

Advanced Spreadsheets

Much of this course and lots of the lecture notes were inspired by or derived from Brown University's CS931. Our thanks go to Prof Shriram Krishnamurthi and Hammurabi Mendes for their kind permission in allowing us to use their materials.

From last time

- We compared all legislators to an arbitrary legislator
- Generated a spreadsheet that can be used by *anybody*.
- Kind of like writing an app — we create something that can be used by anybody without knowing how the “insides” work.

Today...

- Compare *all* orderings

What we have:

	"03/06/2015"-3	"03/06/2015"-41	"03/06/2015"-43	"03/07/2013"-11	"03/07/2013"-3
何俊仁 Albert HO	ABS	YES	ABS	YES	YES
何俊賢 Steven HO	YES	ABS	NO	ABS	ABS
何秀蘭 Cyd HO	ABS	YES	YES	YES	YES
劉慧卿 Emily LAU	ABS	YES	YES	ABS	YES
劉皇發 Dr LAU Wong-fat	ABS	ABS	ABS	ABS	ABS

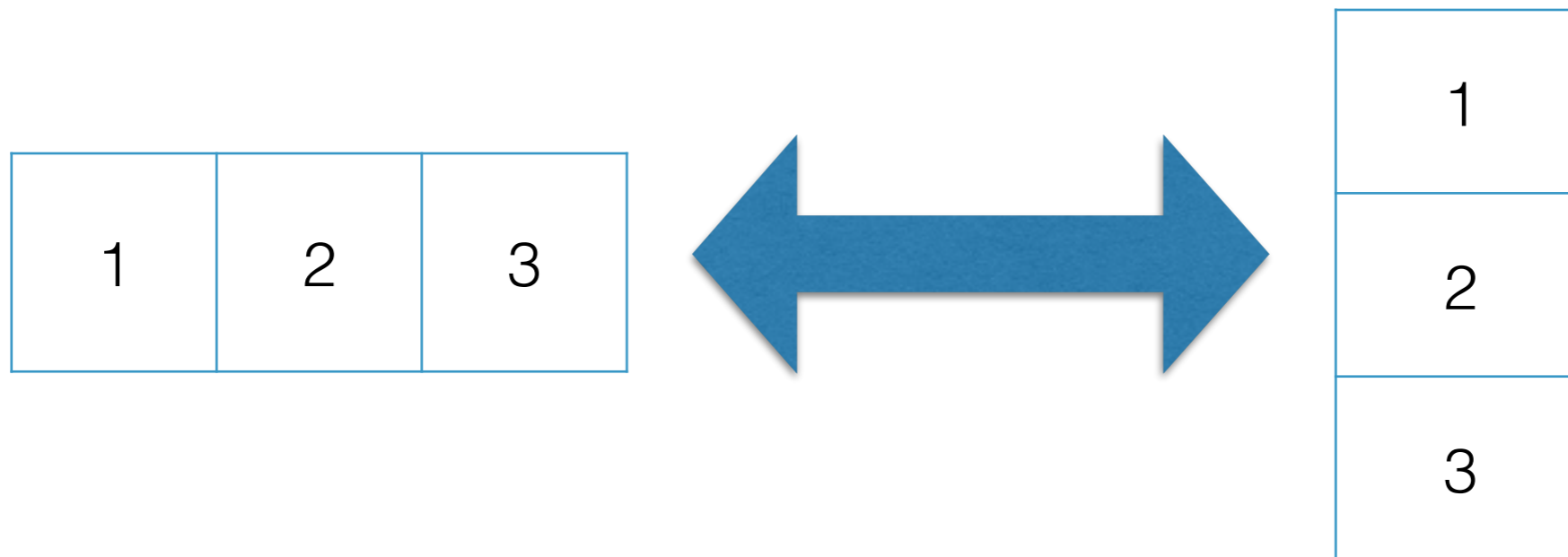
What we want:

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU Wong-fat
何俊仁 Albert HO	sim(Albert, Albert)	sim(Albert, Steven)	sim(Albert, Cyd)	sim(Albert, Emily)	sim(Albert, Lau)
何俊賢 Steven HO	sim(Albert, Steven)	sim(Steven, Steven)	...	...	...
何秀蘭 Cyd HO	sim(Albert, Cyd)	...	sim(Cyd, Cyd)	...	...
劉慧卿 Emily LAU	sim(Albert, Emily)	...	...	sim(Emily, Emily)	...
劉皇發 Dr LAU Wong-fat	sim(Albert, Lau)	...	...	...	sim(Lau, Lau)

We need some more spreadsheet tricks

Transpose

- Makes a “row” into a “column” and vice versa



SUMPRODUCT

- Given two rows of the same length, multiply the corresponding cells and add up all the products.
- Doesn't only work with rows, will work as long as the two selections have the same "shape".
 - Same length, and to be both horizontal or both vertical.
 - (can combine with TRANSPOSE to multiply a horizontal range with a vertical range.)

SUMPRODUCT

	A	B	C	D	E
1	11	7	4		
2	33	2	5		

- =sumproduct(A1:C1,A2:C2)
gives $(11 \times 33) + (7 \times 2) + (4 \times 5) = 7260$
- SUMPRODUCT multiplies corresponding elements.

SUMPRODUCT

	Apples	Oranges	Pears
Aeon	5.0	6.5	7.0
Taste	4.50	6	7.5

	John	Mary
Apples	5	3
Oranges	3	6
Pears	0	2

- How much would John spend if he shopped at Aeon?
- $5 * 5 + 6.50 * 3 + 7 * 0 = 44.50$
- **SUMPRODUCT(B2:D2, TRANSPOSE(B2:B4))**
- Ditto for Mary

SUMPRODUCT

	Apples	Oranges	Pears
Aeon	5.0	6.5	7.0
Taste	4.50	6	7.5

	John	Mary
Apples	5	3
Oranges	3	6
Pears	0	2

	John	Mary
Aeon	44.5	68.0
Taste	40.5	64.5

- The SUMPRODUCTS over all possible row-column pairs will give us the amount that John and Mary would spend if they shopped at Aeon and Taste.

Matrix

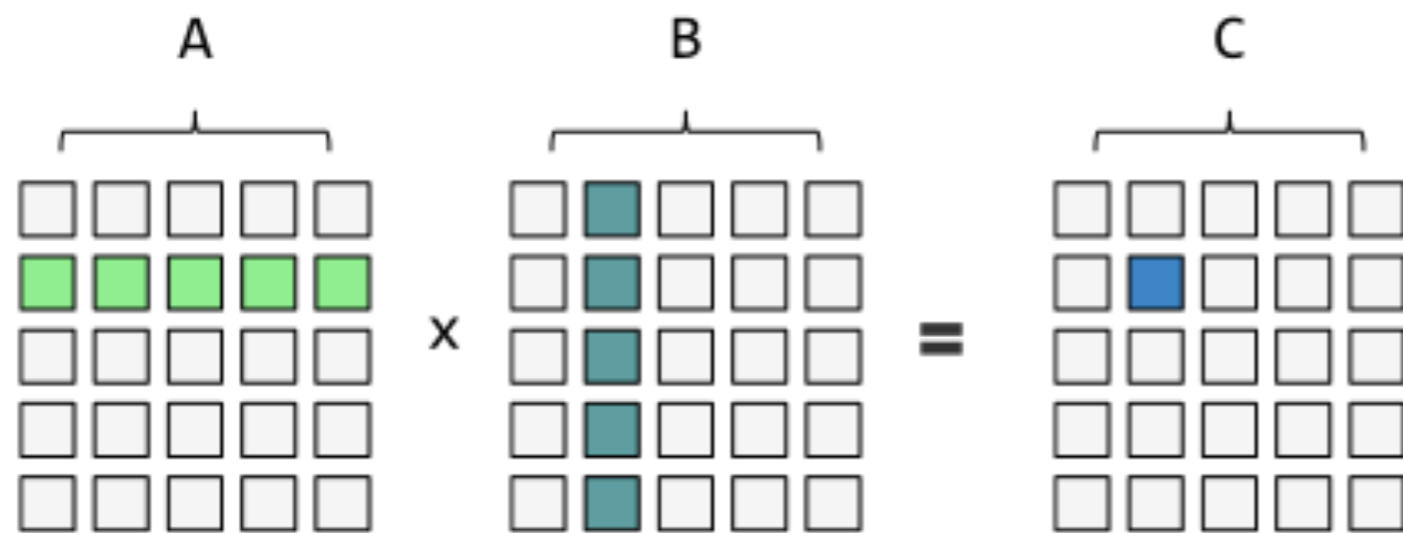
	Apples	Oranges	Pears
Aeon	5.0	6.5	7.0
Taste	4.50	6	7.5

- What we have been calling “tables” in Google Sheets is actually a **MATRIX** (plural: matrices)
- Every row along a matrix is related by in some way
 - First row: prices of products at Aeon
- Ditto for every column
 - First column: prices of apples at different stores.

Matrix Arithmetic

- We can do arithmetic with matrices in the same way as we can work with single numbers
- Some rules: e.g. can only add two matrices of the same size
- *Matrix Multiplication* is very useful when we need to aggregate together series of numbers

Matrix Multiplication



$$C_{ij} = \sum_{k=1}^m A_{ik} B_{kj}$$

Essentially a bunch of SUMPRODUCTS

Matrix Multiplication

	Apples	Oranges	Pears
Aeon	5.0	6.5	7.0
Taste	4.50	6	7.5

x

	John	Mary
Apples	5	3
Oranges	3	6
Pears	0	2

=

	John	Mary
Aeon	44.5	68.0
Taste	40.5	64.5

- =MMULT(**ORANGE**, **BLUE**)

HW1-4

Do Tasks 1 & 2

Back to voting

Yes = 1
No = -1
Did not vote = 0

- The SUMPRODUCT of any 2 votes tells us how they agree:
 - +1 point: both are 1 or both are -1
 - -1 point: one is -1 and the other is 1
 - 0 points: at least one did not vote

	"03/06/2015"-3	"03/06/2015"-41	"03/06/2015"-43	"03/07/2013"-11	"03/07/2013"-3
何俊仁 Albert HO	0	1	0	1	1
何俊賢 Steven HO	1	0	-1	0	0
何秀蘭 Cyd HO	0	1	1	1	1

- What we have:

	A	B	C	D	E	F
1		"03/06/2015"-	"03/06/2015"-	"03/06/2015"-	"03/07/2013"-	"03/07/2013"-
2	何俊仁 Albert HO	0	1	0	1	1
3	何俊賢 Steven HO	1	0	-1	0	0
4	何秀蘭 Cyd HO	0	1	1	1	1

- Formula to calculate *agree - disagree* for Albert and Steven:

$$= \text{SUMPRODUCT}(B2:F2, B3:F3)$$
- Formula to calculate *agree + disagree* for Albert and Steven?

$$= \text{SUMPRODUCT}(\text{ABS}(B2:F2), \text{ABS}(B3:F3))$$

Our task: Do this for each pair of legislators

- One way:
 - For each pair of legislators:
 - Make an agree/disagree list
 - Sum it (*agree - disagree*)
 - Sum its absolute values (*agree + disagree*)
 - Take the quotient (*agree - disagree*)/(*agree + disagree*)

- Or... compare every pair in the same table.

What we have:

	"03/06/2015"-3	"03/06/2015"-41	"03/06/2015"-43	"03/07/2013"-11	"03/07/2013"-3
何俊仁 Albert HO	ABS	YES	ABS	YES	YES
何俊賢 Steven HO	YES	ABS	NO	ABS	ABS
何秀蘭 Cyd HO	ABS	YES	YES	YES	YES
劉慧卿 Emily LAU	ABS	YES	YES	ABS	YES
劉皇發 Dr LAU Wong-fat	ABS	ABS	ABS	ABS	ABS

What we want:

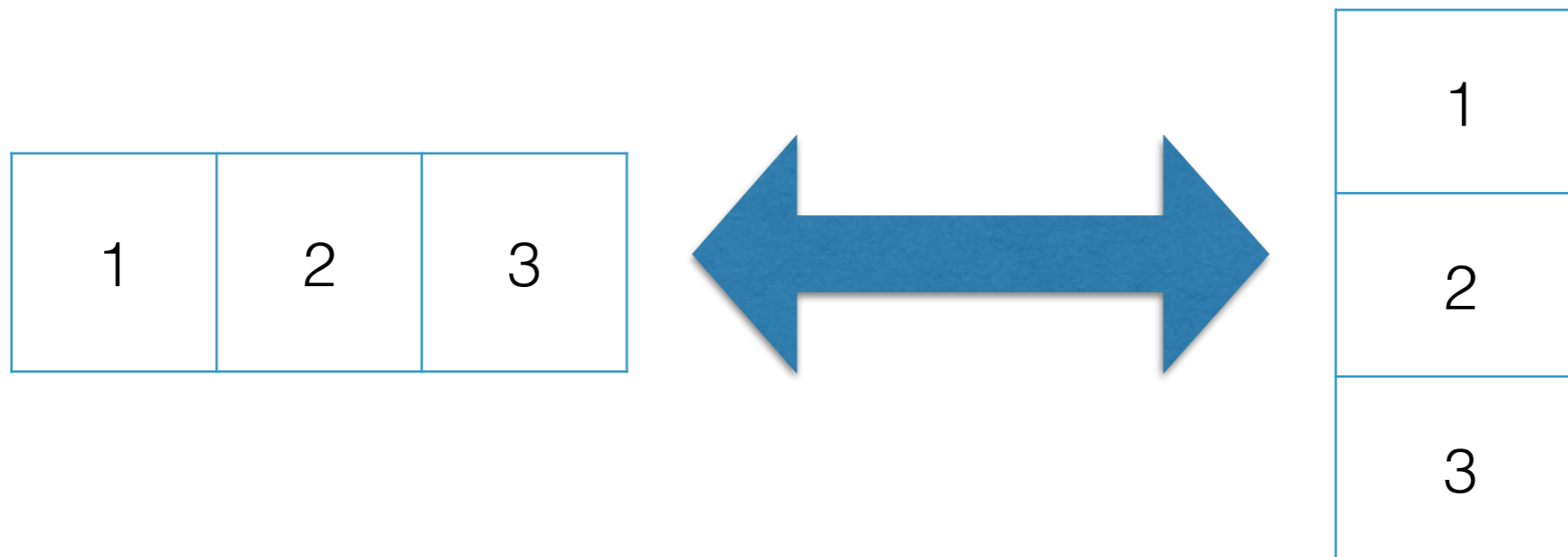
	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU Wong-fat
何俊仁 Albert HO					
何俊賢 Steven HO					
何秀蘭 Cyd HO					
劉慧卿 Emily LAU					
劉皇發 Dr LAU Wong-fat					

Making the Labels

- Row labels are easy: copy from the original table.
- Column labels can be copied from the row labels
 - But “fill” across rather than down.
 - Use TRANSPOSE!

TRANSPOSE

- Makes a “row” into a “column” and vice versa
- Also works with ranges (2x3 becomes 3x2)



	A	B	C	D	E	F
1		"03/06/2015"-3	"03/06/2015"-41	"03/06/2015"-43	"03/07/2013"-11	"03/07/2013"-3
2	何俊仁 Albert HO	0	1	0	1	1
3	何俊賢 Steven HO	1	0	-1	0	0

agree - disagree

- For Albert Ho (#1) and Steven Ho (#2):
= SUMPRODUCT(B2:F2, B3:F3)
- Between 12th and 19th legislator?
= SUMPRODUCT(B13:F13, B20:F20)
= SUMPRODUCT(OFFSET(B2:F2, 11, 0), OFFSET(B2:F2, 18, 0))
= SUMPRODUCT(OFFSET(B1:F1, **12**, 0), OFFSET(B1:F1, **19**, 0))
- Between *i*-th and *j*-th legislator?
 - Data for *i*-th legislator is in OFFSET(B1:F1, *i*, 0)
 - Between *i*-th and *j*-th :
= SUMPRODUCT(OFFSET(B1:F1, *i*, 0), OFFSET(B1:F1, *j*, 0))

Goal: Build a table containing all pairs of agree - disagree values

	A	B	C	D	E	F
1		何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU Wong-fat
2	何俊仁 Albert HO					
3	何俊賢 Steven HO					
4	何秀蘭 Cyd HO					
5	劉慧卿 Emily LAU					
6	劉皇發 Dr LAU Wong-fat					

- = similarity (Albert Ho, Steven Ho)
- = similarity (1st guy, 2nd guy)
- = similarity (guy in row-1, guy in column-1)

Goal: Build a table containing all pairs of agree - disagree values

- The i -th row corresponds to the $(i-1)$ -th legislator (because of the headers)
 - Ditto for the columns.
- i -th guy's data is in `OFFSET(B1:F1, i, 0)`
- If we are in the cell (i, j)
 - `ROW()` gives us i , and `COLUMN()` gives us j .
- Therefore, value that needs to go into that cell is calculated as
= `SUMPRODUCT(OFFSET(B1:F1,ROW(), 0), OFFSET(B1:F1, COLUMN(), 0))`

Similarity Tables

	"03/06/20 15"-3	"03/06/20 15"-41	"03/06/20 15"-43	"03/07/20 13"-11	"03/07/20 13"-3
何俊仁 Albert HO	0	1	0	1	1
何俊賢 Steven HO	1	0	-1	0	0
何秀蘭 Cyd HO	0	1	1	1	1
劉慧卿 Emily LAU	0	1	1	1	1
劉皇發 Dr LAU Wong-fat	0	0	0	0	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
"03/06/20 15"-3	0	1	0	0	0
"03/06/20 15"-41	1	0	1	1	0
"03/06/20 15"-43	0	-1	1	1	0
"03/07/20 13"-11	1	0	1	1	0
"03/07/20 13"-3	1	0	1	1	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
何俊仁 Albert HO	1				
何俊賢 Steven HO	=SUMPRODUCT(row 2, column 2)				
何秀蘭 Cyd HO					
劉慧卿 Emily LAU					
劉皇發 Dr LAU					

Or...

	"03/06/20 15"-3	"03/06/20 15"-41	"03/06/20 15"-43	"03/07/20 13"-11	"03/07/20 13"-3
何俊仁 Albert HO	0	1	0	1	1
何俊賢 Steven HO	1	0	-1	0	0
何秀蘭 Cyd HO	0	1	1	1	1
劉慧卿 Emily LAU	0	1	1	1	1
劉皇發 Dr LAU Wong-fat	0	0	0	0	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
"03/06/20 15"-3	0	1	0	0	0
"03/06/20 15"-41	1	0	1	1	0
"03/06/20 15"-43	0	-1	1	1	0
"03/07/20 13"-11	1	0	1	1	0
"03/07/20 13"-3	1	0	1	1	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
何俊仁 Albert HO	1	0			
何俊賢 Steven HO					
何秀蘭 Cyd HO					
劉慧卿 Emily LAU					
劉皇發 Dr LAU					

=SUMPRODUCT(row 2, column 3)

Or...

	"03/06/20 15"-3	"03/06/20 15"-41	"03/06/20 15"-43	"03/07/20 13"-11	"03/07/20 13"-3
何俊仁 Albert HO	0	1	0	1	1
何俊賢 Steven HO	1	0	-1	0	0
何秀蘭 Cyd HO	0	1	1	1	1
劉慧卿 Emily LAU	0	1	1	1	1
劉皇發 Dr LAU Wong-fat	0	0	0	0	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
"03/06/20 15"-3	0	1	0	0	0
"03/06/20 15"-41	1	0	1	1	0
"03/06/20 15"-43	0	-1	1	1	0
"03/07/20 13"-11	1	0	1	1	0
"03/07/20 13"-3	1	0	1	1	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
何俊仁 Albert HO	1	0	3		
何俊賢 Steven HO					
何秀蘭 Cyd HO					
劉慧卿 Emily LAU					
劉皇發 Dr LAU					

=SUMPRODUCT(row 2, column 4)

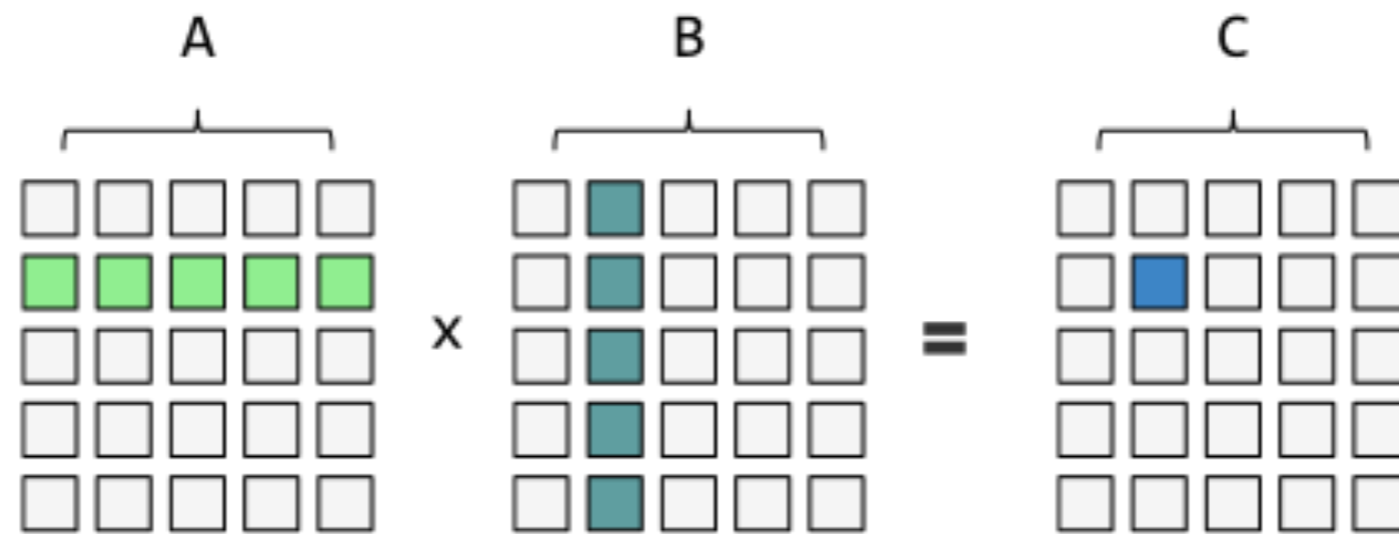
Or...

	"03/06/20 15"-3	"03/06/20 15"-41	"03/06/20 15"-43	"03/07/20 13"-11	"03/07/20 13"-3
何俊仁 Albert HO	0	1	0	1	1
何俊賢 Steven HO	1	0	-1	0	0
何秀蘭 Cyd HO	0	1	1	1	1
劉慧卿 Emily LAU	0	1	1	1	1
劉皇發 Dr LAU Wong-fat	0	0	0	0	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
"03/06/20 15"-3	0	1	0	0	0
"03/06/20 15"-41	1	0	1	1	0
"03/06/20 15"-43	0	-1	1	1	0
"03/07/20 13"-11	1	0	1	1	0
"03/07/20 13"-3	1	0	1	1	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
何俊仁 Albert HO	1	0	3		
何俊賢 Steven HO	0				
何秀蘭 Cyd HO	=SUMPRODUCT(row 3, column 2)				
劉慧卿 Emily LAU					
劉皇發 Dr LAU					

Matrix Multiplication!!!



$$C_{ij} = \sum_{k=1}^m A_{ik} B_{kj}$$

Matrix Multiplication...

	"03/06/20 15"-3	"03/06/20 15"-41	"03/06/20 15"-43	"03/07/20 13"-11	"03/07/20 13"-3
何俊仁 Albert HO	0	1	0	1	1
何俊賢 Steven HO	1	0	-1	0	0
何秀蘭 Cyd HO	0	1	1	1	1
劉慧卿 Emily LAU	0	1	1	1	1
劉皇發 Dr LAU Wong-fat	0	0	0	0	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
"03/06/20 15"-3	0	1	0	0	0
"03/06/20 15"-41	1	0	1	1	0
"03/06/20 15"-43	0	-1	1	1	0
"03/07/20 13"-11	1	0	1	1	0
"03/07/20 13"-3	1	0	1	1	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
何俊仁 Albert HO	1	0	3	3	0
何俊賢 Steven HO	0	1	-1	-1	0
何秀蘭 Cyd HO	3	-1	1	4	0
劉慧卿 Emily LAU	3	-1	4	1	0
劉皇發 Dr LAU	0	0	0	0	0

=MMULT(ORANGE, PURPLE)

MMULT

	"03/06/20 15"-3	"03/06/20 15"-41	"03/06/20 15"-43	"03/07/20 13"-11	"03/07/20 13"-3
何俊仁 Albert HO	0	1	0	1	1
何俊賢 Steven HO	1	0	-1	0	0
何秀蘭 Cyd HO	0	1	1	1	1
劉慧卿 Emily LAU	0	1	1	1	1
劉皇發 Dr LAU Wong-fat	0	0	0	0	0

TRANSPOSE

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
"03/06/20 15"-3	0	1	0	0	0
"03/06/20 15"-41	1	0	1	1	0
"03/06/20 15"-43	0	-1	1	1	0
"03/07/20 13"-11	1	0	1	1	0
"03/07/20 13"-3	1	0	1	1	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
何俊仁 Albert HO	1	0	3	3	0
何俊賢 Steven HO	0	1	-1	-1	0
何秀蘭 Cyd HO	3	-1	1	4	0
劉慧卿 Emily LAU	3	-1	4	1	0
劉皇發 Dr LAU	0	0	0	0	0

Result: Agree - Disagree

MMULT

	"03/06/20 15"-3	"03/06/20 15"-41	"03/06/20 15"-43	"03/07/20 13"-11	"03/07/20 13"-3
何俊仁 Albert HO	0	1	0	1	1
何俊賢 Steven HO	1	0	1	0	0
何秀蘭 Cyd HO	0	1	1	1	1
劉慧卿 Emily LAU	0	1	1	1	1
劉皇發 Dr LAU Wong-fat	0	0	0	0	0

TRANSPOSE

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
"03/06/20 15"-3	0	1	0	0	0
"03/06/20 15"-41	1	0	1	1	0
"03/06/20 15"-43	0	1	1	1	0
"03/07/20 13"-11	1	0	1	1	0
"03/07/20 13"-3	1	0	1	1	0

	何俊仁 Albert HO	何俊賢 Steven HO	何秀蘭 Cyd HO	劉慧卿 Emily LAU	劉皇發 Dr LAU
何俊仁 Albert HO	1	0	3	3	0
何俊賢 Steven HO	0	1	1	1	0
何秀蘭 Cyd HO	3	1	1	4	0
劉慧卿 Emily LAU	3	1	4	1	0
劉皇發 Dr LAU	0	0	0	0	0

Result: Agree + Disagree

Today...

- Activity 1-4