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BY NC ND
Jens Dittrich

Bitmap Index on City

Colleagues		
name	**street**	**city**
peter	unistreet	653
steve	macstreet	42
mike	longstreet	7
tim	unistreet	7
hans	msstreet	653
jens	longstreet	42
frank	unistreet	653
olaf	macstreet	7
stefan	longstreet	7
alekh	unistreet	7
felix	macstreet	653
jorge	longstreet	7

city		
653	**42**	**7**
1	0	0
0	1	0
0	0	1
0	0	1
1	0	0
0	1	0
1	0	0
0	0	1
0	0	1
0	0	1
1	0	0
0	0	1

77
0
0
0
0
0
0
0
0
0
0
0
0

$0_{1 \ldots 1}$ 999

WHERE city = 77

Bitmap Index on City (Extended)

Row vs Column Data Layout

Colleagues		
name	**street**	**city**
peter	unistreet	653
steve	macstreet	42
mike	longstreet	7
tim	unistreet	7
hans	msstreet	653
jens	longstreet	42
frank	unistreet	653
olaf	macstreet	7
stefan	longstreet	7
alekh	unistreet	7
felix	macstreet	653
jorge	longstreet	7
michael	unistreet	9
albert	macstreet	323
volker	longstreet	88

city					
653	**42**	**7**	**9**	**323**	**88**
1	0	0	0	0	0
0	1	0	0	0	0
0	0	1	0	0	0
0	0	1	0	0	0
1	0	0	0	0	0
0	1	0	0	0	0
1	0	0	0	0	0
0	0	1	0	0	0
0	0	1	0	0	0
0	0	1	0	0	0
1	0	0	0	0	0
0	0	1	0	0	0
			1	0	0
				1	0
					1

$N = 15$

$15 \times 1{,}000$ Bits

RLE

Decomposed Bitmap

600 + 50 + 3

Colleagues		
name	street	city
peter	unistreet	653
steve	macstreet	42
mike	longstreet	7
tim	unistreet	7
hans	msstreet	653
jens	longstreet	42
frank	unistreet	653
olaf	macstreet	7
stefan	longstreet	7
alekh	unistreet	7
felix	macstreet	653
jorge	longstreet	7
michael	unistreet	9
albert	macstreet	323
volker	longstreet	88

..7

007

city

0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0

×100

10^2

0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0

×10

10^1

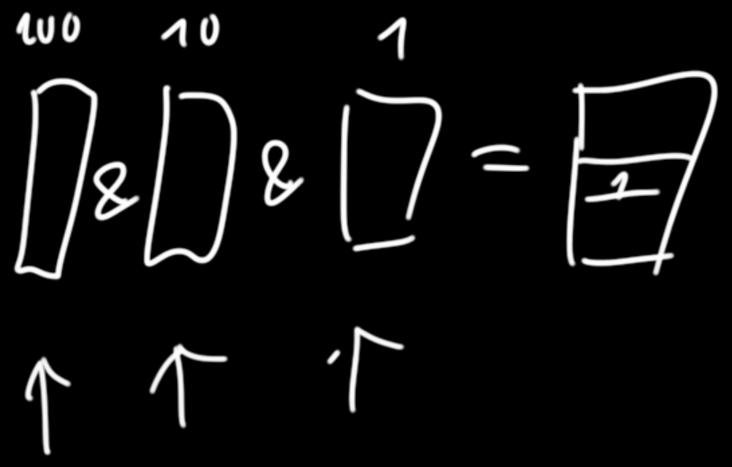
0	1	2	3	4	5	6	7	8	9
0	0	0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0

×1

10^0

Bitmap Operations

WHERE city = 653



city

0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0

×100

0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0

×10

0	1	2	3	4	5	6	7	8	9
0	0	0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0

×1

Space Comparison

$0, \dots, 999$

$D = 1000$

$N = 1\,M$ tuples

uncompressed bitmap:

$D \times N = 1$ billion Bits

$D = \#$ bit lists $\approx$ **120 MB**

decompressed bitmap:

$30 \times N = 30\,M$ Bits

$\approx$ **3.6 MB**

$N = 15$

city

0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0

×100

0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0

×10

0	1	2	3	4	5	6	7	8	9
0	0	0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0

×1

RLE