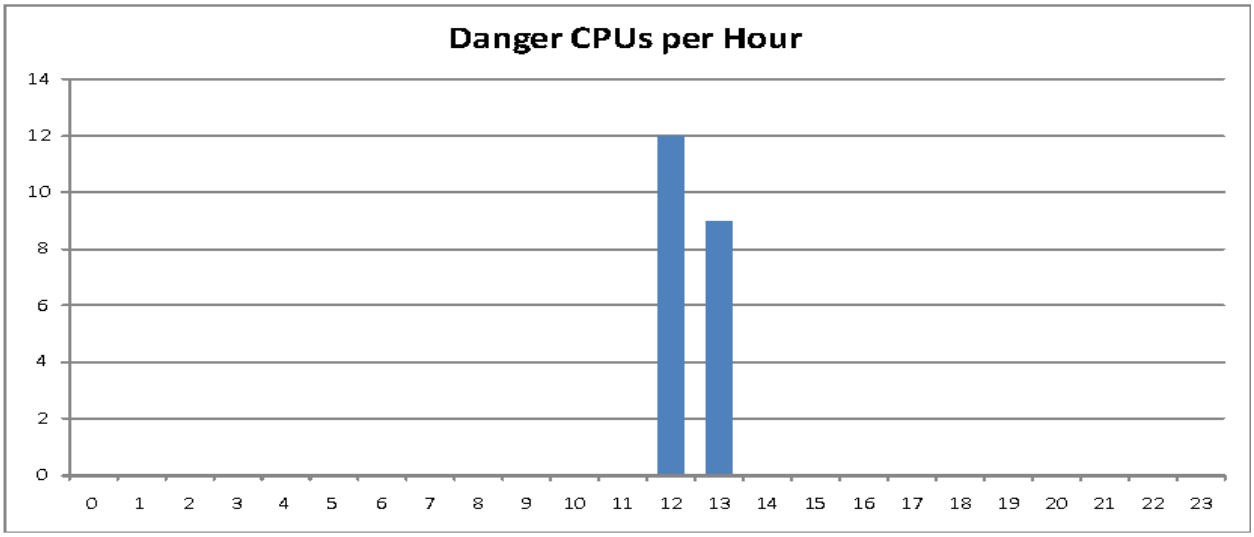
***What is the probability of a CPU failure impacting service?***

Here we will attempt to calculate the probability of component failure impacting the real time service.

Taking each day in turn we determine the hours of the day where a CPU failure could impact the service, this uses the predicted maximum tps for each hour determined previously and illustrated below:

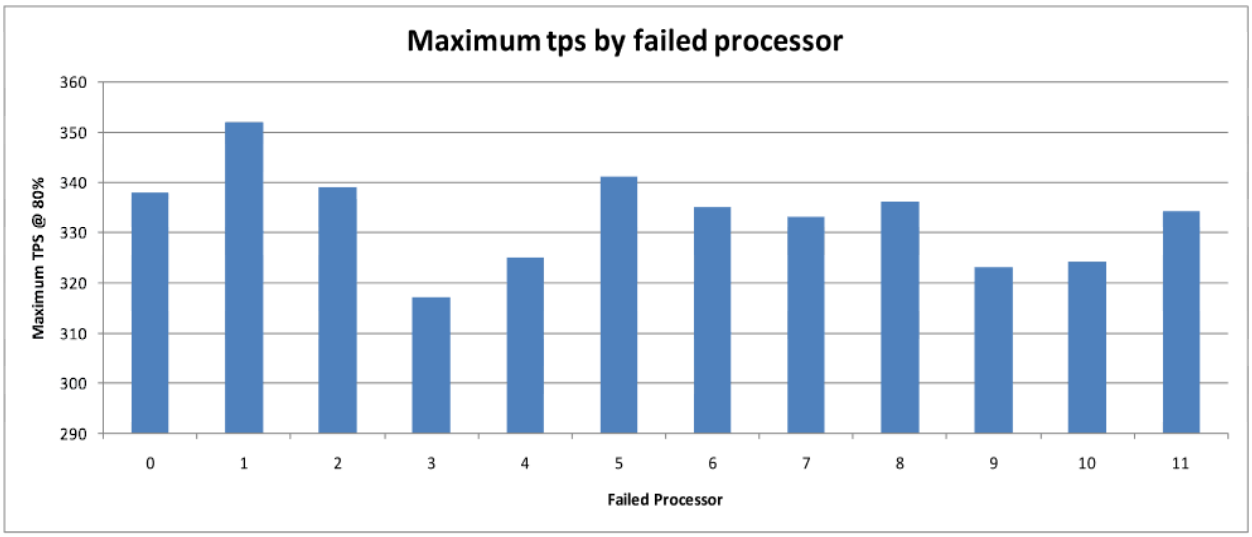



Given the day above a CPU failure in hour 12 or hour 13 could impact the service as we may not have adequate capacity to process the modeled workload comfortably, this is illustrated below:

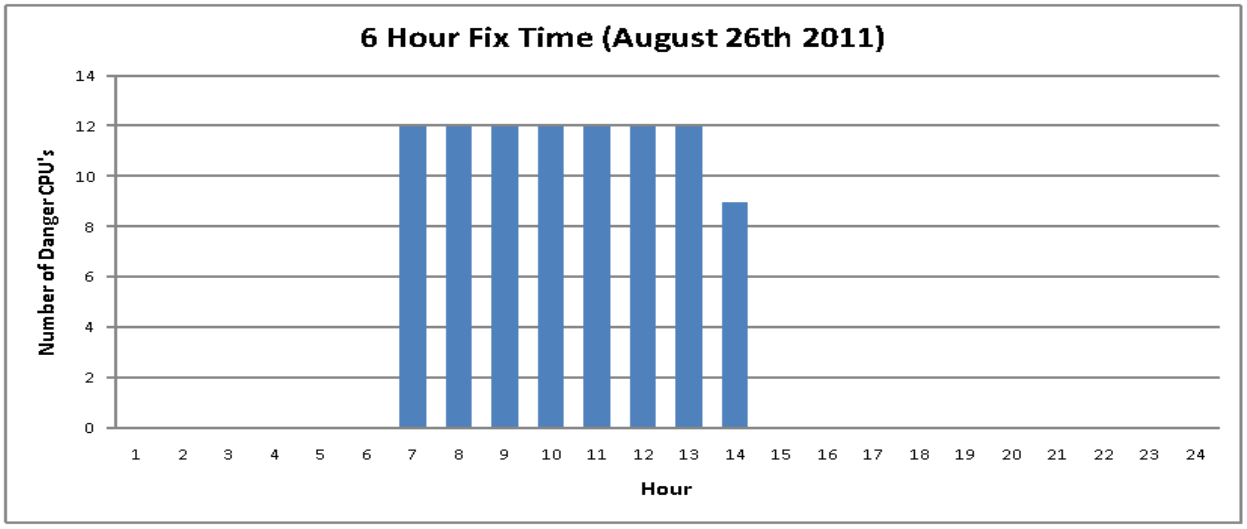



The chart also indicates the number of danger CPU's during each hour, essintially this is taking into account that the system is not perfectly balanced and that the impact of each CPU failing is different. As can be seen when volume reduces in hour 13 the number of danger CPU's also reduces.

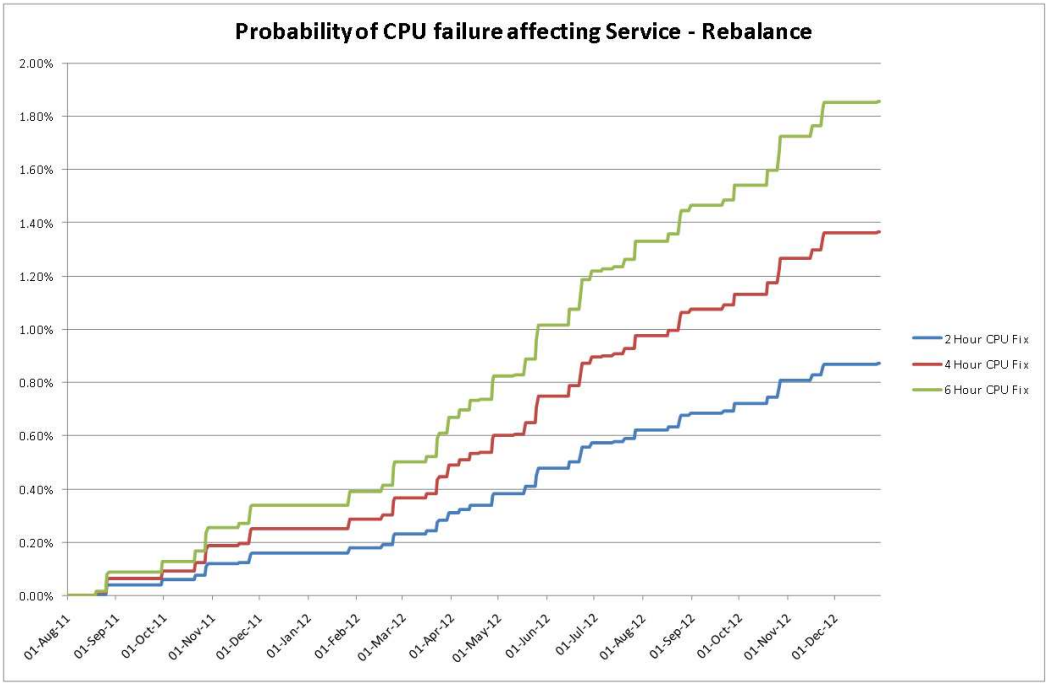
The input to this was the calcuation of max tps should a given CPU fail. This analysis takes into account this CPU's processes will fail over to following the CPU failure.



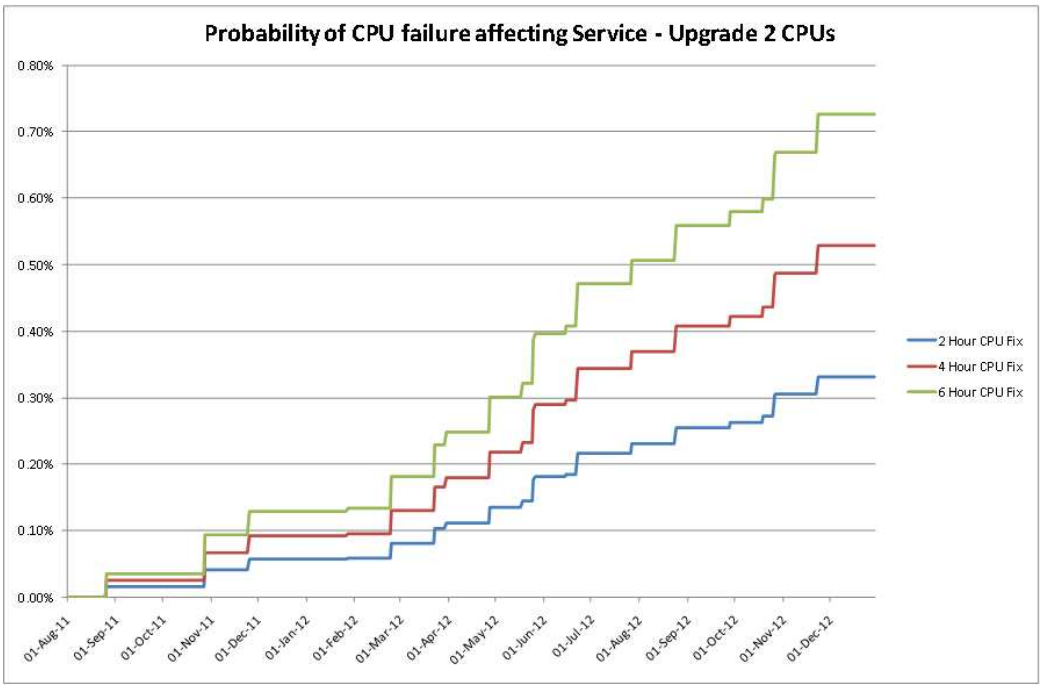

A failure will not be corrected instantly so we also take into account a fix time of 6 hours and add this to the model as illustrated below. This shows that a CPU failure in any of the hours shown below has the possibility of impacting the service, ie should a CPU fail in hour 10 we cannot guarantee it will be repaired and available again in time for the peak processing period in hour 12.



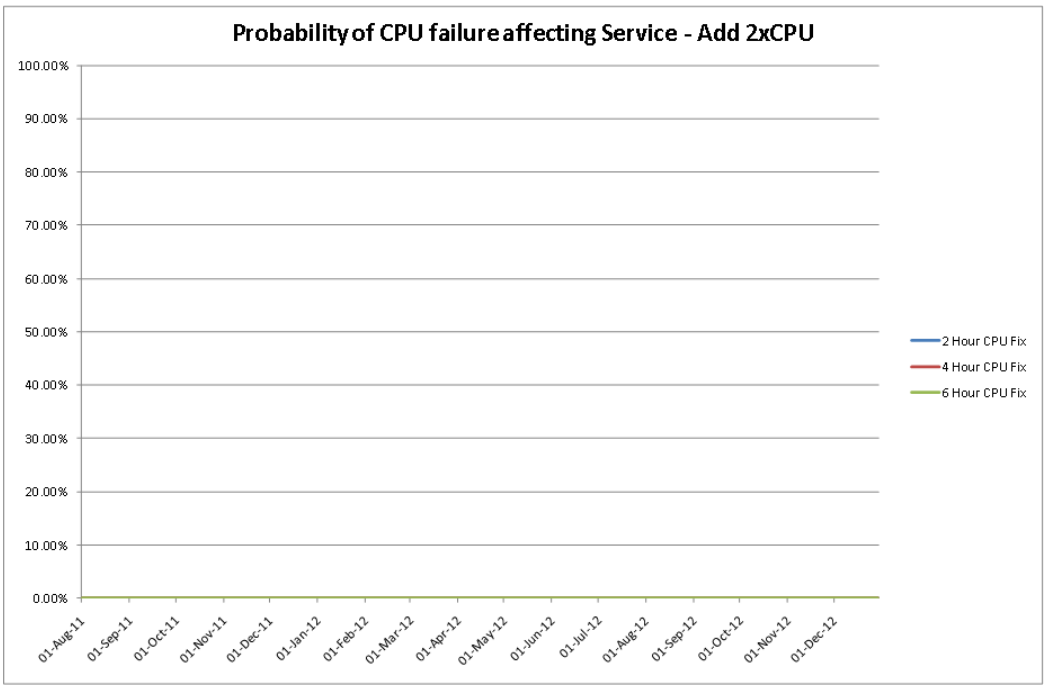

Coupled with this analysis is a computation of the likelihood that a CPU failure will cause an overload condition on any particular day for each of the tabled options.. This probability is calculated over a time period and increases as the time period increases.




For this option the probability of a CPU failure impacting service over the coming 16 months using a 6 hour fix time is circa 1.85%




For this option the probability of a CPU failure impacting service over the coming 16 months using a 6 hour fix time is circa 0.7%




For this option the probability of a CPU failure impacting service over the coming 17 months using a 6 hour fix time is circa 0%, this is also true of the upgrade to NB50000 option.

The analyses described above led to the following failure probabilities over sixteen months for various repair times:

| Expansion Option | 2-hour repair | 4-hour repair | 6-hour repair |
|---|---|---|---|
| Rebalance | 0.85% | 1.35% | 1.85% |
| Upgrade two CPUs | 0.33% | 0.53% | 0.72% |
| Add two CPUs | 0% | 0% | 0% |

**Probability of Overload Failure over 16 months (%)**

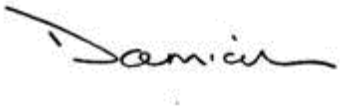
## Summary

Transaction volume forecasting can be as simple as some ratios. The workload imposed on the servers can be determined by using Measure data. Combining forecasted volume with server workload and including failure scenarios can give important insight into future server needs.

The least expensive way to maximize capacity is to ensure that CPUs in the server are well-balanced.

In addition to forecasting performance, these techniques can be used to validate a system's performance under a Service Level Agreement (SLA) specification.

I am happy to discuss this technique with you and can be contacted at damian.Ward@vocalink.com, I can also be found on LinkedIn or in person at any BITUG event.



Damian Ward

NonStop Solution Architect
BITUG Chairman 2012