Table Lookup Illustrated with Product Stress Testing

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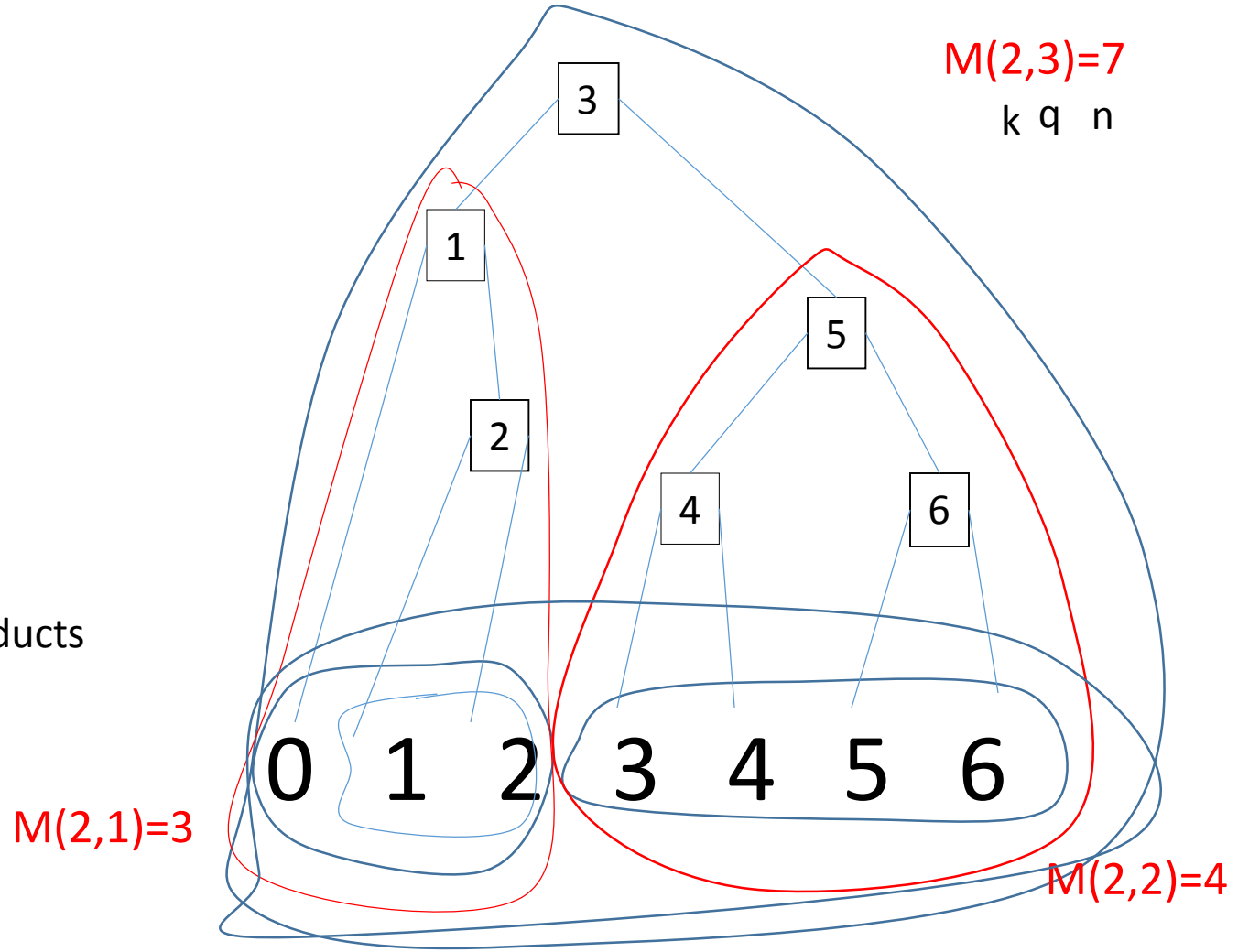
Product Stress Testing

- We have k identical copies of a product, such as a computer chip.
- Each product has n stress levels, numbered from 0 to n-1. Think of a stress level as the frequency applied to the chip.
- We can make at most q stress tests. For each test, the tested product either breaks or not (yes/no answer). If it does not break, we assume that it is like a new product. If it breaks, we have only k-1 products left.
- For each constant q, we want to create a lookup table which tells us for a given n how many products we need (k). We want the minimum k because the products cost money when they get destroyed.

Example Decision Tree

n=7 stress levels
q=3 questions
k=2 products

Meaning of table M(q,k):
With q questions and k products
at most M(q,k) stress levels
can be distinguished.



Solving Product Stress Testing

- Requires some thinking, but solution is surprisingly simple: Solution is given by table M[q,k] which has simple construction rules.
- Typical for computational tasks which have a solution based on Dynamic Programming.
- Build solution for larger problem out of solution of two overlapping simpler subproblems.

Table M

k=0	1	2	3	4	5	6	
1							q=0
1	2						1
1	3	4					2
1	4	7	8				3
1	5	11	15	16			4
1	6	16	26	31	32		5
1	7	22	42	57	63	64	6

- Boundary Conditions
  - Top Diagonal: *2: M[q,q]]=2^q
  - Left: 1: M[q,0]=1
- Internal Rule: easily expressed in Excel and dragged down and over.
  (1 left above + 1 above)
  - M[q,k]=M[q-1,k]+M[q-1,k-1)

Two basic search techniques

- Linear Search: go up the stress levels one by one.
- Binary Search: go to the middle and then search either lower or upper range.

Linear Search

k=0	1	2	3	4	5	6	
1							q=0
1	2						1
1	3	4					2
1	4	7	8				3
1	5	11	15	16			4
1	6	16	26	31	32		5
1	7	22	42	57	63	64	6

Example Linear Search: Left subtree

n=7 stress levels
q=3 questions
k=2 products

Meaning of table M(q,k):
With q questions and k products
at most M(q,k) stress levels
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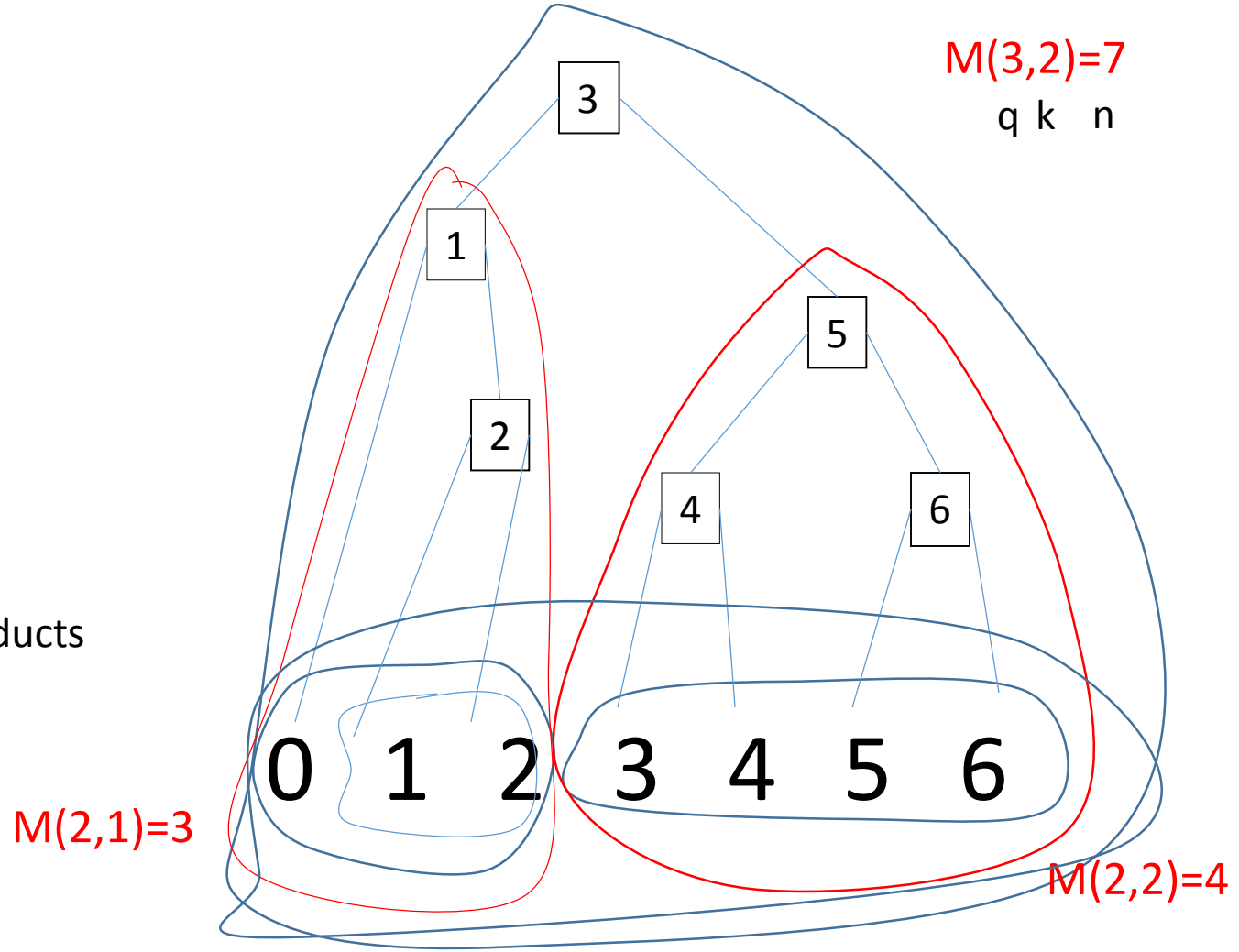
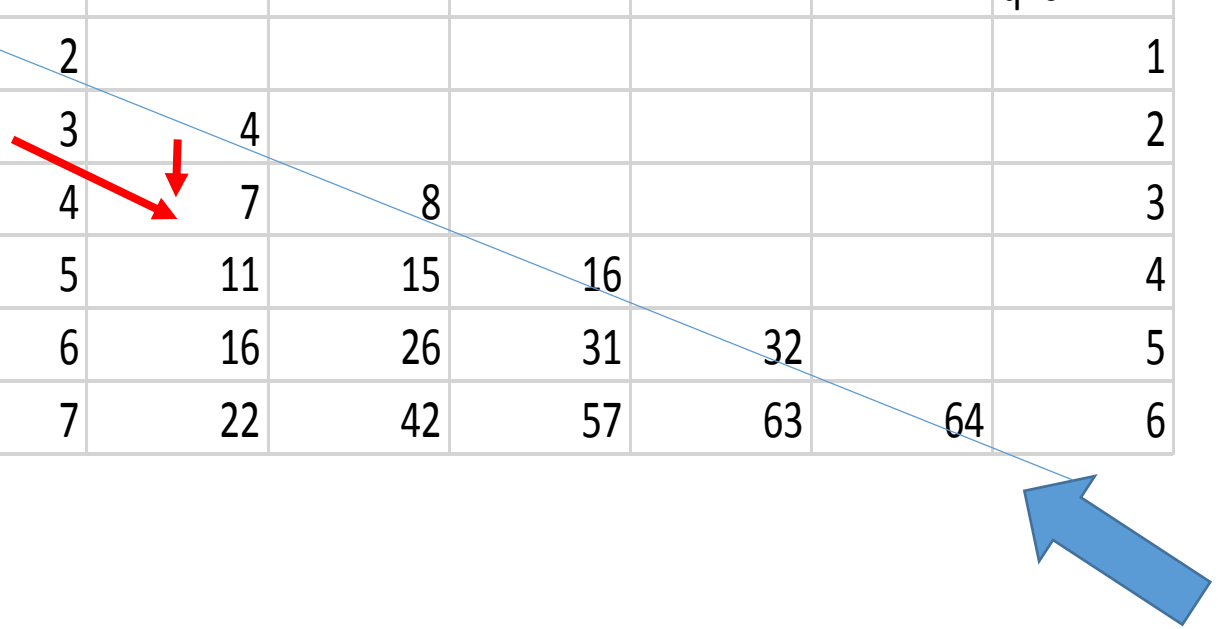


Binary Search

k=0	1	2	3	4	5	6	
1							q=0
1	2						1
1	3	4					2
1	4	7	8				3
1	5	11	15	16			4
1	6	16	26	31	32		5
1	7	22	42	57	63	64	6



Example Binary Search: Right subtree

n=7 stress levels
q=3 questions
k=2 products

Meaning of table M(q,k):
With q questions and k products
at most M(q,k) stress levels
can be distinguished.

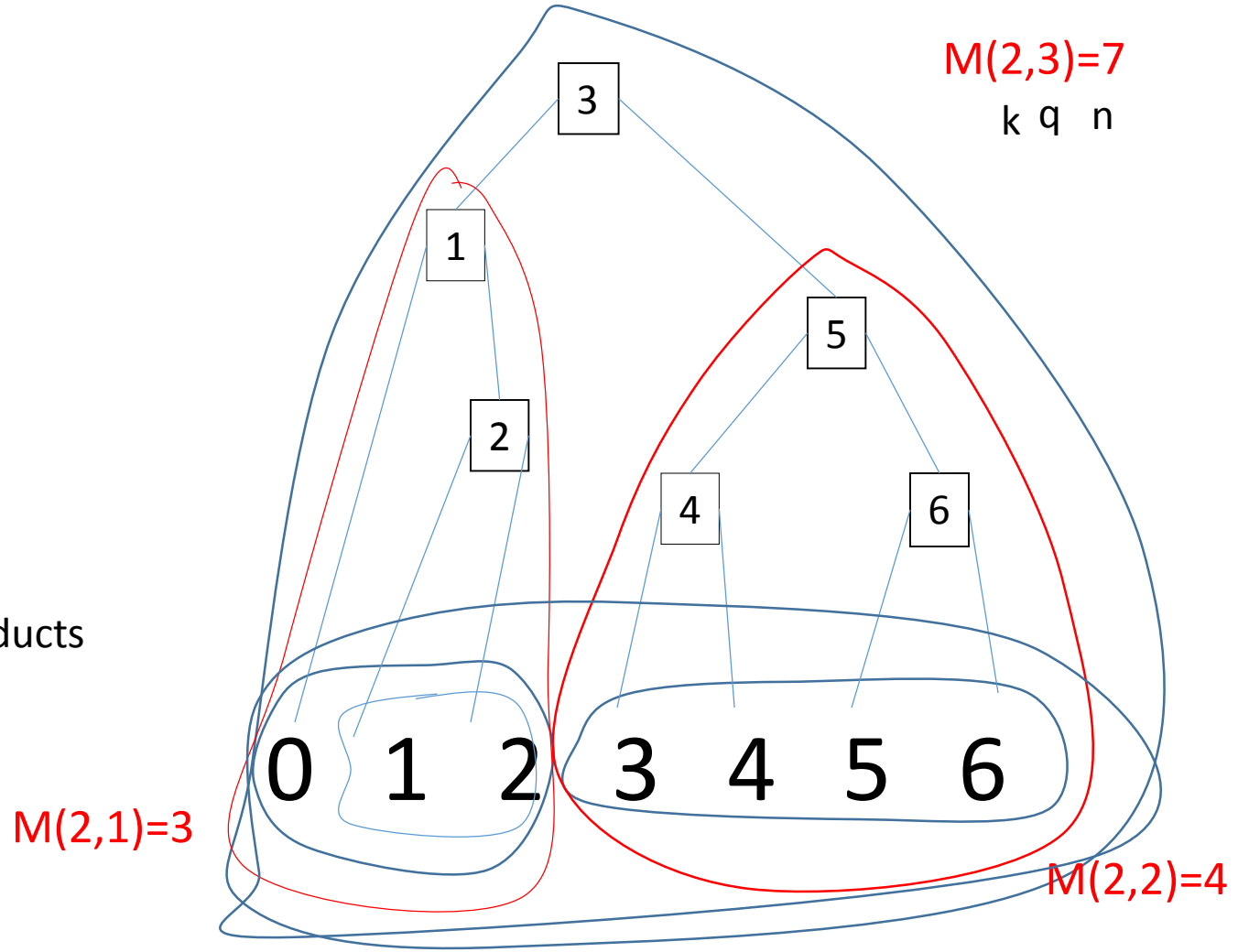


Table M

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1	5	11	15	16			4
1	6	16	26	31	32		5
1	7	22	42	57	63	64	6

- What does table mean?
  - With q=4 questions and n=9 stress levels we need 2 products because M[4,1]=5 and M[4,2]=11 and 9 is between 5 and 11.
  - Will need an interval lookup.

Lookup table preparation

k=0	1	2	3	4
1				
1	2			
1	3	4		
1	4	7	8	
1	5	11	15	16

HTableq4?

We would like to write:
=HLOOKUP(LookupValue,HTableq4,2,TRUE)
e.g., =HLOOKUP(5,HTableq4,2,TRUE)=1
e.g., =HLOOKUP(6,HTableq4,2,TRUE)=2

Need to carefully prepare table HTableq4.

Preparing the table for lookup

k=0	1	2	3	4
1				
1	2			
1	3	4		
1	4	7	8	
1	5	11	15	16

Before

How Excel Interval Lookup works

>=	<
2	6
1	2

	k=0	1	2	3	4
	1				
	1	2			
	1	3	4		
	1	4	7	8	
1	2	6	12	16	17
0	1	2	3	4	#N/A

After

How did we prepare the table:

1. For last row add one to every cell (green).
2. Add additional row at bottom 1,2, …
3. Add additional first column 1,0 (yellow).
4. Add #N/A to cell in right lower corner.
5. HTable4q consists of bottom 2 rows.

Adding Error Handling

Use the Tantrum, not Constructivist Style.
https://github.com/crista/exercises-in-programming-style/tree/master/21-tantrum

	k=0	1	2	3	4
	1				
	1	2			
	1	3	4		
	1	4	7	8	
1	2	6	12	16	17
0	1	2	3	4	#N/A

Only lookup values between
1 and 16 are allowed.

WANT:

17	argument illegal for HLOOKUP in HTableq4
18	argument illegal for HLOOKUP in HTableq4
-1	argument illegal for HLOOKUP in HTableq4
0	argument illegal for HLOOKUP in HTableq4

HOW?

17	=IFERROR(HLOOKUP(#REF!,HTableq4,2,TRUE),"argument illegal for HLOOKUP in HTableq4")
18	=IFERROR(HLOOKUP(#REF!,HTableq4,2,TRUE),"argument illegal for HLOOKUP in HTableq4")
-1	=IFERROR(HLOOKUP(#REF!,HTableq4,2,TRUE),"argument illegal for HLOOKUP in HTableq4")
0	=IFERROR(HLOOKUP(#REF!,HTableq4,2,TRUE),"argument illegal for HLOOKUP in HTableq4")

Review

- We solved the Product Stress Testing Problem.
- We used a tabular technique known as Dynamic Programming. The table M[q,k] has a simple construction which we expressed in a spreadsheet.
- We learned Linear Search and Binary Search. They are special cases of the general solution to Product Stress Testing.
- We prepared the table M[q,k]=n for interval lookup for k given q and n.

Details

- How to extract a table from Excel and insert it into a document?
  - Select the rectangular range of cells you want to extract.
  - Go to Home/Copy/Copy as picture
    - Appearance: as shown on screen
    - Format: Picture
    - OK
  - In the document: use Ctrl-V to insert the table into the document. Works for Word, PowerPoint, etc.

Details

- To prepare a table row for lookup, we had to add 1 to every entry. What is the easiest way to do this?
  - Put a 1 into a cell and copy it.
  - Select the range of numbers and right click – paste special – select ‘add’ -OK